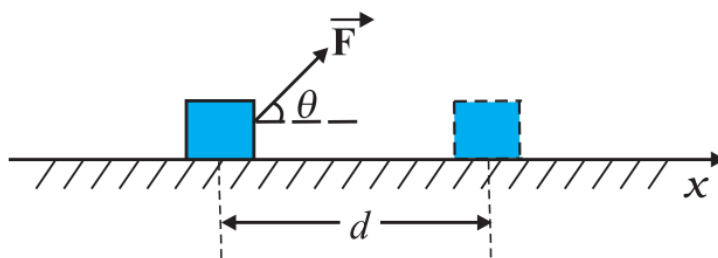


1. A system has done no work if:
 - (a) The force and displacement are perpendicular
 - (b) A large force acts on it, but causes no displacement
 - (c) The force is zero, but it undergoes displacement due to zero friction
 - (d) All the above**

EXPLANATION:

Work is defined as the product of a force and the displacement it causes in the direction of the force. Consider a constant force $\vec{F}$ acting on an object of mass m . The object undergoes a displacement d in the positive x -direction.



An object undergoes displacement 'd' under the influence of the force $\vec{F}$.

It can be said that no work is done if:

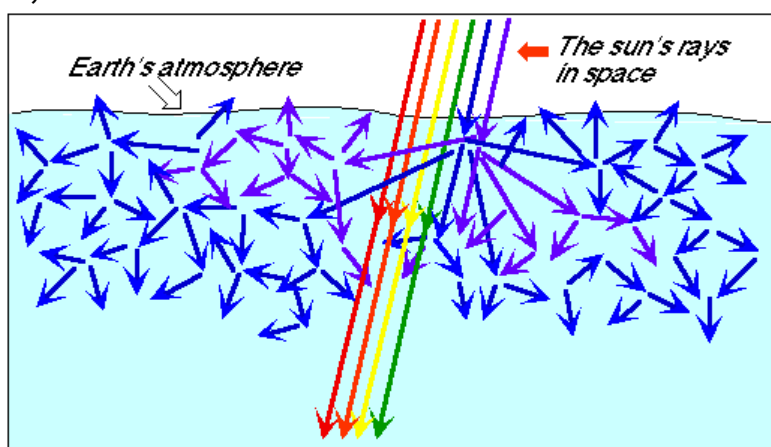
- **The displacement is zero:** If there is no displacement, no work is done, no matter how large the force is.
For example: when you push hard against a rigid brick wall, the wall does not move, so the force you apply does no work on the wall. However, your muscles still use energy, contracting and relaxing, which makes you tired. This shows in physics; work requires both a force and a displacement in the direction of the force.
- **The force is zero:** If there is no force in the direction of displacement, no work is done.
Example: A block moving on a smooth horizontal table experiences no horizontal force (since there is no friction), yet it may undergo a large displacement.
- **The force and displacement are perpendicular:** Work depends on the component of the force along the displacement.
Examples: For a block moving on a smooth horizontal table, the gravitational force does no work because it acts perpendicular to the displacement.
 If we assume the Moon's orbit around the Earth is perfectly circular, the Earth's gravitational force does no work. The Moon's instantaneous displacement is tangential, while the Earth's gravitational force is radially inward, so $\theta = \pi/2$.
 Reason: When $\theta = \pi/2$ rad (90°), $\cos(\pi/2) = 0$, so no work is done. **So, Option (d) is correct.**

2. Consider the following statements:
 1. Blue light scatters more than red light, as blue light has a shorter wavelength.
 2. Water droplets present in clouds scatter light and cause them to appear white.
 3. Sky will appear red for an astronaut when observed outside the karman line.
 How many of the above statements is/are correct?
 - (a) Only one
 - (b) Only two**
 - (c) All three
 - (d) None

EXPLANATION:

Scattering of light is a phenomenon in which light (radiation) interacts with matter, causing it to deviate from its original path.

- Earth's atmosphere contains tiny dust particles, which diffuse sunlight in all directions, allowing light to reach areas not directly illuminated by the sun.
- Sunlight consists of various colors, each with a different wavelength. Blue light has a shorter wavelength, while red light has a longer wavelength.
- When sunlight is scattered, the shorter wavelengths—violet, blue, and green—are scattered more.
- As sunlight passes through the atmosphere, it is scattered by air molecules and particles. Blue light is scattered most because it travels in shorter, smaller waves.
- Although violet light is scattered even more, the human eye is less sensitive to violet, so we perceive the sky as blue. **So, Statement 1 is correct.**



The colour and brightness of clouds depend on the reflection, scattering, and transmission of sunlight. When sunlight reaches a cloud, all colours of light become scattered equally. The equal scattering of light is caused by the large water droplets contained within a cloud.

As a result, when clouds are viewed from Earth, they appear white in colour against the background of a blue sky. Therefore, clouds are white because light from the Sun is white. **So, Statement 2 is correct.**

The sky appears black to an astronaut in a spaceship flying at high altitude, rather than red or blue. This is because the atmosphere at such altitudes is extremely thin, containing very few dust particles or air molecules.

Since the scattering of sunlight requires these particles and molecules to redirect light in different directions, an astronaut at high altitude sees only the darkness of space instead of a colored sky. **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

SCIENCE BEHIND THE SCATTERING OF SUNLIGHT	
About	Sunlight contains a full spectrum of colors, like those seen in a rainbow. Each color has a different wavelength: • Blue: ~400 nm (shortest wavelength) • Red: ~700 nm (longest wavelength) Effect of Particle Size on Scattering ➤ Small particles scatter short wavelengths (like blue) more efficiently. ➤ Large particles, such as water droplets, scatter all wavelengths almost equally. ➤ Millions of water droplets in the atmosphere scatter sunlight in all colors, which combine to appear white, giving clouds their color.

	Mie Scattering in Clouds: ➤ The scattering of sunlight by cloud water droplets occurs through Mie scattering. ➤ Mie scattering is essentially refraction, where light is redirected when it passes through droplets. ➤ Since Mie scattering does not depend on wavelength, all colors are scattered equally. ➤ This random, equal scattering of all colors makes clouds appear white.
Rayleigh's law	➤ The phenomenon of scattering is a two-step process: Absorption of light by the scattering particle and then instant re-emission by it in all possible directions. Thus, this phenomenon is different from reflection. ➤ The scattered light does not obey the laws of reflection. It is important to note that the size of the particle must be less than the wavelength of light incident on it. ➤ A bigger-sized particle will scatter all the wavelengths equally. Rayleigh's law of scattering gives the intensity of scattered light. According to this law, the intensity of scattered light is inversely proportional to the fourth power of its wavelength: $I \propto \frac{1}{\lambda^4}$ Here 'I' is the intensity and 'λ' is the wavelength of the scattered light. Thus, when white light is incident on the scattering particle, the blue light is scattered the most and the red light is scattered the least.

3. Consider the following statements regarding Aditya-L1 Mission:

1. It is India's first dedicated space-based solar mission, aimed at studying the Sun.
2. The satellite is placed in a Halo orbit around the L1 Lagrange Point.
3. L1 is a point in space where the gravitational forces of the Sun and Earth balance each other.
4. A spacecraft placed at the L1 point requires minimal energy to remain in orbit.

Which of the statements given above are correct?

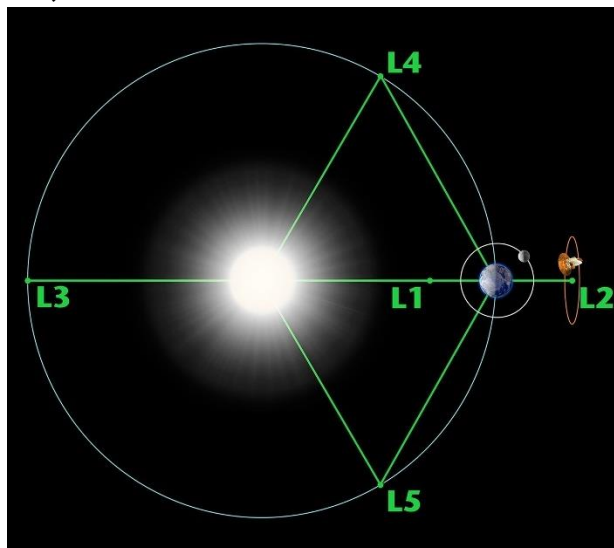
- (a) 1, 3 and 4 only
- (b) 2, 3 and 4 only
- (c) 1 and 2 only
- (d) 1, 2, 3 and 4**

EXPLANATION:

Aditya L1 is the first space-based Indian mission to study the Sun. The spacecraft shall be placed in a halo orbit around the Lagrange point 1 (L1) of the Sun-Earth system, which is about 1.5 million km from the Earth. **So, Statements 1 and 2 are correct.**

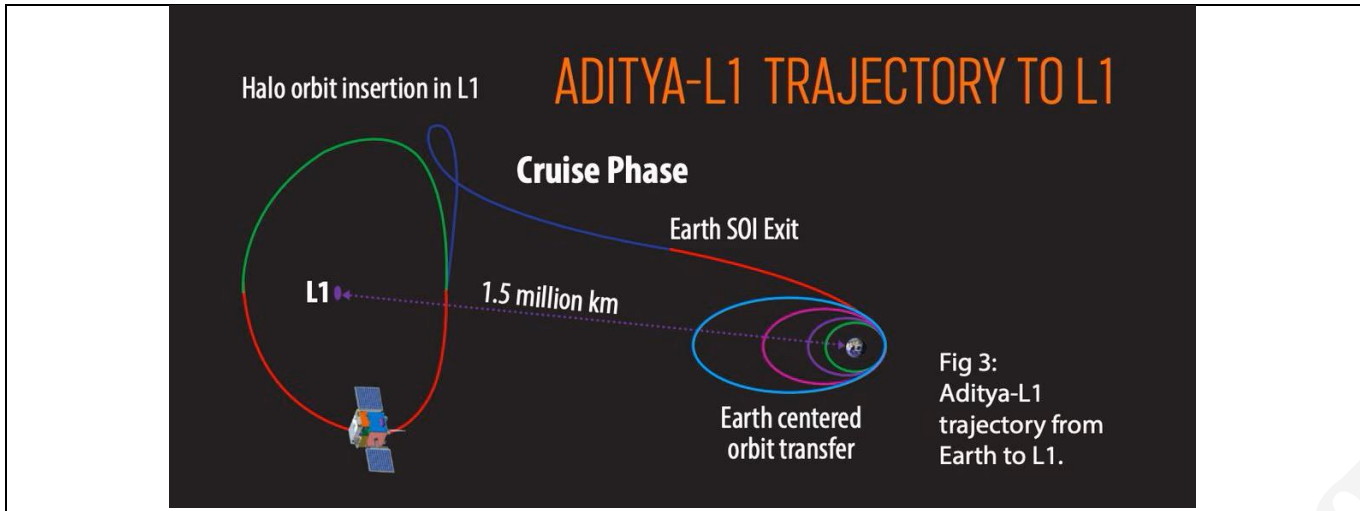
- A satellite placed in the halo orbit around the L1 point has the major advantage of continuously viewing the Sun without any occultation/eclipses.
- Lagrange Points are positions in space where the gravitational forces of a two-body system, like the Sun and the Earth, produce enhanced regions of attraction and repulsion. These can be used by spacecraft to reduce the fuel consumption needed to remain in position. Therefore, a spacecraft placed at the L1 point requires minimal energy to remain in orbit. **So, Statement 4 is correct.**
- Of the five Lagrange points, three are unstable and two are stable. The unstable Lagrange points - labelled L1, L2 and L3 - lie along the line connecting the two large masses. The stable Lagrange points - labelled L4 and L5 - form the apex of two equilateral triangles that have the large masses at their vertices.

- L1 is a location in space where the gravitational forces of two celestial bodies, such as the Sun and Earth, are in equilibrium. This allows an object placed there to remain relatively stable with respect to both celestial bodies. **So, Statement 3 is correct.**



ADDITIONAL INFORMATION:

ADITYA-L1 Mission	
Recently in the News	India's Solar Ultraviolet Imaging Telescope (SUIT) onboard Aditya-L1 Captures Unprecedented Solar Flare Details.
About	➤ Aditya-L1 is a satellite dedicated to the comprehensive study of the Sun. It has 7 distinct payloads developed, all developed indigenously. Five by ISRO and two by Indian academic institutes in collaboration with ISRO. ➤ The spacecraft carries seven payloads to observe the photosphere, chromosphere and the outermost layers of the Sun (the corona) using electromagnetic, particle and magnetic field detectors. ➤ Using the special vantage point L1, four payloads directly view the Sun, and the remaining three payloads carry out in-situ studies of particles and fields at the Lagrange point L1, thus providing important scientific studies of the propagatory effect of solar dynamics in the interplanetary medium. ➤ Aditya L1 payloads are expected to provide the most crucial information to understand the problem of coronal heating, coronal mass ejection, pre-flare and flare activities and their characteristics, dynamics of space weather, propagation of particles and fields, etc. ➤ Aditya-L1 stays in Earth-bound orbits for 16 days, during which it undergoes 5 manoeuvres to gain the necessary velocity for its journey. ➤ Subsequently, Aditya-L1 undergoes a Trans-Lagrangian1 insertion manoeuvre, marking the beginning of its 110-day trajectory to the destination around the L1 Lagrange point. ➤ Upon arrival at the L1 point, another manoeuvre binds Aditya-L1 to an orbit around L1, a balanced gravitational location between the Earth and the Sun. ➤ The Satellite spends its whole mission life orbiting around L1 in an irregularly shaped orbit in a plane roughly perpendicular to the line joining the Earth and the Sun.



4. Consider the following statements about black holes:
1. Not all black holes are formed from supernova explosions.
 2. Black holes can be observed using visible light telescopes.
 3. Black holes can spin, and their spin affects the gravitational waves they emit.
- How many of the statements given above is/are correct?
- (a) Only One
(b) Only two
 (c) All three
 (d) None

EXPLANATION:

Black holes are among the most mysterious cosmic objects, much studied but not fully understood. These objects aren't really holes. They're huge concentrations of matter packed into very tiny spaces. A black hole is so dense that gravity just beneath its surface, the event horizon, is strong enough that nothing – not even light – can escape. The event horizon isn't a surface like Earth's or even the Sun's. It's a boundary that contains all the matter that makes up the black hole.

The possibility of birth of supermassive black holes:

- One possibility is that supernova explosions of massive stars in the early Universe formed stellar-mass black holes that, over billions of years, grew supermassive.
- A single stellar-mass black hole can grow rapidly by consuming nearby stars and gas, often in plentiful supply near the galaxy centre.
- The black hole may also grow through mergers with other black holes that drift to the galactic centre during collisions with other galaxies. Astronomers are actively investigating these and other scenarios through observations and computer simulations.

Thus, it shows not all black holes are formed from supernova explosions. **So, Statement 1 is correct.**

Black holes don't emit or reflect light, making them effectively invisible to telescopes. Scientists primarily detect and study them based on how they affect their surroundings:

- Black holes can be surrounded by rings of gas and dust, called accretion disks, that emit light across many wavelengths, including X-rays.
- A supermassive black hole's intense gravity can cause stars to orbit around it in a particular way. Astronomers tracked the orbits of several stars near the center of the Milky Way to prove it houses a supermassive black hole, a discovery that won the 2020 Nobel Prize.
- When very massive objects accelerate through space, they create ripples in the fabric of space-time called gravitational waves. Scientists can detect some of these by the ripples' effect on detectors.

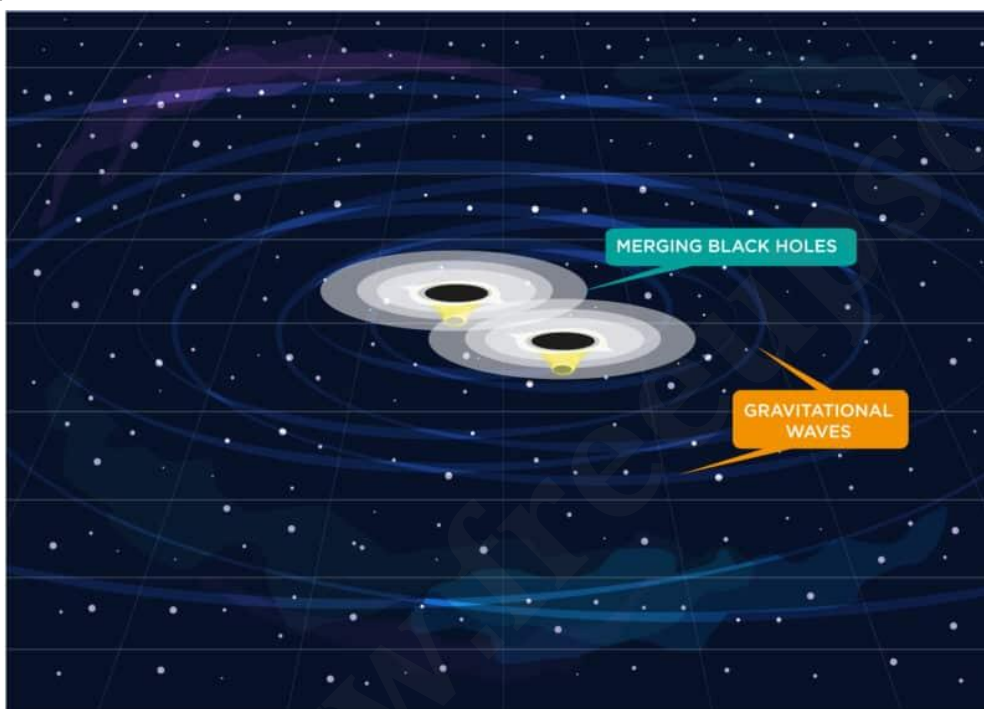
➤ Massive objects like black holes can bend and distort light from more distant objects. This effect, called gravitational lensing, can be used to find isolated black holes that are otherwise invisible. Therefore, Black holes cannot be observed using visible light telescopes, because they do not emit light. However, their presence can be detected indirectly through their gravitational waves they produce or through gravitational lensing effects caused by their strong gravity.

So, Statement 2 is not correct.

Black hole mergers refer to the event where two black holes combine, resulting in the emission of gravitational waves. This process is characterised by the mass being contained within the event horizon, preventing any information from escaping.

- The gravitational wave signature of a binary black hole (BBH) merger is dependent on its component mass and spin.
- All black holes spin but the challenging to measure the spin of individual components in a merging BBH, the mass-weighted effective spin parameter of the binary can be relatively well estimated from the observed gravitational wave signal. The fastest-known black hole spin – named GRS 1915+105 – clocks in at over 1,000 rotations per second.

This demonstrates that a black hole's spin influences the gravitational waves it emits. **So, Statement 3 is correct.**



ADDITIONAL INFORMATION:

BLACK HOLE	
About	➤ The nearest known black hole, called Gaia BH1, is about 1,500 light-years away. ➤ The most distant black hole detected, at the center of a galaxy called QSO J0313-1806, is around 13 billion light-years away. ➤ The most massive black hole observed, TON 618, tips the scales at 66 billion times the Sun's mass. ➤ The lightest-known black hole is only 3.8 times the Sun's mass. It's paired up with a star. ➤ Spaghettification: a real term that describes what happens when matter gets too close to a black hole. It's squeezed horizontally and stretched vertically, resembling a noodle.

- Particle accelerators: Monster black holes at the centers of galaxies can launch particles to near light speed.
- Gravity's the same: If you replaced the Sun with a black hole of the same mass, the solar system would get a lot colder, but the planets would stay in their orbits.
- Most Milky Way-sized galaxies have monster black holes at their centers. Our is called Sagittarius A* (pronounced ey-star), and it's 4 million times the Sun's mass.

5. Consider the following statements:

1. Buoyant force exerted by a liquid is directly proportional to its liquid density.
 2. If the gravitational force acting on an object is higher than the buoyant force acting on it, it floats.
- Which of the statements given above is/are correct?

- (a) 1 only
 (b) 2 only
 (c) Both 1 and 2
 (d) Neither 1 nor 2

EXPLANATION:

The buoyant force is the upward force that acts on an object when it is submerged in a fluid. When a body is placed in a liquid, two forces act on it: the gravitational force, which pulls it downward, and the force exerted by the fluid, which pushes it upward. This upward force exerted by the liquid is called the buoyant force.

Archimedes' principle: states that when an object is submerged partially or fully in a fluid, the magnitude of the buoyant force on it is always equal to the weight of the fluid displaced by the object.

Archimedes' principle



The magnitude of buoyant force depends on several factors:

Density of the fluid: The buoyant force is directly proportional to the density of the liquid. Denser liquid exerts a greater buoyant force than less dense liquid.

For example, an object will experience a greater buoyant force in saltwater compared to freshwater.

So, Statement 1 is correct.

Volume of the displaced fluid: Buoyant force is also directly proportional to the volume of the fluid displaced by the object. The more fluid an object displaces, the greater the buoyant force it experiences. This explains why larger objects tend to float more easily than smaller objects in the same fluid.

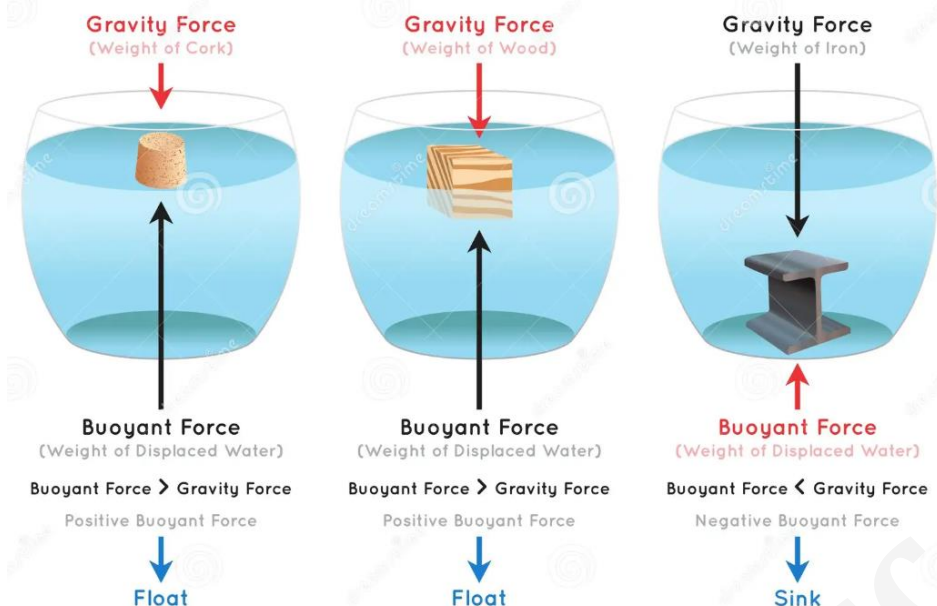
Floating: An object floats if it is less dense than the surrounding fluid. In this case, the buoyant force acting upward is greater than the gravitational force, resulting in a net upward force that makes the object rise and float.

Sinking: An object sinks if it is denser than the surrounding fluid. Here, the buoyant force is smaller than the gravitational force, producing a net downward force that causes the object to sink.

Whether an object floats or sinks depends on the balance between the gravitational force pulling it downward and the buoyant force pushing it upward.

Example: A stone sinks in water because its weight exceeds the buoyant force acting on it. **So, Statement 2 is not correct.**

Buoyant Force



6. Consider the following statements:

Statement I: Communication through sound waves isn't possible on the moon.

Statement II: Mechanical waves cannot propagate through a vacuum.

Statement III: Sound travels faster through solids than liquids.

Which of the following is correct with respect to the above statements?

(a) Both Statement II and Statement III are correct, and both of them explain Statement I.

(b) Both Statement II and Statement III are correct, but only one of them explains Statement I.

(c) Only one of Statements II and III is correct, and that explains Statement I.

(d) Neither Statement II nor Statement III is correct.

EXPLANATION:

Sound is produced by vibrations of an object. These vibrations create disturbances in the surrounding medium, which travel in the form of waves.

Sound waves are longitudinal mechanical waves, meaning the particles of the medium vibrate parallel to the direction of wave propagation. They require a material medium (like air, water, or solids) to travel and cannot propagate through a vacuum. Sound waves cannot travel on the Moon because sound requires a material medium to propagate. The Moon has no atmosphere, meaning there are no air molecules to transmit the vibrations that constitute a sound wave. **So, Statements I and II are correct. And statement II explains Statement I.**

Sound is a type of mechanical wave that is created when an object vibrates, causing the particles of the surrounding medium to vibrate too. These vibrations pass from one particle to another, carrying sound energy.

The speed of sound depends on how closely packed the particles of the medium are:

Solids: Particles are tightly packed, so vibrations pass quickly from one particle to another. That's why sound travels fastest in solids (e.g., through metal or wood).

Liquids: Particles are less tightly packed than solids, so the speed is slower than in solids but faster than in gases (e.g., sound travels well through water).

Gases: Particles are far apart, so it takes more time for vibrations to move between them, making sound slowest in gases (e.g., through air).

Sound travels fastest in solids, slower in liquids, and slowest in gases, because particle interaction is strongest in solids. **So, Statement III is correct but it does not explain statement I**

7. With reference to properties of electric charge, which one of the following statements is **not** correct?

- (a) Charge can be positive or negative
- (b) Charge can be quantised
- (c) Charge can be conserved
- (d) **None of the above**

EXPLANATION:

Electric charge is a fundamental property of matter that indicates the amount of electric potential energy stored in a particle. It can be positive or negative and is measured in coulombs (C). The charge of an object depends on the number of protons (positive) and electrons (negative) it contains.

- If the number of protons and electrons is equal, the object is neutral.
- If there are more protons, the object becomes positively charged.
- If there are more electrons, the object becomes negatively charged.

Protons are located in the nucleus of an atom, while electrons move around the nucleus. The balance between protons and electrons determines whether the atom is neutral or charged. **So, statement in Option (a) is correct.**

Electric charge is quantized, meaning it comes in discrete units. The fundamental unit of charge is the charge of an electron, which is approximately -1.602×10^{-19} Coulombs (C). All other charges are multiple of this elementary charge. **So, statement in (b) is correct.** According to the quantization of electric charge, Electric charges are defined as the Integral multiple of the charge present on them, hence, in any system, The charges will be,

$$q = ne$$

n = Integer numbers

e = value of the charge (1.6×10^{-19} C)

Conservation of Charge: The total electric charge in an isolated system remains constant. This means that charge cannot be created or destroyed, but it can be transferred from one object to another. For example, when two objects with opposite charges come into contact, electrons can flow from one object to the other, changing the charges of both objects. **So, statement in option (c) is correct.**

All the given statements (a), (b), and (c) correctly describe the properties of electric charge. Since the question asks which, statement is not correct, and all are true, **the correct answer is Option (d) None of the above.**

ADDITIONAL INFORMATION:

ELECTRIC CHARGE	
Electric charge	Electric charges can be created in three main ways: ➤ Friction – Rubbing two objects can transfer electrons, giving them opposite charges. ➤ Contact – When two charged objects touch, electrons can flow between them, neutralizing the charges. ➤ Induction – Bringing a charged object near an uncharged object can polarize it, displacing electrons without direct contact.

Measuring Electric charge	Electric charge is a fundamental property of matter that describes how much electric potential an object has. It is measured in coulombs (C), named after Charles-Augustin de Coulomb. To measure charge, we quantify the amount of charge present in an object or system. The following are a few methods used to measure electric charge: Electroscope: ➤ A simple device to detect the presence and polarity of electric charge. ➤ Made of a metal rod with a light conducting leaf or ball. ➤ When brought near a charged object, the leaf moves because of electrostatic force, showing the type of charge. Electrostatic Voltmeter: ➤ Measures electric potential difference between two points. ➤ A movable metal vane is placed between two metal plates. ➤ Voltage causes the vane to move, and the deflection is proportional to the voltage. Faraday Ice Pail Experiment ➤ A classic method to measure charge. ➤ A charged object is brought near or inside a metal container (pail) connected to an electroscope. ➤ The deflection of the electroscope shows the amount of charge transferred. Current Measurement ➤ Charge can also be found using electric current. ➤ Current is the rate of flow of charge (in amperes, A). ➤ By measuring current over time, we calculate the total charge transferred. ➤ Commonly used in electrical circuits. Charge-Coupled Devices (CCDs) ➤ Used in digital cameras and imaging systems. ➤ Light falling on each pixel creates a charge proportional to light intensity. ➤ This charge is then measured and converted into digital signals.
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8. With reference to atomic clocks, consider the following statements:

1. They are more stable than quartz crystal clocks.
2. They are used in Global Navigation Satellite Systems.
3. Caesium and Rubidium are used in atomic clocks

Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 2 only
- (c) 1 and 3 only
- (d) **1, 2 and 3**

EXPLANATION:

Most modern clocks, from wristwatches to those used on satellites, keep time using a quartz crystal oscillator. These devices take advantage of the fact that quartz crystals vibrate at a precise frequency when voltage is applied to them. The vibrations of the crystal act like the pendulum of a grandfather clock, ticking off how much time has passed.

Atomic clocks use atoms, more precisely the electronic transition from one state to another, as their 'pendulum'. They take advantage of the fact that all atoms of a particular element (e.g. Caesium and Rubidium) have the same electron configuration. Different atomic clocks using the same element thus use the same 'pendulum', unlike, e.g. different mechanical clocks which each deploy a slightly different pendulum (due to inaccuracies in the manufacturing process).

- By space navigation standards, quartz crystal clocks aren't very stable. After only an hour, even the best-performing quartz oscillators can be off by a nanosecond (one billionth of a second). After six weeks, they may be off by a full millisecond (one thousandth of a second), or a distance error of 300 kilometres. That would have a huge impact on measuring the position of a fast-moving spacecraft.
- While Atomic clocks combine a quartz crystal oscillator with an ensemble of atoms to achieve greater stability, NASA's Deep Space Atomic Clock will be off by less than a nanosecond after four days and less than a microsecond (one millionth of a second) after 10 years. This is equivalent to being off by only one second every 10 million years.

Therefore, in comparison, atomic clocks are more stable than quartz crystal clocks. **So, Statements 1 and 3 are correct.**

Global Navigation Satellite Systems (GNSS) rely on a network of atomic clocks on board satellites, all synchronised to a common time reference. These precise clocks measure the time it takes for signals to travel from satellites to receivers on Earth, allowing the system to calculate locations with high accuracy. The atomic clocks on satellites are extremely stable, maintaining accuracy to a single nanosecond over a few hours and only a few nanoseconds over the course of a day, which ensures reliable positioning for GPS and other GNSS applications. **So, Statement 2 is correct.**

ADDITIONAL INFORMATION:

ATOMIC CLOCKS	
Recently in the News	ISRO has made its historic 100th launch with the Advanced navigation satellite with Made-in-India atomic clocks.
About	➤ An atomic clock is a type of clock that uses the vibrations of atoms to measure time. Specifically, it uses the oscillations of the electrons in atoms to keep time. ➤ Atomic clocks work by using a type of atom called a "caesium atom". Caesium atoms are very stable and have a very specific frequency at which their electrons vibrate. This frequency is used as the basis for the atomic clock's timekeeping. ➤ To measure time using caesium atoms, an atomic clock uses a device called a "microwave cavity". The microwave cavity is a chamber that is filled with caesium vapor. A microwave signal is then sent into the cavity, which causes the caesium atoms to vibrate. ➤ As the caesium atoms vibrate, they emit radiation at a very specific frequency. This frequency is then detected by a detector, which compares it to a standard frequency. The difference between the two frequencies is used to adjust the clock's timekeeping.
Types	There are two types of atomic clocks: caesium atomic clocks and hydrogen maser atomic clocks. ➤ Caesium atomic clocks are the most common and are used to define the international standard for time, called Coordinated Universal Time (UTC). ➤ Hydrogen maser atomic clocks are even more accurate than caesium atomic clocks and are used in scientific research.
Applications	Atomic clocks are used in many applications that require very precise timing. Some of the most common applications include: ➤ GPS systems: GPS systems use atomic clocks to measure the time it takes for a signal to travel from a satellite to a receiver on Earth. This allows GPS systems to calculate the receiver's location with great accuracy. ➤ Telecommunications networks: Telecommunications networks use atomic clocks to synchronize the timing of signals that are sent over long distances. ➤ Scientific research: Atomic clocks are used in many scientific experiments that require precise timing, such as studies of the behavior of atoms and molecules.

9. Consider the following:

1. Resource for lunar exploration missions
2. Supply of oxygen
3. Supply of drinking water
4. Hydrogen fuel for rockets

How many of the above is/are potential uses of lunar water?

- (a) Only one
(b) Only two
(c) Only three
(d) **All four**

EXPLANATION:

Lunar water has two possible origins. On one hand, comets and other celestial bodies that hit the Moon deliver water in the form of ice. On the other hand, some water is produced directly on the lunar surface.

Theoretically, this occurs when hydrogen ions from the solar wind chemically combine with oxygen atoms in lunar minerals, forming hydroxyl (OH) groups within the crystals of rock minerals and in the bubbles of lunar glass. In shaded areas, water is stored in the form of ice.

The potential uses of lunar water:

- The Moon's south pole is believed to contain water ice, which could be a valuable resource for future exploration.
- Water ice could provide drinking water, be used to cool equipment, or be processed to produce fuel and oxygen. Several space agencies are planning missions to the Moon's south pole in the coming years.
- For the Moon to support human life, oxygen and water must be available. Oxygen can be extracted from rocks in the form of oxides, but obtaining water is more complex.
- The discovery of lunar water is significant. The accumulated ice could be extracted to provide liquid water for drinking and growing plants. Additionally, water could be split into hydrogen and oxygen through electrolysis using solar energy, providing fuel and breathable oxygen.
- In the future, if hydrogen and oxygen are generated from water collected on the lunar surface, hydrogen can be used as rocket fuel, while oxygen can support human life on the Moon. Therefore, all the above can be considered as the potential uses of lunar water. **So, Option (d) is correct.**

ADDITIONAL INFORMATION:

LUNAR WATER	
Recently in news	A dishwasher-sized NASA satellite was launched into space from Florida on Wednesday to identify where water – a precious resource for lunar missions – resides on the moon's surface in places such as the permanently shadowed craters at its poles.
About	➤ Finding out that water can be created naturally by solar wind changes how we think about resources on the Moon. ➤ If even small amounts of water can form this way, astronauts on future missions might be able to harvest it directly from the lunar soil, providing drinking water, breathable oxygen, or even fuel for rockets. ➤ This could make long-term human presence on the Moon much more sustainable and less dependent on costly Earth-based supply missions.
Lunar exploration	➤ NASA's focus on the Moon's South Pole, an area where permanently shadowed craters might trap frozen water, now seems even more important. ➤ Future missions might combine mining frozen water deposits with harnessing the ongoing water-creation process sparked by the Sun.

India's moon missions so far	➤ Recently, India formally approved the joint ISRO-JAXA Chandrayaan-5 (LUPEX) mission to study water ice at the Moon's south pole. ➤ India's first Moon mission, Chandrayaan-1, was successfully launched in 2008, collecting chemical, mineralogical, and photo-geologic data from the Moon. ➤ The next mission, Chandrayaan-2, was launched in 2019 to study the Moon's topography and mineral composition. It included an orbiter, lander, and rover to explore the previously uncharted South Pole region. Although the mission faced setbacks during its final stages, the Chandrayaan-2 orbiter continues to send back high-resolution images of the Moon. ➤ Chandrayaan-3's lander, named Vikram, successfully soft-landed on the Moon's south pole on August 23, 2023. ➤ IN 2024, the Indian government approved two significant space missions, including Chandrayaan-4, which ISRO aims to launch by 2027. The objective of Chandrayaan-4 is to collect lunar samples and return them to Earth. In February, Science and Technology Minister Jitendra Singh confirmed that the mission will bring back samples of Moon rocks. ➤ India is also planning to launch its first manned space mission, the Gaganyaan Mission, in 2028.
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10. With reference to the Navigation with Indian Constellation (NavIC), consider the following statements:

1. It provides position, velocity and timing services to users.
2. It can be used for navigation and as a disaster alert system.
3. Its range is limited to the Indian landmass.

Which of the statements given above is/are correct?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

EXPLANATION:

Navigation with Indian Constellation (NavIC) is an independent, stand-alone navigation satellite system developed by the Indian Space Research Organisation (ISRO).

It is designed with a constellation of 7 satellites and a network of ground stations operating 24 x 7.

NavIC is designed to provide precise Position, Velocity, and Timing (PVT) services to users within India and up to 1,500 km beyond its borders, the system's primary service area. Its range is not limited to the Indian landmass. **So, Statement 1 is correct and Statement 3 is not correct.**

NavIC (Navigation with Indian Constellation) is designed to meet India's positioning, navigation, and timing requirements. It provides two services:

- Standard Positioning Service (SPS), which provides location accuracy better than 20 meters and timing accuracy better than 40 nanoseconds across the core service area, and
- Restricted Service (RS) which is a more secure service for authorised users.

Recently, the NavIC-based Early Warning System has been expanded, which contributes to disaster early warning systems by providing precise location information that can be integrated with meteorological and seismic data.

For instance, during cyclones, accurate positioning helps in tracking the storm's path and speed, enabling better prediction and timely evacuation of vulnerable areas. **So, Statement 2 is correct.**

ADDITIONAL INFORMATION:

NAVIGATION WITH INDIAN CONSTELLATION (NavIC)	
Recently in news	Recently, officials at the Indian Space Research Organisation (ISRO) have stated that they plan to launch at least three satellites before the end of 2026 to replace defunct satellites in the Indian GPS system, NavIC (Navigation with Indian Constellation).
About	➤ NavIC (Navigation with Indian Constellation) is the name of the independent, stand-alone navigation satellite system of India. ➤ This system was earlier known as IRNSS (Indian Regional Navigation Satellite System). ➤ The Hon. Prime Minister of India coined the name NavIC on the occasion of the completion of the constellation in April 2016. ➤ Global navigation system caters to users in the entire world, whereas regional navigation system caters to users in a limited service area.
Current Navigation System	Currently, there are four global systems, viz., ➤ GPS from the USA, ➤ GLONASS from Russia, ➤ Galileo from the European Union and ➤ BeiDou from China. In addition, there are two regional systems, viz., NavIC from India and QZSS from Japan.
GAGAN	➤ GAGAN stands for GPS Aided Geo Augmented Navigation. ➤ It is a satellite-based augmentation system developed primarily for safety-of-life civil aviation applications catering to the Indian airspace. ➤ It provides correction and integrity messages for GPS. ➤ GAGAN has been established jointly by ISRO and AAI. It is being operated and maintained by AAI.

11. Consider the following statements:

1. Meteoroids are meteors that enter the Earth's atmosphere.
2. Meteorites are meteors that enter the atmosphere and hit the ground.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

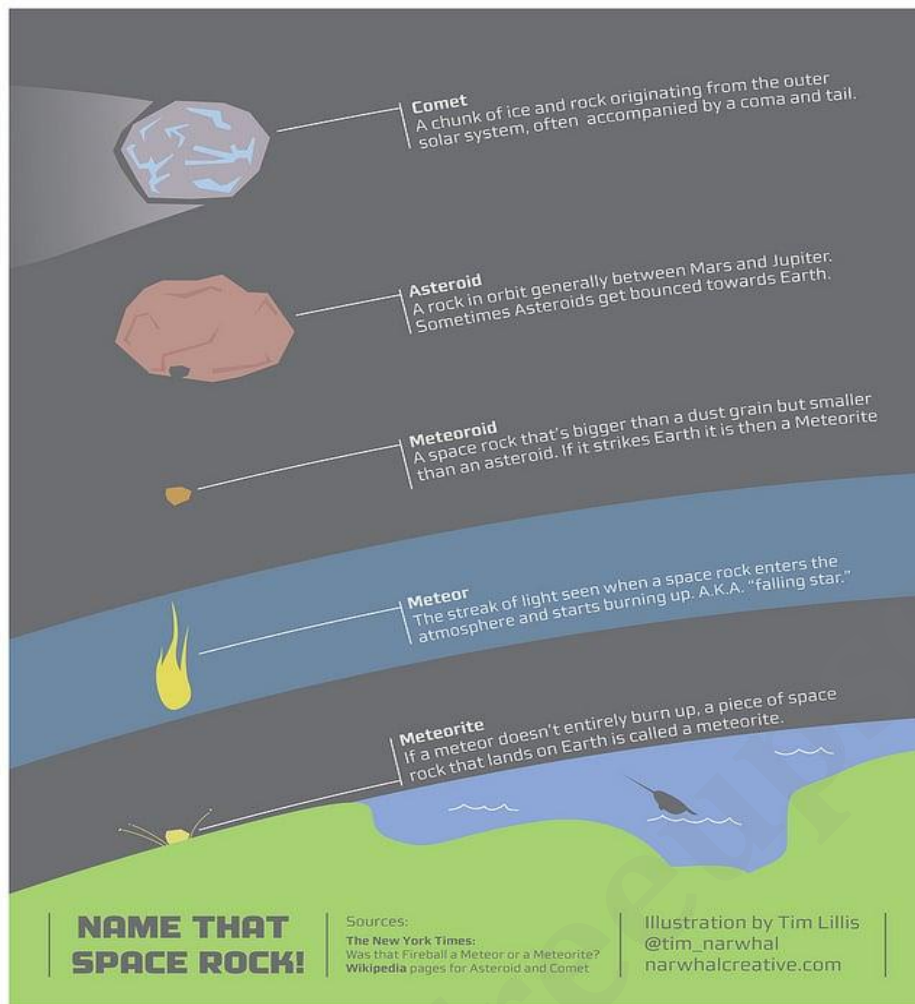
EXPLANATION:

Meteoroids are space rocks that range in size from dust grains to small asteroids. This term only applies when these rocks are still in space.

Most meteoroids are pieces of other, larger bodies that have been broken or blasted off. Some come from comets, others from asteroids, and some even come from the Moon and other planets. Some meteoroids are rocky, while others are metallic or a combination of rock and metal. Thus, Meteoroids are not meteors that enter the Earth's atmosphere. **So, Statement 1 is not correct.**

- When meteoroids enter Earth's atmosphere, or that of another planet, at high speed and burn up, they're called meteors. This is also when we refer to them as "shooting stars." Sometimes meteors can even appear brighter than Venus – that's when we call them "fireballs." Scientists estimate that about 48.5 tons (44,000 kilograms) of meteoritic material falls on Earth each day.

- When a meteoroid survives a trip through the atmosphere and hits the ground, it's called a meteorite. Therefore, Meteorites are meteoroids (not meteors) that enter the atmosphere and hit the ground. **So, Statement 2 is not correct.**



ADDITIONAL INFORMATION:

CELESTIAL BODIES	
Stars	➤ Stars are celestial bodies which revolve independently within the universe around the center of the galaxy. ➤ Stars are defined as objects with a self-emitting light source that are created as a result of ongoing thermonuclear fusion.
Comets	➤ Comets are like cosmic "dirty snowballs." They are made up of dust and tiny rocks mixed with frozen gases like water, carbon dioxide, methane, and ammonia. ➤ These materials come together to create a comet's nucleus, which is the solid core of the comet. ➤ Comets are fascinating celestial objects that have been liked by people for centuries.
Asteroids	➤ Asteroids are rocky objects that vary in size, from a few feet to hundreds of miles across. ➤ They are leftover building blocks from the early solar system when planets were forming. You can think of them as space rocks that orbit the sun.

Galaxies	➤ A galaxy, a celestial body, is a massive collection of stars, gas, dust, and dark matter that is bound together by gravity. ➤ Our home galaxy is called the Milky Way, and it contains billions of stars, including our Sun. ➤ There are many different types of galaxies, like spiral galaxies with swirling arms, round-shaped elliptical galaxies, and irregular galaxies with no specific shape. ➤ Galaxies can be very, very big, containing billions or even trillions of stars, and they can be incredibly far away from us in space.
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12. Which one of the following best describes the term “AI washing”?

- (a) **Companies exaggerating the level of AI technologies used in their products**
 (b) Unauthorised use of AI to access the sensitive information of users
 (c) Manipulation of data used to train AI models, leading to biased outcomes
 (d) Creation of highly realistic AI fake content to manipulate public opinion

EXPLANATION:

AI washing is a marketing practice where companies falsely exaggerate or misrepresent the use of artificial intelligence in their products or services, to make it look more sophisticated, innovative or intelligent than it is.

It's like 'greenwashing', where companies falsely claim to be environmentally friendly. The goal of AI washing is to create a false perception of advanced technology to attract customers and investors, even if the AI involvement is minimal or non-existent.

- Example: Amazon's Just Walk Out technology promises a queue-free shopping experience using AI and sensors to track purchases and issue digital receipts. However, reports in April 2024 revealed heavy reliance on manual transaction reviews by workers in India, raising questions about the system's true AI capabilities. This case highlights the rise of AI washing—marketing that overstates the use of AI to capitalise on its hype without genuine implementation.

Among the given statements, the one that best defines the term "AI washing" is: companies exaggerating the extent to which their products or services use artificial intelligence. **So, Option (a) is correct.**

ADDITIONAL INFORMATION:

ARTIFICIAL INTELLIGENCE	
About	Artificial intelligence (AI) is technology that enables computers and machines to simulate human learning, comprehension, problem solving, decision making, creativity and autonomy.
Generative AI	Generative AI uses deep learning: a sophisticated form of machine learning (ML) that handles complex tasks and large datasets to create new content in response to simple natural language prompts. Generative AI's capability to generate novel output, whether text, images, music, or code, represents a significant advancement in AI technology.
Predictive AI	Predictive AI forecasts outcomes based on analysis of historical data. It can analyse past behaviours, detect patterns, and predict future outcomes with high accuracy. Predictive AI is foundational in finance, healthcare, manufacturing, and marketing.
Traditional AI	Traditional AI automates and optimises specific tasks.

	Because it relies on Machine learning (ML) models with predefined rules and algorithms, it's most widely used in industries for repetitive tasks where efficiency and precision are crucial, such as in manufacturing or data processing. Traditional AI includes predictive AI and conversational AI.
Conversational AI	Conversational AI powers chatbots and virtual assistants that facilitate natural language interactions between humans and machines through text or voice interfaces. Conversational AI relies on ML models and natural language processing (NLP) to comprehend natural language and generate human-like responses.

13. Consider the following statements:

1. Hypersonic missiles can achieve speeds higher than the speed of sound.
2. Ramjet engines are more efficient than Scramjet engines at hypersonic speeds.
3. Every hypersonic weapon must be launched by a rocket.

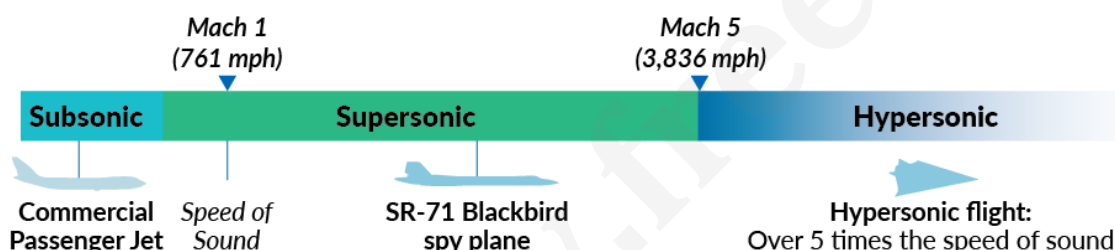
How many of the above statements is/are correct?

- (a) **Only one**
 (b) Only two
 (c) All three
 (d) None

EXPLANATION:

Mach 1 means that a jet or aeroplane is travelling at the same speed as sound – that's about 700 mph or 1,126 km/h.

Hypersonic means something that travels at speeds of Mach 5 or faster. (That's five times the speed of sound or 3,858 mph.) This puts them in a different league than something that is just supersonic, meaning travelling at above the speed of sound (767 mph). Thus, Hypersonic missiles can achieve speeds higher than the speed of sound. **So, Statement 1 is correct.**



A ramjet is a type of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion, eliminating the need for a rotating compressor.

Fuel is injected into the combustion chamber, where it mixes with the compressed air and ignites, producing thrust.

Ramjets operate most efficiently at supersonic speeds around Mach 3 and can function up to approximately Mach 6. However, their efficiency drops as the vehicle enters hypersonic speeds.

A scramjet engine is an advanced version of the ramjet. It allows supersonic combustion, enabling efficient operation at hypersonic speeds.

Hence, scramjet engines (Supersonic Combustion Ramjets) are more efficient than ramjet engines at hypersonic speeds. **So, Statement 2 is not correct.**

There are two types of hypersonic weapons:

- **Hypersonic boost-glide vehicles:** They are typically boosted to high speed/altitude by a rocket, then glide at hypersonic speeds toward the target. These generally do use a rocket booster for the initial phase.

- **Hypersonic cruise weapons:** They use air-breathing engines such as scramjets to sustain hypersonic flight. These vehicles can be air-launched from an aircraft or carried on other platforms; they may or may not use a rocket booster for initial acceleration, depending on design.

Thus, the statement that every hypersonic weapon must be launched by a rocket is not correct. **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

HYPERSONIC MISSILE	
About	➤ A hypersonic missile travels at a speed greater than Mach 5 or five times the speed of sound (nearly 3,800 miles per hour or 6,100 kms per hour). ➤ These missiles have the advantage of low radar visibility and extreme manoeuvrability. These missiles can swiftly change direction and often fly at lower altitudes, which enables them to stay under radar detection for longer periods. ➤ The Hypersonic Cruise Missiles are powered by a scramjet engine, which allows them to maintain hypersonic speeds during their flight. ➤ The scramjets use high-speed airflow to compress air into the engine, which allows a high-speed flight. The speed of these cruise missiles reduces the window for adversaries to attack. ➤ The combination of speed, manoeuvrability and low flight paths makes it difficult for the enemies to counter.

14. Consider the following statements:

1. It is an indigenously developed intercontinental ballistic missile.
2. It is a solid-fueled, three-stage and canister-launched missile.
3. The missile can be equipped with Multiple Independently Targetable Re-entry Vehicle technology.

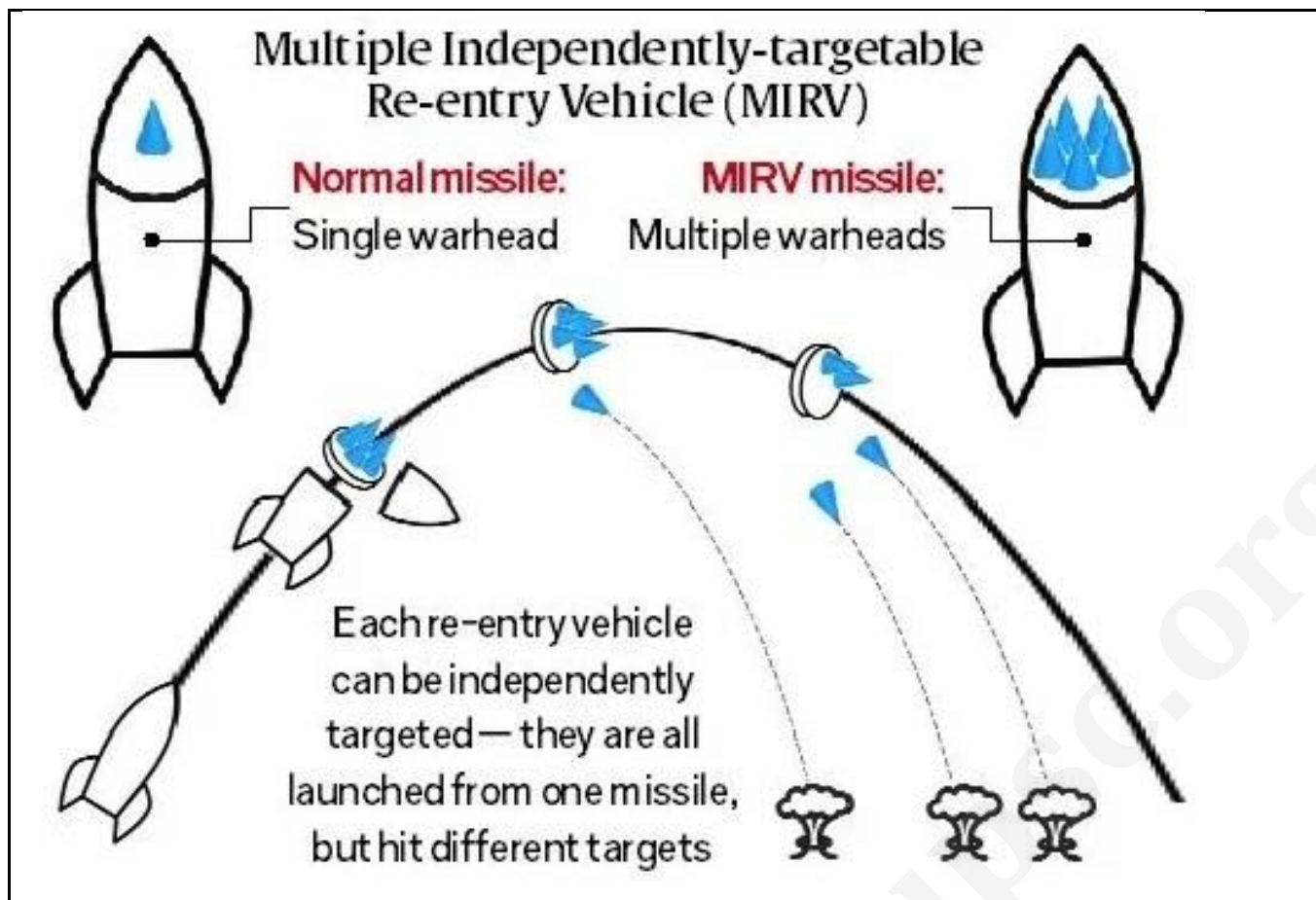
Which of the following types of missiles is described above?

- (a) BrahMos
- (b) Prithvi-II
- (c) Agni-V**
- (d) Astra

EXPLANATION:

Recently, India successfully tested Agni-prime missile from rail-based launcher. Agni-V is a 50-tonne, 17.5-metre-tall, three-stage solid-fuel intercontinental ballistic missile developed by the Indian Defence Research and Development Organisation (DRDO). An upgraded version of the Agni-III, the canister-launch Agni-V missile system is specially tailored for road mobility providing it the capability for speedy deployment. **So, Statement 1 and 2 are correct.**

- The Agni-V will also have the capability to carry multiple independently targetable re-entry vehicles (MIRV). This payload will be able to deliver up to 10 nuclear warheads in a single launch assigned to different widely separated targets. Alternatively, two or more warheads can be assigned to a single target. **So, Statement 3 is correct.**
- India is the eighth country with ICBM capability after the United States, United Kingdom, Russia, China, France, Israel and North Korea.
- The Agni-V system is being developed to provide a powerful deterrent through a credible second-strike capability.



ADDITIONAL INFORMATION:

TYPES OF MISSILES	
Brahmos	➤ Brahmos is a two-stage missile with a solid propellant booster engine as its first stage which brings it to supersonic speed and then gets separated. ➤ The liquid ramjet or the second stage then takes the missile closer to 2.8 Mach speed in cruise phase. ➤ Stealth technology and guidance system with advanced embedded software provides the missile with special features. ➤ The missile has flight range of up to 290 km with supersonic speed all through the flight, leading to shorter flight time, consequently ensuring lower dispersion of targets, quicker engagement time and non-interception by any known weapon system in the world. ➤ Brahmos operates on 'Fire and Forget' principle, adopting varieties of flight paths on its way to the target. ➤ The missile's destructive power is enhanced due to the large kinetic energy on impact. Its cruising altitude could be up to 15 km and terminal altitude is as low as 5 meters. ➤ Brahmos carries a conventional warhead upto 200 kgs.

	
Prithvi-II	➤ The Indian Defence Research and Development Organisation (DRDO) has developed a new short-range ballistic missile called the Prithvi-II. This is the latest addition to the Prithvi series of missiles, which includes the Prithvi-I, Prithvi-II, Prithvi-III and Dhanush. ➤ The Prithvi-II is a surface-to-surface missile capable of carrying a payload of up to 500 kgs over a distance of 350 km. ➤ This missile is not only nuclear capable, but also versatile, with capability to use both nuclear and conventional warheads. ➤ The technology behind the propulsion of this missile is a liquid propulsion system with a high thrust engine making it highly reliable. 
Astra	➤ Astra is an indigenously developed Beyond Visual Range Air - to - Air missile comprising of Astra Missile and Launcher. ➤ Propulsion: Solid Rocket Motor ➤ Range: 80 -110 km ➤ Max Speed: Mach 4.5

15. Which of the following best describes “Cobots” in the field of robotics?

- (a) Robots that collaborate with other robots to complete high-precision industrial tasks.
- (b) Robots designed to work collaboratively with human beings in a shared workspace.**
- (c) Robots connected through cloud-based systems for collective data analysis and automation.
- (d) Robots capable of cognitive learning through continuous observation of human behaviour.

EXPLANATION:

A cobot is a collaborative robot designed to work alongside human operators in a shared workspace. Unlike traditional industrial robots, cobots are optimised for physically interacting with humans. Cobots may feature adaptable robot arms capable of handling various payloads. With customised end-effectors, they excel in specific robot applications across diverse industries. These machines prioritise human-robot collaboration, automating repetitive tasks to enhance overall efficiency in the work environment.

Key Features:

- Interaction with humans - Designed for safe, direct collaboration
- Safety systems - Built-in sensors and force limiters
- Programming - Intuitive, low-code or no-code interfaces
- Deployment - Easy to install, move, and reprogram
- Flexibility - Ideal for small-batch and variable tasks
- Cost-effectiveness - Lower total cost of ownership. **So, Option (b) is correct.**

ADDITIONAL INFORMATION:

ROBOTS	
Industrial Robots	Industrial robots are machines built to complete automated manufacturing tasks in warehouses or factories, such as product assembly, material handling and more. Types of industrial robots; ➤ SCARA robots are high-speed and precise, and are often used in pick and place applications in industries like electronics manufacturing or food. ➤ Articulated robots provide a full range of motion and workspace compared to a SCARA, using 4, 5 or 6 axes. They are among the most common types of industrial robots with applications in almost every domain, ranging from manufacturing to logistics to food and agriculture. ➤ A cylindrical robot has either a single or articulated arm extending from a rotating base, giving it access to the entire field that's within range of the effector, the device allowing the robot to interact with its task. ➤ Mobile industrial robots are wheeled robot bases used to move material around in factories and warehouses. Some robots (called AGVs or automated guided vehicles) follow fixed paths using embedded wires in the floor, but recent advances have enabled robots to move more freely.
Mobile robots	➤ Mobile robots are autonomous or semi-autonomous machines capable of moving around. ➤ Unlike industrial robots (which are designed to operate within a fixed workspace), mobile robots can freely navigate and move around their environment. ➤ Mobile robots rely heavily on sensors to perceive their surroundings. Some common examples include cameras, laser scanners (LiDAR), ultrasonic sensors, and more. These allow the robot to "see" obstacles, map its environment, and make decisions accordingly. ➤ Some even have advanced sensors like thermal imaging cameras or gas detectors for specific applications.

16. In the context of robotics in healthcare, consider the following statements:

1. Robots assist in minimally invasive surgeries and rehabilitation therapy.
2. Robotic applications can enhance telemedicine and healthcare delivery in rural areas.
3. Ethical concerns have led to a prohibition on medical robots in India.

Which of the statements given above is/are correct?

- (a) 1 and 2 only**
 (b) 2 and 3 only
 (c) 1 only
 (d) 1, 2 and 3

EXPLANATION:

Minimally Invasive Surgery (MIS) is a medical procedure that uses smaller incisions compared to traditional surgeries involving significant cuts. Robotic technology has transformed MIS by providing surgeons with greater precision, control, and visualisation during operations.

- Robotic arms can move in ways beyond human capability, enabling more accurate movements and better access to hard-to-reach areas.
- High-definition 3D imaging offers a detailed view of the surgical site, improving accuracy and reducing complications.
- Rehabilitation robotics is another fast-growing field that uses advanced robotic systems to assist patients in regaining motor functions after neurological impairments such as stroke or spinal cord injury (SCI).

These robots guide a patient's hands or feet through specific movements and exercises, helping improve mobility and quality of life. **So, Statement 1 is correct.**

Telepresence robots equipped with AI and computer vision enable remote monitoring of patients through two-way audio-visual communication.

They can measure vital signs without physical contact and assist healthcare workers in managing patients from a distance.

Such systems reduce the workload on medical staff, automate simple tasks like medicine dispensing, and ensure continuous patient monitoring.

These innovations, especially valuable in rural areas with limited healthcare access, have gained importance since the COVID-19 pandemic, enhancing telemedicine and overall healthcare delivery. **So, Statement 2 is correct.**

Close to 30% of complicated surgeries performed in India use robots for minimal invasion and precision. One of the most significant ethical issues is ensuring fair access to robotic surgical care. The high costs of acquiring and maintaining robotic systems often limit their availability to well-funded hospitals and private clinics, leading to disparities that reflect broader social inequalities.

The Code of Medical Ethics Regulations from 2002 doesn't ban the use of robotic technology. However, it does require doctors to inform patients when such technology is being used. As for guidelines on how robotics should be supervised and implemented in surgeries, the National Medical Commission (NMC) has yet to provide specific details.

Thus, Ethical concerns have not led to a prohibition on medical robots in India. **So, Statement 3 is not correct.**

17. Consider the following pairs:

S. no	Made in India Robot		Description
1.	DAKSHA	-	India's first 3D-printed humanoid robot.
2.	Vyommitra	-	Spacefaring humanoid robot
3.	MANAV	-	Automated mobile platform for multi-purpose payloads.

How many of the above pairs is/are correct?

- (a) Only one
(b) Only two
(c) All three
(d) None

EXPLANATION:

DRDO has developed a Remotely Operated Vehicle (ROV) – ‘Daksha’, which is an automated mobile platform for multi-purpose payloads.

- It is an electrically powered state-of-the-art Robot capable of being remotely controlled over a distance of 500 metres line-of-sight. It can be utilised continuously for 3 hours before recharge.
- It has stair-climbing capability and can be used primarily for handling Improvised Explosive Devices (IEDs).
- This remotely operated vehicle has been developed indigenously. It is an automated mobile platform, not a humanoid robot. **So, Pair 1 is not correct.**



Vyommitra is India’s first humanoid robot developed by ISRO to assist in human space missions. With human-like expressions, speech, and intelligence, Vyommitra stands at the heart of Gaganyaan, India’s maiden human spaceflight programme.

This humanoid robot is designed to act as an intelligent, anthropomorphic companion for astronauts, handling both mechanical tasks and communication duties aboard India’s crewed spacecraft. **So, Pair 2 is correct.**



India's first 3D-printed humanoid robot, named Manav, translates to "human" in Hindi. It is developed by A-SET Training and Research Institute.

- Manav weighs only a few kilograms and boasts sound processing capabilities. It has been designed for research purposes.
- Manav can perform activities like push-ups, headstands, and even play football. It is also equipped with WiFi, Bluetooth, and a rechargeable lithium polymer battery lasting up to an hour on a single charge. It is a humanoid robot, not an automated platform like DAKSHA. **So, Pair 3 is not correct.**



ADDITIONAL INFORMATION:

NATIONAL STRATEGY FOR ROBOTICS	
Recently in news	The Indian Space Research Organisation will send the first humanoid robot to space to aid in space exploration and test environments before manned crews are sent to the unknown.
National Strategy on Robotics	➤ The Ministry of Electronics and Information Technology (MeitY) is the nodal agency for robotics in India. ➤ MeitY has proposed a two-tier institutional framework to implement the National Strategy on Robotics, which will be executed as the 'National Robotics Mission.' ➤ The Draft 'National Strategy for Robotics' aims to position India as a global leader in robotics by 2030 and harness its transformative potential. ➤ It builds upon Make in India 2.0, which has identified robotics as one of 27 sub-sectors to strengthen India's participation in the global value chain. ➤ The Strategy focuses on strengthening all pillars of the robotics innovation cycle, including research, development, testing, and deployment. ➤ It proposes a robust institutional framework to ensure effective and coordinated implementation of all initiatives. ➤ A whole-of-ecosystem approach is adopted to engage industry, academia, startups, and government agencies, promoting innovation, adoption, and scalability of robotics technology in India.
Vision	➤ The vision is guided by the principles of 'Sabka Saath, Sabka Vikas, Sabka Prayas', 'Make AI in India and Make AI Work for India', and the 'AtmaNirbhar Bharat Abhiyan'. ➤ It aligns with the broader IndiaAI vision, aiming to maximize the economic and socio-technical benefits of robotics while minimizing associated risks and challenges.

18. Particles in steam at 100°C have more energy than those in boiling water at the same temperature because:

- (a) Steam particles are lighter than water molecules.
- (b) Steam particles possess additional energy in the form of latent heat of vaporisation.**
- (c) Water loses energy during boiling, making its molecules slower
- (d) Steam has a higher specific heat capacity than water.

EXPLANATION:

Particles in steam, that is, water vapour at 373 K (100 °C), have more energy than water at the same temperature. This is because particles in steam have absorbed extra energy in the form of latent heat of vaporisation.

This energy is used to break the intermolecular forces holding liquid molecules together, allowing them to move freely as a gas.

Thus, steam molecules have more total energy (kinetic + latent heat) than liquid water molecules at the same temperature.

This extra energy is why steam can do more work, like driving turbines or causing burns, even though its temperature is the same as boiling water. **So, Option (b) is correct.**

ADDITIONAL INFORMATION:

LATENT HEAT	
About	Latent heat is the amount of heat energy absorbed or released by a substance during a phase of change (such as melting, boiling, or condensation) without any change in temperature. Example: ➤ If heat is added to a given quantity of ice at -10°C, the temperature of the ice increases until it reaches its melting point (0°C). At this temperature, the addition of more heat does not increase the temperature but causes the ice to melt or change its state. Once the entire ice melts, adding more heat will cause the temperature of the water to rise. ➤ A similar situation occurs during the liquid-gas change of state at the boiling point. Adding more heat to boiling water causes vaporisation, without an increase in temperature. Types of Latent Heat: ➤ The latent heat of fusion (L_f) is the heat per unit mass required to change a substance from solid into liquid at the same temperature and pressure. ➤ The latent heat of vaporisation (L_v) is the heat per unit mass required to change a substance from liquid to the vapour state without change in temperature and pressure."
Heat Transfer	Heat transfer is the movement of thermal energy, in the form of heat, between physical systems with different temperatures using four distinct mechanisms that advection, conduction, convection, and radiation. ➤ Thermal Advection: Heat is transferred by the motion of a fluid, moving thermal energy from one place to another. Unlike natural convection, this motion is caused by an external force, not buoyancy. Example: A fan cooling a computer motherboard. ➤ Conduction: Heat flows through a solid from the hotter part to the cooler part due to temperature differences. Example: When one end of a metal rod is heated, the other end also becomes hot. Solids conduct heat better than liquids, and liquids better than gases.

	➤ Convection: Heat transfer occurs through the actual movement of fluid. It only happens in liquids and gases. • Natural convection: Heated fluid becomes less dense, rises, and is replaced by cooler fluid. Example: Water boiling in a pot. • Forced convection: Fluid is moved by external forces, like fans or pumps. ➤ Radiation: Heat is transferred through electromagnetic waves (like infrared) without needing any medium. Example: Sun warming the Earth or feeling heat from a fire without touching it.
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19. Consider the following statements:

Statement I: Manufacturers usually flush bags of chips with nitrogen gas.

Statement-II: Nitrogen prevents the oxidation of fats and oils, which otherwise leads to rancidity and a change in taste and smell.

Which of the following is correct with respect to the above statements?

- (a) **Both Statement-I and Statement-II are correct, and Statement-II is the correct explanation for Statement-I**
- (b) Both Statement-I and Statement-II are correct, and Statement-II is not the correct explanation for Statement-I
- (c) Statement I is correct, but Statement II is incorrect
- (d) Statement I is incorrect, but Statement II is correct

EXPLANATION:

Manufacturers flush bags of chips with nitrogen gas using a process called Modified Atmosphere Packaging (MAP). This protects the chips during transport and storage by preventing crushing and moisture damage.

- Nitrogen is an inert, colourless, odourless, and flavourless gas. Unlike oxygen, it does not react with the fats and oils in the chips. By displacing oxygen, nitrogen prevents the oxidation of fats and oils, which would otherwise lead to rancidity, off-taste, and unpleasant smell.
- Nitrogen also inhibits bacterial growth and helps maintain the crispiness and shelf life of chips.

Therefore, Manufacturers flush bags of chips with nitrogen gas, as nitrogen prevents the oxidation of fats and oils, which otherwise leads to rancidity and a change in taste and smell. **Both Statement I and Statement II are correct, and Statement II is the correct explanation for Statement I.**

20. Consider the following purposes:

1. Manufacture of borax
2. Removal of permanent hardness of water
3. Ingredients in the glass and soap industries

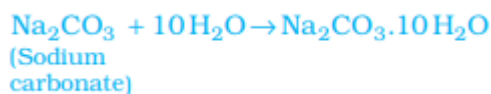
Washing soda can be used in the production of how many of the above-mentioned purposes?

- (a) Only one
- (b) Only two
- (c) All three**
- (d) None

EXPLANATION:

Washing soda, or Sodium carbonate decahydrate, is an efflorescent crystalline compound widely used for washing, especially in the textile industry. It is a chemical compound of sodium, and its chemical formula is $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.

Sodium carbonate can be obtained by heating baking soda; recrystallisation of sodium carbonate gives washing soda. It is also a basic salt



Uses of washing soda:

- Sodium carbonate (washing soda) is used in glass, soap and paper industries. **So, Statement 3 is correct.**
- It is used in the manufacture of sodium compounds such as borax. **So, Statement 1 is correct.**
- Sodium carbonate can be used as a cleaning agent for domestic purposes.
- It is used for removing permanent hardness of water. **So, Statement 2 is correct.**

ADDITIONAL INFORMATION:

COMMON SALT — A RAW MATERIAL FOR CHEMICALS

Bleaching powder	Chlorine is produced during the electrolysis of aqueous sodium chloride (brine). This chlorine gas is used for the manufacture of bleaching powder. ➤ Bleaching powder is produced by the action of chlorine on dry slaked lime $[\text{Ca}(\text{OH})_2]$. ➤ Bleaching powder is represented as $\text{Ca}(\text{ClO})_2$, though the actual composition is quite complex. $2\text{Ca}(\text{OH})_2 + 2\text{Cl}_2 \rightarrow \text{Ca}(\text{ClO})_2 + \text{CaCl}_2 + 2\text{H}_2\text{O}$ USES: ➤ for bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories and for bleaching washed clothes in laundry ➤ as an oxidising agent in many chemical industries; and ➤ To make drinking water free from germs.
Baking soda	Baking soda is commonly used in the kitchen for making tasty, crispy pakoras, etc. Sometimes it is added for faster cooking. The chemical name of the compound is sodium hydrogencarbonate (NaHCO_3). It is produced using sodium chloride as one of the raw materials. $\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2 + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl} + \text{NaHCO}_3$ (Ammonium chloride) (Sodium hydrogencarbonate) It is a mild, non-corrosive basic salt. The following reaction takes place when it is heated during cooking – $2\text{NaHCO}_3 \xrightarrow{\text{Heat}} \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$ (Sodium hydrogencarbonate) (Sodium carbonate) USES: ➤ For making baking powder, which is a mixture of baking soda (sodium hydrogencarbonate) and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place – $\text{NaHCO}_3 + \text{H}^+ \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{Sodium salt of acid}$ (From any acid) Carbon dioxide produced during the reaction can cause bread or cake to rise, making it soft and spongy. ➤ Sodium hydrogencarbonate is also an ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief. ➤ It is also used in soda-acid fire extinguishers.

21. Consider the following phenomena:

1. Twinkling of stars
2. Advanced sunrise and delayed sunset
3. Apparent flattening of the Sun's disc at sunrise and sunset
4. The formation of a rainbow

Which of the above phenomena can be explained by atmospheric refraction?

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1, 2 and 3 only
(d) 1, 2, 3 and 4 only

EXPLANATION:

Atmospheric refraction refers to the bending of light as it travels through the Earth's atmosphere. This bending occurs because the atmosphere is composed of layers with varying optical densities caused by differences in temperature and pressure. When light passes from a rarer (less dense) medium to a denser one, it bends toward the normal.

As light travels from outer space toward the Earth's surface, it moves through these progressively denser atmospheric layers. This continuous bending of light rays results in the phenomenon known as atmospheric refraction.

- Twinkling of stars occurs because starlight passes through layers of the atmosphere with varying density and temperature, causing its path to bend irregularly. This results in fluctuations in the star's apparent brightness and position, which is explained by atmospheric refraction. **So, Statement 1 is correct.**
- Advanced sunrise and delayed sunset happen because atmospheric refraction makes the Sun appear above the horizon even when it is actually below it. This causes the sunrise to be seen earlier and the sunset to occur later than the actual geometric times. **So, Statement 2 is correct.**
- Apparent flattening of the Sun's disc at sunrise and sunset is due to atmospheric refraction, bending the light from the lower part of the Sun's disc more than the upper part. This differential bending causes the Sun to appear vertically squashed or flattened near the horizon. **So, Statement 3 is correct.**
- The formation of a rainbow begins with the refraction of sunlight as it enters a raindrop. Refraction is the change in direction of a wave (in this case, light waves) as it passes from one medium to another, caused by its change in speed. The sunlight is refracted as it enters the water droplet, which causes the sunlight to disperse, or spread out, into its component colours. This separation of colours through raindrops, similar to what happens in a prism, is what gives a rainbow its distinct bands of colour. Thus, the formation of a rainbow can be explained by atmospheric refraction. **So, Statement 4 is correct.**

ADDITIONAL INFORMATION:

REFRACTION OF LIGHT	
About	When light passes from a denser medium to a rarer medium, it bends away from the normal. When it passes from a rarer medium to a denser medium, it bends towards the normal. This phenomenon of bending of light is called refraction of light.
Refractive Index of the Medium	When light travels from one medium to another, its speed changes. This shows that the speed of light varies in different media, and different media have different abilities to bend or refract light. ➤ This bending ability of a medium is called the index of refraction or refractive index. ➤ It is defined as the ratio of the speed of light in a vacuum to the speed of light in the material medium.

	Therefore, the refractive index of a medium, $n \approx \text{speed of light in vacuum} / \text{speed of light in medium}$
Laws of Refraction	When a beam of light travels from one medium to another, then it follows two laws of refraction: ➤ The first law of refraction states that the incident ray, the refracted ray, and the normal to the interference of the medium lie in the same plane. ➤ The ratio between the sine of the angle of incidence and the sine of the angle of refraction is constant to the interference of the medium, also called Snell's law of refraction. $K = \sin i / \sin r$ Where 'k' is constant, 'i' is the angle of incident and 'r' is the angle of refraction.

22. Consider the following statements about Linear Induction Motors (LIMs):

1. It is a specialised type of induction motor engineered to produce linear motion instead of rotational motion.
2. A linear induction motor works on the same principle as a conventional induction motor.
3. LIMs are used in futuristic transport systems like Hyperloop pods.

Which of the statements given above is/ are correct?

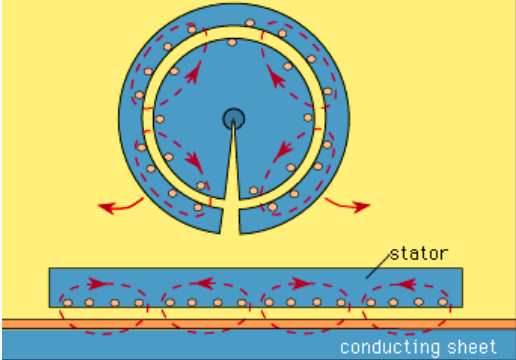
- (a) 1 and 2 only
- (b) 1 and 3 only
- (c) 2 only
- (d) 1, 2 and 3

EXPLANATION:

A Linear Induction Motor (or LIM) is a specialised induction motor engineered for straight motion instead of the rotational movement typical of standard motors. These motors modify the traditional design to serve unique functions while maintaining a similar working principle, increasing their operational versatility. **So, Statements 1 and 2 are correct.**

Hyperloop is a high-speed transportation system where passenger or cargo pods travel through sealed tubes in a near-vacuum environment, allowing them to glide at exceptional speeds using Magnetic Levitation and Linear Induction Motor propulsion systems. Thus, LIMs are used in futuristic transport systems like Hyperloop pods. **So, Statement 3 is correct.**

ADDITIONAL INFORMATION:

LINEAR INDUCTION MOTOR	
Recently in News	Avishkar Hyperloop team of IIT Madras, in collaboration with TuTr (a startup), has recently completed a 410-meter Hyperloop test track, the first such experiment in Hyperloop technology in India.
About	A linear induction motor provides linear force and motion rather than rotational torque. The shape and operation of a linear induction motor can be visualised as depicted in the figure by making a radial cut in a rotating induction machine and flattening it out. 

	➤ The result is a flat “stator,” or upper section, of iron laminations that carry a three-phase, multipole winding with conductors perpendicular to the direction of motion. ➤ The “rotor,” or lower section, could consist of iron laminations and a squirrel-cage winding, but more normally consists of a continuous copper or aluminum sheet placed over a solid or laminated iron backing. ➤ One application of linear motors is in rapid-transit vehicles for public transportation. ➤ The “stator” is carried on the underside of the vehicle, and the “rotor” is located between the rails on the track. ➤ An advantage of this type of propulsion is that high acceleration and braking can be obtained without dependence on adhesion of the steel wheels to the steel rails in the presence of rain, ice, or a steep slope.
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23. Consider the following statements:

1. Mesh networking is a network topology in which all devices are connected to a central hub, which acts as the main point for data transmission.
2. In a mesh network, data can travel between any devices, enabling multiple communications.
3. The majority of home Wi-Fi networks and office LANs rely on mesh networking.

Which of the following statements is/are correct?

- (a) 1 only
(b) 2 only
(c) 1 and 3 only
(d) 1, 2 and 3

EXPLANATION:

Network topology refers to the physical and logical arrangement of nodes and connections in a computer network, which governs how data flows between devices. Network topology impacts network performance, security and scalability, making it a crucial concept in network design and management.

- Both physical and logical topology are important considerations when planning network infrastructure. The physical topology outlines how devices are physically connected, while the logical topology focuses on how data moves through the network.
- A node is a point of connection in a network that can send and receive data. Nodes include both physical devices and communication equipment such as computers, phones, IoT devices, routers, switches, repeaters and hubs.
- Links are the transmission media that are used to send information between the nodes in a network. They can be wired or wireless, and internet service providers often dictate the type of cabling and equipment used.

In a star network (Not a Mesh Network), all the nodes are connected to a central hub. The nodes are positioned around that central hub in a shape that roughly resembles a star. If a single node fails, the rest of the network is unaffected, as long as the central hub is operational.

A star topology is generally easy to troubleshoot and manage, which makes it a popular choice for LANs. Its centralised structure also makes adding or removing devices relatively easy, contributing to its scalability. In a star network, the performance of the entire network depends on the central hub and the connections to it. If the central hub goes down, then the entire network goes down with it. **So, Statement 1 is not correct.**

A mesh network is a highly interconnected network structure where each node is directly linked to multiple other nodes. In a full mesh configuration, every node connects to every other node within a single network, creating redundant paths for data transmission. **So, Statement 2 is correct.**

- This high level of interconnectivity enhances network resilience and fault tolerance, as data can reroute through alternative paths if a connection fails.

- The decentralised structure of mesh networks reduces reliance on a single point of failure, enhancing both security and efficiency. Mesh networks provide several advantages, such as improved data transmission speeds and scalability.

Tree topology combines elements of both bus and star networks, creating a hierarchical structure. Unlike star topology, where all nodes connect directly to a central hub, tree topology allows for multiple levels of hierarchy. In a tree network, branches extend from the main trunk, enabling more complex connections. This hierarchical structure is beneficial for more extensive networks as it organises devices efficiently.

- Tree topology is commonly implemented using wired connections. In a wired network, such as an office setup, Ethernet cables link network nodes in a tree structure. Each node connects to a central node or switch, forming branches like a tree.
- Wireless networks also utilise a tree topology by connecting devices through access points or routers. Just like in wired setups, wireless networks create multiple levels of hierarchy with parent and child nodes.

Therefore, the majority of home Wi-Fi networks and office LANs rely on tree networking and star networking (Not mesh networking). **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

TYPES OF NETWORK TOPOLOGIES	
Point-to-Point Topology	➤ A point-to-point network is the simplest and most basic type of network topology. ➤ It consists of two nodes that are connected by a single link. ➤ Data travels back and forth between these two endpoints. Though easy to set up, its simplicity limits its use in modern networks.
Bus Topology	➤ In a bus topology, all nodes are connected to a single cable—known as the bus or backbone—like bus stops branching off from a bus route. ➤ Data travels in both directions along the cable. ➤ This topology is cost-effective and easy to implement, but it has limitations, such as a single point of failure; if the backbone fails, the entire network goes down. Bus networks are also less secure due to the shared backbone. ➤ Additionally, as more nodes share a central cable, the risk of data collisions increases, reducing network efficiency and potentially causing network slowdowns.
Ring Topology	➤ In a ring topology, nodes are connected circularly, with each node having exactly two neighbours. ➤ Data flows in one direction around the ring, though dual-ring systems can send data in both directions. These networks are generally cheap to install and expand, and data flows quickly within the network. ➤ The main vulnerability of ring networks is that a failure of a single node can bring down the whole network. ➤ Dual-ring networks are used to protect against this type of failure. A dual-ring network features two concentric rings instead of one. The rings send data in opposite directions. The second ring is used when there is a failure in the first ring. This redundancy minimises downtime and makes sure that data can continue flowing if one ring fails.
Hybrid Topology	➤ A hybrid topology combines elements of different topologies to meet specific needs. ➤ For instance, a network might use star and mesh configurations to balance scalability with reliability. A tree network that combines a star network and a bus network is also an example of a hybrid topology.

	➤ Each hybrid network topology can be customised to build an efficient network architecture based on specific use cases and business needs. ➤ However, creating a customised network architecture can be challenging and can require more cabling and network devices, raising maintenance costs.
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24. Consider the following:

Statement I: White hydrogen is naturally tapped in the Earth's porous rocks and cracks.

Statement II: White hydrogen is formed when underground water reacts with iron-rich rocks in a process called serpentinisation.

Which one of the following is correct with respect to the above statements?

- (a) Both Statement I and Statement II are correct, and Statement II explains Statement I
 (b) Both Statement I and Statement II are correct, but Statement II does not explain Statement I
 (c) Statement I is correct, but Statement II is incorrect
 (d) Statement I is incorrect, but Statement II is correct

EXPLANATION:

White hydrogen (also called natural hydrogen or geologic hydrogen) is found naturally in underground reservoirs like porous rocks, faults, and cracks in the Earth's crust.

Like oil and gas, it is produced naturally within the Earth through continuous geochemical reactions in hard rocks.

Geological hydrogen forms through natural processes deep within the Earth. One common mechanism is a reaction between water and iron-rich rocks, a process known as serpentinisation.

Because hydrogen is small and light, it can escape through porous rocks and cracks, often seeping toward the surface and into the atmosphere.

In some places, it escapes to the surface, while in others, it can become trapped under impermeable rocks like salt or shale, forming underground hydrogen accumulations.

So, Both Statement I and Statement II are correct, and Statement II explains Statement I.

ADDITIONAL INFORMATION:

HYDROGEN	
Recently in news	Recently, France has discovered a massive 46-million-ton white hydrogen reserve in the Moselle region, valued at \$92 trillion. Unlike gray and green hydrogen, white hydrogen requires no industrial production and emits no CO₂, making it a game-changer for clean energy.
About	➤ Hydrogen is an invisible gas, and despite the various colour-based descriptions, there is no visible difference between the different types of hydrogen. ➤ Terms such as green hydrogen, blue hydrogen, brown hydrogen, yellow hydrogen, turquoise hydrogen, and pink hydrogen are essentially industry conventions used to distinguish hydrogen production methods. ➤ The assigned colour corresponds to the specific production process employed. ➤ However, there is no globally standardised naming system, and these definitions may vary across countries or evolve over time.
Hydrogen Colour Code	➤ Green Hydrogen: It is made using clean electricity from renewable sources like solar or wind to electrolyse water, splitting it into hydrogen and oxygen without emitting carbon dioxide. Currently, it is a small part of hydrogen production because it is expensive, but costs are expected to decrease as production increases. ➤ Blue Hydrogen: It comes mainly from natural gas via steam reforming, which produces hydrogen and carbon dioxide. Carbon capture and storage (CCS) is used to trap the CO₂. It is called 'low-carbon hydrogen,' but greenhouse gases are still generated in the process.

	➤ Grey Hydrogen: It is the most common type and is produced from natural gas or methane using steam methane reforming, without capturing CO₂. It is essentially the same as blue hydrogen but lacks carbon capture. ➤ Black and Brown Hydrogen: These are produced from black coal or lignite (brown coal) and are the most environmentally damaging. Hydrogen made from fossil fuels via gasification may also be called black or brown hydrogen. Recently, Japan and Australia launched a project to produce liquefied hydrogen from brown coal in Australia for shipping to Japan. ➤ Pink Hydrogen: It is made through electrolysis powered by nuclear energy and may also be called purple or red hydrogen. Nuclear heat can also produce steam to improve other hydrogen production methods. ➤ Turquoise Hydrogen: It is produced by methane pyrolysis, creating hydrogen and solid carbon. Production at scale is still unproven. Its environmental value depends on using renewable energy and storing or using carbon. ➤ Yellow Hydrogen: It is made via electrolysis using solar power. ➤ White Hydrogen: White hydrogen is naturally occurring, found in underground deposits, and formed through processes like fracking. There are currently no strategies to exploit it.
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25. With reference to the lunar surface, consider the following statements:

1. Pragyan rover of the Chandrayaan-3 collects data on lunar regolith.
2. The lunar surface comprises both low flat plains and highlands.
3. There is a presence of molten lava beneath the lunar surface.

How many of the above statements is/are correct?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

EXPLANATION:

The Pragyan rover, part of India's Chandrayaan-3 mission, successfully landed near the Moon's south pole and conducted scientific experiments. It utilised an Alpha Particle X-ray Spectrometer (APXS) to analyse the chemical composition of the lunar regolith, providing valuable data on the Moon's surface materials. **So, Statement 1 is correct.**

According to the data from Chandrayaan-3, the Moon's surface has a varied topography, including low plains called "maria" and high-elevation regions called "highlands".

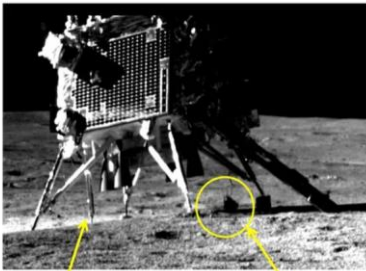
- Highlands are heavily cratered and are the Moon's oldest terrain.
- Maria a younger plain formed by ancient volcanic activity.

There is molten lava beneath the lunar surface:

- Data from Chandrayaan-3 support the theory of a global Lunar Magma Ocean.
- The Moon's outer layer was entirely molten shortly after its formation, and cooling led to the solid crust we see today. **So, Statements 2 and 3 are correct.**

ADDITIONAL INFORMATION:

INDIA'S CHANDRAYAAN-3 MISSION	
Recently in the news	Recently, the Indian scientists have released the first detailed geological map of the Moon's south pole, created using data from India's Chandrayaan-3 mission.

	Vikram as seen by Pragyan August 30, 2023, 07:35 Hrs. IST   ChaSTE ILSA
About	➤ Chandrayaan-3 was the first mission to land in a high-latitude polar region, 630 km from the Moon's south pole, ideal for studying lunar magma. ➤ In September 2024, the Alpha Particle X-ray Spectrometer (APXS) on the Pragyan rover detected magma under the landing site, confirming that the ancient magma ocean extends across the Moon. ➤ Scientists created the first detailed geological map of the Moon's south pole using data from Pragyan. ➤ The map shows evidence of a global magma ocean, traces the origins of craters, and highlights concerns about lunar contamination from future missions. ➤ Researchers developed the map from PRL (Ahmedabad), Panjab University (Chandigarh), and ISRO's Laboratory for Electro-Optics Systems (Bengaluru). ➤ Data was collected by Pragyan, deployed by the Vikram lander during a nine-day mission to analyse the chemical composition of lunar regolith.
Lunar regolith	➤ Lunar regolith is the layer of unconsolidated dust, rock fragments, and other debris that covers the Moon's surface, formed over billions of years from meteorite impacts and solar wind bombardment. ➤ It is a mixture of fine, abrasive dust and larger pieces of rock, and it differs from Earth soil in that it has no organic matter.

26. Neurological diseases can paralyse muscles that assist humans in speech. In this context, which one of the following is an Artificial Intelligence-assisted technology that converts brain activity into audible words on a computer in real time?

- (a) **Brain-computer interface**
 (b) Transcranial magnetic stimulation
 (c) Brain stimulation devices
 (d) Neurofeedback

EXPLANATION:

According to recent research, combining Brain-Computer Interface (BCI) technology with Artificial Intelligence (AI) can significantly improve how effectively people with paralysis perform various tasks.

- Neurological diseases can often damage the pathways between the brain and the muscles responsible for speech, including those controlling the jaw, lips, and tongue.

- To address this, researchers at the University of California have developed an advanced BCI that can quickly translate brain activity into audible words on a computer.
- A BCI is a device that converts brain signals into actions, enabling users to control machines with their thoughts.
- This innovative technology has the potential to restore real-time, natural communication for individuals who have lost their ability to speak due to paralysis or disease.

Thus, BCI directly translates brain activity into audible words in real time, enabling natural communication for people with speech loss. **So, Option (a) is correct.**

Transcranial magnetic stimulation (TMS) is a medical device that delivers electrical pulses to the brain through a magnetic coil placed over the head.

- A stimulator sends an electric current to the coil, and as the current flows through its loops, it generates a magnetic field. This magnetic field passes through the skull and reaches the brain, where it creates electrical stimulation.
- By applying a specific pattern (or waveform) of current to the coil, the same pattern is reproduced in the brain.
- This controlled stimulation can alter brain activity and is used to help treat various neurological and psychiatric disorders, including major depressive disorder.

Therefore, TMS stimulates brain activity to treat certain disorders but does not convert brain signals into speech. **So, Option (b) is not correct.**

Deep brain stimulation (DBS) is a treatment that uses an implanted device to deliver electrical currents to specific areas of the brain, improving their function.

It is commonly used to treat Parkinson's disease and Epilepsy and is being studied for other neurological and psychiatric conditions as well.

Thus, DBS delivers electrical currents to specific brain regions to treat diseases like Parkinson's, but is not used for real-time speech generation. **So, Option (c) is not correct.**

Neurofeedback, also known as EEG (electroencephalogram) biofeedback, is a therapeutic technique that gives real-time feedback on a person's brainwave activity using a computer-based program.

- The system provides auditory or visual signals to help individuals become aware of their thought patterns and work on changing them.
- By learning to regulate their brain activity through this feedback process, patients may improve brain function and reduce symptoms associated with various neurological and mental health conditions.

Therefore, Neurofeedback provides feedback to help regulate brainwave activity but does not produce spoken output from brain signals. **So, Option (d) is not correct.**

27. With reference to the NASA ISRO Synthetic Aperture Radar Mission (NISAR), consider the following statements:

1. It will be placed in the sun-synchronous polar orbit.
2. It will carry out imaging of the entire Earth every 30 days.
3. It will aid in natural disaster monitoring.

How many of the above statements is/are correct?

- (a) Only one
- (b) Only two**
- (c) All three
- (d) None

EXPLANATION:

NISAR (NASA-ISRO Synthetic Aperture Radar) is the first of its kind mission, jointly developed by ISRO and NASA. It is an L and S-band, global, microwave imaging mission, with the capability to acquire fully polarimetric and interferometric data.

- Recently, India-US marked their maiden space collaboration with the successful flight of a GSLV rocket that placed an earth observation satellite, NISAR, in a precise orbit. ISRO's GSLV F-16 injected the Synthetic Aperture Radar satellite into the intended Sun Synchronous Polar Orbit (SSPO), after a flight of about 19 minutes and around 745 km. **So, Statement 1 is correct.**

NISAR will observe Earth's land and ice-covered surfaces globally with 12-day regularity, not 30 days, on ascending and descending passes, sampling Earth on average every 6 days for a baseline 3-year mission. **So, Statement 2 is not correct.**

The primary objectives of the mission are to study land and ice deformation, land ecosystems, and oceanic regions in areas of common interest to the scientific communities.

The NISAR mission will help scientists track subtle changes in Earth's ecosystems, including sea level rise, groundwater and natural hazards like earthquakes, floods, volcanoes and landslides, aiding early warnings, disaster response and infrastructure damage assessment. **So, Statement 3 is correct.**

Watching from above

NISAR, which has a mission life of five years, will observe Earth with a swathe of **242 km** and high spatial resolution



Key applications include: Shoreline monitoring, storm characterisation, mapping of surface water resources, and disaster response

1 It is the first major earth-observing **satellite with radars of two frequencies**

2 The radars will allow **NISAR to monitor both surface and subsurface changes** through clouds, smoke, vegetation

■ Its scan-on-receive method will give a spatial resolution of

3-10 metres and centimetre-scale vertical mapping



Giant leap: ISRO's GSLV-F16 carrying the NISAR satellite lifts off from Sriharikota on Wednesday. AP

ADDITIONAL INFORMATION:

NISAR (NASA-ISRO SYNTHETIC APERTURE RADAR)																	
Recently in news	ISRO's launch vehicle GSLV-F16 carrying the NISAR earth observation satellite lifts off from the launch pad at the Satish Dhawan Space Centre, in Sriharikota, Andhra Pradesh, on July 30, 2025																
About	➤ The NISAR, which has a mission life of five years, is the first Satellite jointly developed by the ISRO and the US's National Aeronautics and Space Administration (NASA). ➤ NISAR will give decision-makers the tools to monitor critical infrastructure, respond faster and smarter to natural disasters such as earthquakes, floods, and landslides, as well as map farmland to improve crop output and more.																
Helps to	<i>The NISAR mission will help to</i> ➤ measure the woody biomass and its changes ➤ track changes in the extent of active crops ➤ understand the changes in wetlands' extent ➤ map Greenland's & Antarctica's ice sheets, dynamics of sea ice and mountain glaciers ➤ characterise land surface deformation related to seismicity, volcanism, landslides, and subsidence & uplift associated with changes in subsurface aquifers, hydrocarbon reservoirs, etc.																
Characteristics	<table border="1"> <thead> <tr> <th colspan="2">Major Mission Characteristics (Joint Mission of ISRO & NASA)</th></tr> </thead> <tbody> <tr> <td>Mainframe Bus</td><td>13K Structure with ~2400Kg Lift Off Mass 70V Bus 3-axis stabilized spacecraft</td></tr> <tr> <td>Imaging Payload</td><td> • Dual Frequency (L & S-Band) Synthetic Aperture Radar (SAR). • L-band SAR (NASA); S-band SAR (SAC-ISRO) • Large size 12m diameter common unfurlable reflector antenna mounted on deployable 9m Boom. • ~240 km observable swath with 5-100 m resolution Free and open data policy </td></tr> <tr> <td>Orbit</td><td>Sun synchronous, Polar (6PM)</td></tr> <tr> <td>Orbit altitude</td><td>747 km – Circular</td></tr> <tr> <td>Inclination</td><td>98.405 deg</td></tr> <tr> <td>Launcher</td><td>GSLV Mk-II with 4m PLF</td></tr> <tr> <td>Mission Life</td><td>5 Years</td></tr> </tbody> </table>	Major Mission Characteristics (Joint Mission of ISRO & NASA)		Mainframe Bus	13K Structure with ~2400Kg Lift Off Mass 70V Bus 3-axis stabilized spacecraft	Imaging Payload	• Dual Frequency (L & S-Band) Synthetic Aperture Radar (SAR). • L-band SAR (NASA); S-band SAR (SAC-ISRO) • Large size 12m diameter common unfurlable reflector antenna mounted on deployable 9m Boom. • ~240 km observable swath with 5-100 m resolution Free and open data policy	Orbit	Sun synchronous, Polar (6PM)	Orbit altitude	747 km – Circular	Inclination	98.405 deg	Launcher	GSLV Mk-II with 4m PLF	Mission Life	5 Years
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28. With reference to supersolids, consider the following statements:

1. It is a state of matter that exhibits properties of a solid as well as a liquid.
2. It tends to show zero viscosity.
3. It forms at extremely high temperatures.

How many of the above statements is/are correct?

- (a) Only one
(b) Only two
 (c) All three
 (d) None

EXPLANATION:

Supersolids are a strange state of matter defined by quantum mechanics where particles condense into an orderly, crystalline solid but also move like a liquid that has no viscosity. Viscosity refers to a substance's internal Friction, governing how smoothly it flows. Usually, solids don't move on their own, but supersolids change direction and density depending on particle interactions while maintaining an organised lattice structure.

Therefore, supersolids exhibit properties of solid as well as liquid states of matter that have zero viscosity. **So, Statements 1 and 2 are correct.**

Supersolids form only at extremely low temperatures, near absolute zero (-273.15°C or -459.67°F). At this point, most particles settle into their lowest energy state, as even a small amount of heat makes them move around energetically, preventing the supersolid state from forming. Absolute zero is the theoretical lowest possible temperature where all molecular motion stops, equal to 0 Kelvin (K), -273.15 degrees Celsius ($^{\circ}\text{C}$), and -459.67 degrees Fahrenheit ($^{\circ}\text{F}$). **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

SUPERSOLIDS	
Recently in the News	Scientists have turned light into a "supersolid" for the first time, marking a groundbreaking achievement in physics.
About	➤ A supersolid is an exotic phase of matter in which particles are arranged in a crystalline structure but also move like a non-viscous fluid. In other words, it combines the friction-free flow of a superfluid with the ordered structure of a crystalline solid. ➤ Usually, solids don't move on their own, but supersolids change direction and density depending on their particles' interactions while maintaining an organised internal structure. ➤ Physicists predicted the idea of a supersolid in the 1960s and first created it in a laboratory in 2017.
Light into Supersolids	➤ In an exciting scientific breakthrough, researchers have successfully turned light into a "supersolid" for the first time ever. ➤ This innovative achievement opens up new possibilities in the field of physics, where light, typically considered a form of energy, has now been transformed into a solid-state material with extraordinary properties. ➤ The experiment, conducted by a team of scientists, has resulted in a novel phase of matter, combining the characteristics of both solids and superfluids. This "supersolid" formed by light could have wide-ranging applications, potentially revolutionising fields like quantum computing, materials science, and energy storage. ➤ Solids and liquids are two common phases of matter. Solids turn into liquids when they are heated, and liquids turn into solids when they are cooled. There are also certain quantum states of matter that turn into each other in peculiar ways. ➤ The new research used a quantum mechanical approach that relied on the properties of polaritons. These are hybrid particles that behave sometimes like light and sometimes like matter. They are created by coupling photons with packets of energy inside materials, like phonons (vibrational energy) or excitons (electron-hole pairs).

29. With reference to the Axiom-4 mission, consider the following:

1. Effects of cosmic radiation on the growth of edible microalgae
2. Muscle cell regeneration
3. Ageing patterns of tardigrades
4. Cyanobacteria growth in space

Which of the experiments given above was conducted successfully during the mission?

- (a) 1, 2 and 4 only
- (b) 2, 3 and 4 only
- (c) 1, 3 and 4 only
- (d) 1, 2, 3 and 4**

EXPLANATION:

The AXIOM 4 mission was a private flight to the International Space Station (ISS) that launched on June 25, 2025, with four crew members, including India's Group Captain Shubhanshu Shukla. It was a joint effort by Axiom Space, NASA, ESA, and ISRO.

The mission carried out scientific experiments, technology tests, and educational activities over 18 days.

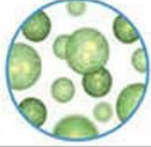
Gaganyatri Shubhanshu Shukla completed a suite of seven microgravity experiments developed by Indian research institutions under the Human Space Flight Centre's (HSFC) coordination. These experiments explored muscle regeneration, algal growth, crop viability, microbial survivability, cognitive performance in space, and the behaviour of cyanobacteria—each aimed at enhancing understanding of human spaceflight and microgravity science. The experiments are listed below.

- Space Microalgae (ICGEB & BRIC-NIPGR, New Delhi): Growth and radiation response of edible algae. **So, Statement 1 is correct.**
- Myogenesis (BRIC-InStem, Bengaluru): Muscle regeneration with supplement treatment. **So, Statement 2 is correct.**
- Sprouts (UAS & IIT Dharwad): Microgravity growth of methi and moong
- Tardigrade-(a microscopic, eight-legged invertebrate that forms its own phylum) (IISc, Bengaluru): Resilience and ageing patterns of tardigrades. **So, Statement 3 is correct.**
- Electronic Displays (IISc, Bengaluru): Cognitive testing with in-flight user interface displays
- Cyanobacteria in Microgravity (ICGEB, New Delhi): Comparative growth and proteomics. **So, Statement 4 is correct.**
- Food Crop Seeds (IIST & KAU, Thiruvananthapuram): Impact of microgravity on seed physiology

Thus, all the experiments given above are successfully completed during the Axiom-4 mission.

SPACE EXPERIMENTS

7 India-specific microgravity experiments that Shubanshu Shukla will conduct on ISS

1 Impact Of Microgravity Radiation In ISS On Edible Microalgae Institutions International Centre for Genetic Engineering & Biotechnology & National Institute of Plant Genome Research; Department of Biotechnology (DBT)	
2 Sprouting Salad Seeds In Space: Relevance to Crew Nutrition Institutions University of Agricultural Sciences, Dharwad; and Indian Institute of Technology, Dharwad	
3 Survival, Revival, Reproduction And Transcriptome (complete set of RNA transcripts) Of Eutardigrade Paramacrobiotus sp. BLR Strain In Space Institution Indian Institute of Science (IISc)	
4 Effect of Metabolic Supplements On Muscle Regeneration Under Microgravity Institution Institute of Stem Cell Science and Regenerative Medicine (InStem), DBT	
5 Analysing Human Interaction with Electronic Displays in Microgravity Institution Indian Institute of Sciences (IISc)	
6 Comparative growth and proteomics responses of cyanobacteria on urea and nitrate in microgravity Institution International Centre for Genetic Engineering & Biotechnology; DBT	
7 Impact of Microgravity On Growth And Yield Parameters In Food Crop Seeds Institution/s Indian Institute of Space Science and Technology, Dept of Space; & College of Agriculture, Vellayani; Kerala Agricultural University	

ADDITIONAL INFORMATION:

MAJOR INDIAN SPACE PROGRAMMES

India's space programme, led by ISRO, has transformed the nation into a major player in global space exploration, starting with the launch of Aryabhata in 1975 to cost-effective satellite launches using PSLV, deploying over 400 foreign satellites.

- **NISAR (2025)**
 - Joint Earth observation mission by ISRO and NASA.
 - Launched on July 30, 2025, via GSLV-F16 from Sriharikota.
 - Studies land and ice deformation, ecosystems, and oceans.
 - First joint NASA-ISRO Earth observation mission, providing all-weather, day-night imaging.
- **Axiom-4 Mission (2025)**
 - Private human spaceflight to ISS with crew from India, Poland, and Hungary.
 - Conducted experiments on microalgae, seed sprouting, muscle regeneration, tardigrades, human-device interaction, and crop seeds in microgravity.
 - Strengthened India's operational experience for human spaceflight programs.
- **SpaDeX (2025)**
 - Demonstrated docking, undocking, refuelling, and payload transfer capabilities.
 - India became the fourth country to perform satellite docking in LEO.
 - Two 20 kg satellites docked from 11–12 km apart.
 - Approval granted for a five-module space station, with first module launch in 2028.
- **Chandrayaan-3 (2023)**
 - Landed near the Moon's south pole on July 14, 2023.
 - India became the first country to achieve a soft landing in this region, exploring permanently shadowed craters for water ice.
- **Aditya-L1 (2023)**
 - India's first solar mission, orbiting the Sun-Earth Lagrangian point L1 (1.5 million km).
 - SUT telescope captured solar flare details in photosphere and chromosphere (Feb 2025).
- **NavIC (2023)**
 - Navigation with Indian Constellation using IRNSS satellites.
 - Provides regional Positioning, Navigation, and Timing (PNT) services.
 - 11 satellites launched; NVS-03 planned by end of 2025, followed by NVS-04 & NVS-05.
- **EOS Series (2021–2024)**
 - Earth Observation Satellites (EOS-01, 03, 04, 06, 08) for agriculture, forestry, disaster management, and ocean studies.
 - EOS-08 launched via SSLV-D3 in August 2024 to test microsatellite and payload technologies.
- **Chandrayaan-2 (2019)**
 - Included orbiter, lander (Vikram), and rover (Pragyan).
 - Lander failed to achieve soft landing but mission succeeded in scientific data and technology.
- **Mangalyaan (2014)**
 - India became the fourth country to send a spacecraft to Mars orbit on September 23, 2014.
 - Achieved this with cost-effective methods, making ISRO the first Asian agency to reach Mars.

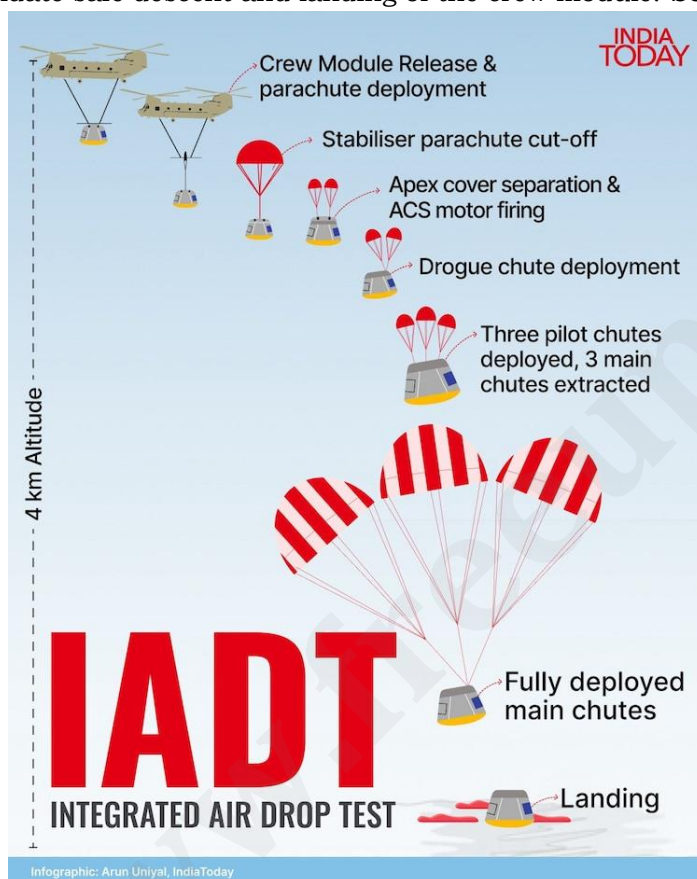
30. Which of the following correctly describes the purpose of the Integrated Air Drop Test for Gaganyaan?

- (a) To test the Gaganyaan crew module life support system in orbit
- (b) To check the Crew Escape System during launch
- (c) To validate safe descent and landing of the crew module.**
- (d) To deploy communication satellites from the Gaganyaan module

EXPLANATION:

Recently, the Indian Space Research Organisation (ISRO) successfully carried out its first Integrated Air Drop Test (IADT-1), a crucial milestone in the preparation for the Country's maiden human spaceflight mission, Gaganyaan.

- This test successfully demonstrated the objective of end-to-end performance validation of the critical parachute-based deceleration system of the Crew Module for the Gaganyaan mission in one of the typical mission scenarios.
- This test is part of the system-level qualification of the parachute-based deceleration system, in which a simulated Crew Module (CM), encompassing the deceleration system, is dropped using a helicopter.
- In Gaganyaan missions, a parachute-based Deceleration system is employed during the terminal phase of the Crew Module (CM) descent to reduce the touchdown velocity of the Crew Module to an acceptable limit for safe landing on the sea. Thus, the purpose of the Integrated Air Drop Test for Gaganyaan is to validate safe descent and landing of the crew module. **So, Option (c) is correct.**



ADDITIONAL INFORMATION:

GAGANYAAN	
Recently in news	ISRO Chairman V. Narayanan said that India's maiden manned space mission, Gaganyaan, will conduct its first test flight in December this year. He added, Gaganyaan is progressing well, as 80 per cent of the tests, or around seven thousand 700 tests, have been conducted so far.
About	Gaganyaan project envisages demonstration of human spaceflight capability by launching a crew of 3 members to an orbit of 400 km for a 3-day mission and bringing them back safely to Earth, by landing in the Indian Sea waters.
Major milestones	Integrated Air Drop Test (IADT-1):

- The IADT is designed to evaluate the parachute-based deceleration system that will bring the Gaganyaan crew module down safely after reentry. In IADT-1, the parachutes were expected to deploy in a precise sequence after the module was released from a height of about 3 km.
- Although the capsule was uncrewed and the drop was conducted from a helicopter, the test simulated the last stages of an actual space mission.
- In the real scenario, the capsule will first be slowed by atmospheric drag and its heat shields, followed by smaller drogue parachutes and finally the three 25-m main parachutes.

The aim was to ensure the capsule slowed to around 8 m/s before splashdown.

Test vehicle mission:

- The first test vehicle mission (TV-D1) will check the processes for aborting the mission mid-air, the parachute system that will bring the crew module down to sea, and the recovery of the crew members from the module after splashdown.
- The test vehicle is a single-stage liquid propellant rocket meant to test all the systems of Gaganyaan at the sub-orbital level before a complete uncrewed mission that will mimic the complete final human mission.

Pad Abort Test:

- The Crew Escape System is an emergency escape measure designed to quickly pull the crew module along with the astronauts to a safe distance from the launch vehicle in the event of a launch abort.
- The first test (Pad Abort Test) demonstrated the safe recovery of the crew module in case of any exigency at the launch pad.



31. Consider the following statements:

Statement I:

According to Bohr's model of the hydrogen atom, electrons revolve around the nucleus only in certain permitted circular orbits.

Statement II:

Each permitted orbit in Bohr's model has a definite energy and corresponds to a stationary state of the electron.

Statement III:

According to Bohr's model, the energy of an electron is maximum when it is in the orbit closest to the nucleus.

Which one of the following is correct in respect of the above statements?

- (a) Both Statement II and Statement III are correct, and both explain Statement I
- (b) Both Statement II and Statement III are correct but only one of them explains Statement I
- (c) **Only one of the Statements II and III is correct and that explains Statement I**
- (d) Neither Statement II nor Statement III is correct

EXPLANATION:

Niels Bohr (1913) was the first to explain quantitatively the general features of the structure of the hydrogen atom and its spectrum. He used Planck's concept of quantisation of energy. Though the theory is not modern quantum mechanics, it can still be used to rationalise many points in the atomic structure and spectra. Bohr's model for the hydrogen atom is based on the postulate:

- The electron in the hydrogen atom can move around the nucleus in a circular path of fixed radius and energy. These paths are called orbits, stationary states or allowed energy states. These orbits are arranged concentrically around the nucleus. **So, Statement I is correct.**

Each Bohr orbit has a fixed energy called a discrete energy level. These fixed-energy orbits are called stationary states because electrons do not radiate energy while revolving in them. An electron changes its energy only when it jumps between two stationary states, absorbing or emitting a photon equal to the energy difference between those levels. **So, Statement II is correct.**

According to Bohr's model, when an electron is completely free from the nucleus, it experiences no attraction, so its energy is taken as zero.

This condition corresponds to the principal quantum number $n = \infty$ and represents an ionised hydrogen atom.

When the electron is captured by the nucleus and moves to an orbit with finite n , it becomes bound to the atom. In doing so, it emits energy, and its total energy decreases — showing that it is now stable and bound to the nucleus.

Therefore, according to Bohr's model, the energy of an electron is not maximum (Lowered) when it is in the orbit closest to the nucleus. **So, Statement III is not correct.**

According to Bohr's model of the hydrogen atom, electrons revolve around the nucleus only in certain permitted circular orbits. These orbits have a definite energy and correspond to a stationary state of the electron.

Only one of the Statements II and III is correct, and that explains Statement I.

ADDITIONAL INFORMATION:

INTRODUCTION TO BOHR'S MODEL OF THE ATOM	
About	Niels Bohr, a Danish physicist, had already made a name for himself with his contributions to understanding the behaviour of electrons in atoms. His Nobel Lecture in 1922 focused on the development of his atomic model, which he had introduced in 1913.
Its impact	Bohr began his lecture by elaborating on the central ideas behind his model, which were based on the work of Ernest Rutherford and Max Planck's quantum theory. His model proposed that: ➤ Electrons Orbit in Stable Orbits: Electrons move in fixed orbits or "shells" around the nucleus without radiating energy, contrary to classical electromagnetic theory, which predicted that electrons would lose energy and spiral into the nucleus. ➤ Quantised Energy Levels: The energy of the electron is quantised, meaning that electrons can only occupy specific orbits with defined energies. This explained the spectral lines observed in atomic spectra, as electrons could only jump between these orbits by absorbing or emitting precise amounts of energy. ➤ Radiation Emission and Absorption: Bohr explained that when an electron moves between orbits, it either absorbs or emits a quantum of light, known as a photon. The frequency of this photon corresponds to the difference in energy between the two orbits, explaining the discrete nature of atomic spectra. ➤ Angular Momentum Quantisation: Bohr introduced the concept that the angular momentum of an electron in orbit is quantised and can only take integer

	multiples of $h/2\pi\hbar/2\pi$, where h is Planck's constant. This quantisation explained the stability of electron orbits and their energy levels.
Significance	The Bohr model provided a quantum explanation for atomic stability and radiation, something that classical physics had failed to explain. Before Bohr, atoms were seen as fragile and unstable structures. ➤ Classical electrodynamics predicted that electrons in orbit around a nucleus would radiate energy and spiral into the nucleus, leading to the collapse of the atom. ➤ Bohr's model, however, suggested that certain orbits were stable and would not radiate energy. ➤ Moreover, the model was able to explain the hydrogen atom's spectral lines, a problem that had baffled scientists for years. By applying quantum theory, Bohr demonstrated that the observed spectra of hydrogen could be explained by the transitions of electrons between quantised energy levels.

32. 3I/ATLAS recently seen in the news is a:

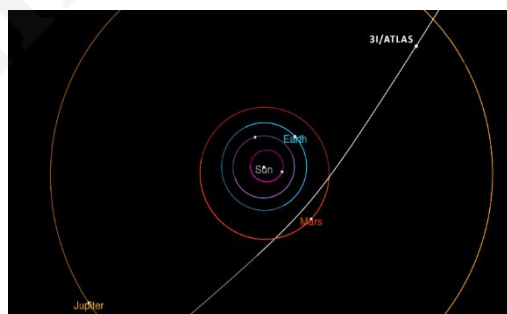
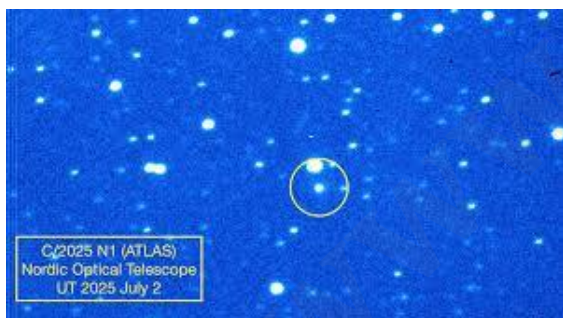
- (a) **Interstellar object**
- (b) Black hole
- (c) Gravitational telescope
- (d) Protostar

EXPLANATION:

3I/ATLAS, also called C/2025 N1 (ATLAS), is an interstellar object, an object that has entered the solar system from interstellar space. Discovered July 2025 by the Asteroid Terrestrial-impact Last Alert System (ATLAS) station in Chile, it is the third known interstellar object after 1I/'Oumuamua (discovered in October 2017) and 2I/Borisov (discovered in August 2019).

- NASA's Hubble Space Telescope captured this image of interstellar comet 3I/ATLAS on July 21, 2025, when the comet was 277 million miles from Earth.
- All three interstellar objects studied so far are thought to be comet-like, which supports theories about planet formation and the ejection of icy bodies, but they are all slightly different as well.

So, Option (a) is correct.



ADDITIONAL INFORMATION:

INTERSTELLAR OBJECT	
1I/'Oumuamua	➤ Discovered in October 2017, 'Oumuamua was the very first confirmed interstellar object. It had a strange, elongated shape - like a cigar or a pancake - and showed no typical comet tail. - Its odd orbit and acceleration puzzled astronomers, sparking debates about whether it was a comet, asteroid, or something entirely new.

2I/Borisov	➤ Just two years later in 2019, amateur astronomer Gennadiy Borisov discovered a second interstellar visitor. Unlike 'Oumuamua, Borisov looked like a comet, complete with a glowing coma and a tail. It was the first chance for astronomers to study the chemistry of material from another star system up close.
3I/ATLAS	➤ In July 2025, the ATLAS survey in Chile spotted the third interstellar object: 3I/ATLAS. This comet is already showing signs of activity, releasing gas and dust as it approaches the Sun. It will reach its closest point in late October 2025, at about 1.4 AU from the Sun. Early observations suggest its coma is rich in carbon dioxide, making it a fascinating new case for comparison with Borisov and other comets.
Protostar	Recently, First time in the world, a team of researchers at the IIST, Thiruvananthapuram, in association with international scientists, have detected and measured magnetism near an infant massive star. A protostar is the earliest known stage of a star that is beginning to form. ➤ Massive protostars in our galaxy, that would later evolve to have a mass of over 8-10 times that of the Sun, have remained an enigma for astrophysicists for decades. ➤ For the first time in the world, a team of researchers at the Indian Institute of Space Science & Technology (IIST), Thiruvananthapuram, in association with international scientists, have detected and measured magnetism near an infant massive star. ➤ The finding opens an exciting window into the understanding of how massive stars form, which later go on to shape entire galaxies. ➤ The study was carried out on protostar IRAS 18162-2048, located 4,500 light-years away, using the National Radio Astronomy Observatory's Karl G Jansky Very Large Array in the US.

33. Consider the following statements regarding the Major Atmospheric Cherenkov Experiment (MACE) that was in the news:

1. It is one of the highest observatory sites in the world, located at Hanle in Ladakh.
2. It is designed to study Cherenkov radiation and gamma rays.
3. It has been developed jointly by ISRO and DRDO.

Which of the statements given above are correct?

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

EXPLANATION:

Recently, the Major Atmospheric Cherenkov Experiment (MACE) Observatory was inaugurated. MACE is Asia's Largest and the World's Highest Imaging Cherenkov Observatory located at Hanle in Ladakh.

So, Statement 1 is correct.

- Situated at an altitude of 4,300 m, the MACE telescope will observe high-energy gamma rays, contributing to global efforts to understand the most energetic phenomena in the Universe, such as supernovae, black holes, and gamma-ray bursts.
- An Imaging Cherenkov Observatory is a facility designed to detect and observe Cherenkov radiation produced by high-energy cosmic particles, such as gamma rays or cosmic rays, when they interact with Earth's atmosphere. **So, Statement 2 is correct.**

- The Bhabha Atomic Research Centre, the Tata Institute of Fundamental Research, the Electronics Corporation of India Ltd., and the Indian Institute of Astrophysics built the facility. **So, Statement 3 is not correct.**



THE MAJOR ATMOSPHERIC CHERENKOV EXPERIMENT (MACE) TELESCOPE

About	➤ MACE's main goal is to study gamma rays with more than 20 billion eV of energy. ➤ The telescope can examine high-energy gamma rays emitted from near black holes beyond the Milky Way, which are digesting large volumes of matter. ➤ Other potential astrophysical targets include gamma-ray pulsars, blazars, and gamma-ray bursts. ➤ One important goal is to find dark matter particles. ➤ Dark matter is a type of matter believed to make up more than 85% of the total mass in our Universe. It is a fundamental part of the standard model of cosmology. ➤ One of the proposed particle constituents of dark matter is weakly interacting massive particles (WIMPs). Scientists have predicted that these particles can produce high-energy gamma rays when they collide with and destroy each other. These gamma rays could be produced in large galaxy clusters, small galaxies, and/or the centre of large galaxies, including the Milky Way. ➤ MACE telescope is also expected to address a range of cosmological topics such as constraining the intensity of Extragalactic Background Light (EBL) and strength of Intergalactic Magnetic Field (IGMF), cosmic ray electron spectrum, search for Dark Matter (DM) particles and some fundamental physics problems like Lorentz Invariance Violation (LIV), anomaly in photon-photon pair production and photon-Axion Like Particle (ALP) oscillations.
Imaging Atmospheric Cherenkov Telescopes (IACTs)	➤ When a gamma ray from a cosmic source enters the atmosphere, it interacts with molecules in the air to produce a copious shower of electron-positron pairs. As these charged particles travel through the atmosphere at speeds greater than the speed of light in air, they emit a faint blue light, called

	Cherenkov radiation. This radiation has wavelengths typical of violet and blue light of the visible spectrum and of the ultraviolet wavelength range. ➤ The light is emitted in about a fraction of a second, and the light particles spread out evenly over a vast region on the Earth's surface. ➤ This region (MACE lab, Hanle, Ladakh) is a suitable place to locate a detector that can collect the photons and study them to indirectly understand the gamma rays. Instruments used for this kind of detection are called imaging atmospheric Cherenkov telescopes (IACTs). The MACE telescope is an IACT. ➤ Every IACT has a light collector and a camera. The size of the light collector determines the minimum energy of gamma rays it can detect. MACE's light collector has 356 mirror panels. Each panel consists of four smaller mirrors arranged in a honeycomb structure. These honeycomb arrangements have been shown to be lighter yet more stable than solid mirrors because they reduce the empty space between segments and increase the total reflective area. The James Webb Space Telescope uses honeycomb-segmented mirrors for this reason.
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34. Consider the following statements:

1. No planets move in circular orbits with the sun.
2. Planets appear to move faster when they are farther from the sun than when they are nearer.
3. All planets revolve around the Sun in the same counterclockwise direction when viewed from above the Sun's north pole.

How many of the statements given above is/are **not** correct?

- (a) **Only one**
 (b) Only two
 (c) All three
 (d) None

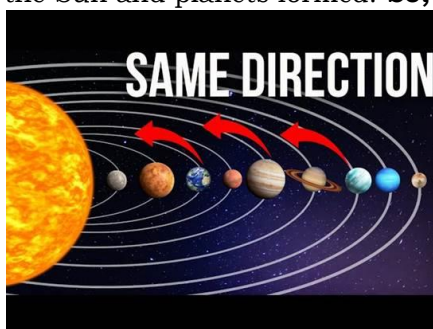
EXPLANATION:

Kepler's laws of planetary motion, published by Johannes Kepler, describe how planets orbit the Sun.

- Kepler's First Law: Each planet moves in an elliptical orbit (not circular orbits) with the Sun at one focus. This means the distance between a planet and the Sun constantly changes as the planet orbits. **So, Statement 1 is correct.**
- Kepler's Second Law: The line joining a planet and the Sun sweeps out equal areas in equal time intervals, so planets move faster when closer to the Sun (perihelion) and slower when farther away (aphelion). **So, Statement 2 is not correct.**
- Kepler's Third Law: The square of a planet's orbital period is proportional to the cube of the semi-major axis of its orbit. This means planets farther from the Sun take much longer to complete one orbit—for example, Mercury takes 88 days, Earth 365 days, and Saturn 10,759 days.

The planets in our solar system follow a consistent pattern in their motion around the Sun. Almost all planets, from Mercury to Neptune, revolve around the Sun in a counter-clockwise direction when viewed from above the Sun's north pole.

This motion is called prograde motion and is a result of the original rotation of the solar nebula, the cloud of gas and dust from which the Sun and planets formed. **So, Statement 3 is correct.**



35. With reference to black boxes in flights, consider the following statements:
1. They consist of a Cockpit Voice Recorder and a Digital Flight Data Recorder.
 2. They are made of stainless steel and are resistant to explosions.
- Which of the above statements is/are correct?
- (a) 1 only
 (b) 2 only
 (c) Both 1 and 2
 (d) Neither 1 nor 2

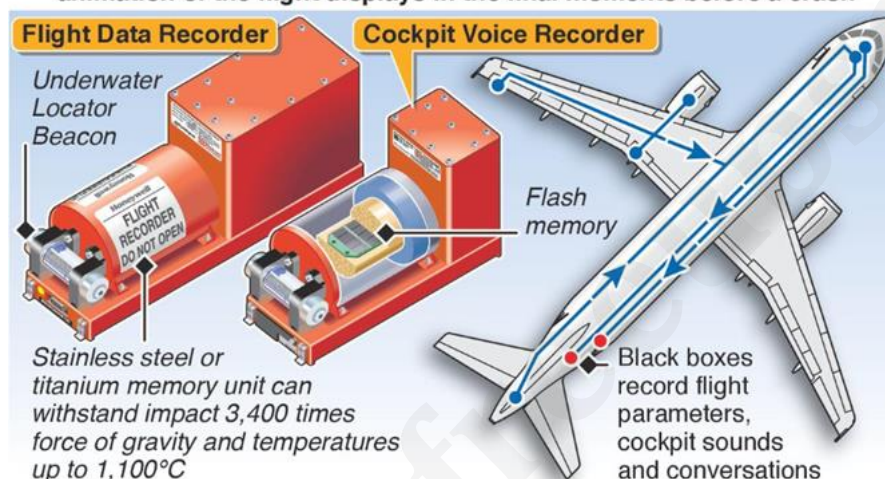
EXPLANATION:

In modern aircraft, the black box refers to two main components: the Cockpit Voice Recorder (CVR) and the Digital Flight Data Recorder (DFDR). In some aircraft, these two are integrated into a single unit.

The DFDR records technical flight parameters such as speed, altitude, and engine performance, while the CVR captures cockpit audio, including pilot conversations and communications with air traffic control. **So, Statement 1 is correct.**

How black boxes reconstruct a crash

Information from an aircraft's flight data recorder and cockpit voice recorder – the so-called “black boxes” – is used to create an interactive animation of the flight displays in the final moments before a crash



Although called a black box, it is actually painted bright orange with reflective material to make it easy to locate after a crash.

Black Boxes are built to withstand incredibly harsh conditions. They are encased in a strong titanium or stainless-steel shell and insulated to resist extreme heat and pressure. It is purposely placed towards the tail end of the aircraft, where the impact of a crash is usually the least.

The following are the key features of the black box:

- **Fire Resistance:** The Black Box can survive temperatures up to 1,100°C (2,000°F) for at least 60 minutes.
- **Impact Resistance:** It is built to withstand impacts of up to 3,400 Gs (the force of 3,400 times the pull of gravity).
- **Waterproofing:** It can stay submerged in water as deep as 6,000 meters (about 20,000 feet) for 30 days without losing data.

Also, Black Boxes are equipped with underwater locator beacons (ULBs), which send out signals to help search teams locate them in a water crash. **So, Statement 2 is correct.**

36. With reference to the SPArc therapy for tumours, consider the following statements:

1. It helps in targeted treatment of tumour cells, minimising damage to other tissues.
2. It is less expensive compared to conventional therapies for cancer.

Which of the statements given above is/are correct?

- (a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

EXPLANATION:

Recently, a team of experts in the US has successfully used a technique called step-and-shoot spot-scanning proton arc therapy (SPArc) to treat a patient's adenoid cystic carcinoma (A Type of Cancer) for the first time.

SPArc works by targeting tumours with protons while sparing (to minimise damage) surrounding tissue, ie, it's likely to be valuable in large or extensive tumours, where the tumour can be targeted accurately with limited collateral damage to the surrounding tissues. **So, Statement 1 is correct.**

The most common conventional treatments are surgery, chemotherapy, and radiation. Other options include targeted therapy, immunotherapy, laser, hormonal therapy, and others.

While SPArc (Spot-Scanning Proton Arc) therapy is an advanced form of proton therapy that combines the precision of proton beam delivery with the efficiency of arc-based treatment techniques, it aims to deliver highly conformal radiation doses to tumours while minimising exposure to surrounding healthy tissues.

The significant concern in the SPArc therapy is its cost, which is expensive compared to other conventional therapies. The higher costs are primarily due to the specialised equipment, infrastructure, and operational expenses associated with proton therapy facilities.

So, Statement 2 is not correct.

37. Consider the following statements:

1. Conventional computing chips rely on sequential processing, whereas quantum computing chips allow parallel and asynchronous processing.
2. Conventional computing chips use 0 or 1 bits, whereas quantum computing chips use "qubits," which can exist in superposition states.

Which of the statements given above is/are correct?

- (a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

EXPLANATION:

Conventional Chip Computing	Quantum Chip Computing
Conventional computing is based on the classical phenomenon of electrical circuits being in a single state at a given time, either on or off. Conventional computing is cost-effective and accessible to many users, as it does not require specialised hardware.	Quantum Computing is based on the phenomenon of Quantum Mechanics, such as superposition and entanglement, the phenomenon where it is possible to be in more than one state at a time.
Stores information in bits with a discrete number of possible states, 0 or 1.	Stores information in qubits as 0, 1 or a superposition of 0 and 1.

Processes data logically and sequentially.	Processes data with quantum logic at parallel instances, relying on entanglement and interference.
The circuit behaviour is governed by classical physics.	The circuit behaviour is governed by quantum physics or quantum mechanics.
In conventional computers, data processing is done in the Central Processing Unit or CPU, which consists of the Arithmetic and Logic Unit (ALU), processor registers and a control unit.	In quantum computers, data processing is done in a Quantum Processing Unit or QPU, which consists of a number of interconnected qubits.

Therefore, conventional chips rely on sequential processing and binary bits, while quantum chips rely on parallel processing and qubits. **So, Statements 1 and 2 are correct.**

ADDITIONAL INFORMATION:

CONVENTIONAL COMPUTING vs QUANTUM COMPUTING	
Advantages	Conventional Computing: ➤ Well-established: Conventional computing is well-established and widely used in many applications. ➤ Cost-effective: Conventional computing is cost-effective and accessible to many users, as it does not require specialised hardware. ➤ Fast for certain types of problems: Conventional computing is fast and efficient for problems that can be easily broken down into sequential steps and for problems that do not involve large numbers of variables. ➤ Deterministic: Conventional computing is deterministic, meaning that given the same inputs, the output is always the same. Quantum Computing: ➤ Massive parallel processing: Quantum computing can perform massive parallel processing, which can enable faster solutions for certain types of problems. ➤ Efficient for certain types of problems: Quantum computing is efficient for certain types of problems that involve large numbers of variables or complex relationships. ➤ Non-deterministic: Quantum computing is non-deterministic, which can enable the exploration of many potential solutions simultaneously.
Disadvantages	Conventional Computing: ➤ Limited parallel processing: Conventional computing can perform limited parallel processing, which can limit its performance for certain types of problems. ➤ Inefficient for certain types of problems: Conventional computing can be inefficient for certain types of problems that involve large numbers of variables or complex relationships. ➤ Limited by classical physics: Conventional computing is limited by classical physics, which can make certain types of problems impossible to solve or prohibitively difficult. Quantum Computing: ➤ Specialised hardware: Quantum computing requires specialised hardware, including cryogenic equipment to maintain the qubits at low temperatures and specialised control electronics to manipulate the qubits. ➤ Expensive: Quantum computing is expensive, as it requires specialised hardware and expertise.

	➤ Limited applicability: Quantum computing is highly specialised and is suited for certain types of problems, making it less applicable for many applications. ➤ Fragile: Quantum computing is fragile and sensitive to external disturbances, which can cause errors in computations.
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38. With reference to the India Semiconductor Mission (ISM), consider the following statements:

1. It functions under the Ministry of Commerce and Industry.
2. It aims to provide financial support to companies investing in semiconductors.
3. Recently, India and Taiwan inked a pact to set up a semiconductor fab for national security.

Which of the statements given above is/are correct?

(a) 1 and 3 only

(b) 2 only

(c) 2 and 3 only

(d) 1, 2 and 3

EXPLANATION:

India Semiconductor Mission (ISM) functions under the Ministry of Electronics and Information Technology (MeitY). **So, Statement 1 is not correct.**

The India Semiconductor Mission (ISM) aims to build a strong semiconductor and display ecosystem, positioning India as a global hub for electronics manufacturing and design, while serving as the nodal agency for the efficient and seamless implementation of semiconductor and display schemes. **So, Statement 2 is correct.**

Recently, India & the United States partnered to establish a semiconductor fabrication unit for national security needs. A multi-material semiconductor fabrication unit is set to be established in Jewar, Uttar Pradesh, as part of an agreement between India and the US.

- The cutting-edge semiconductor plant will produce chips for advanced warfare technologies, including night vision devices, missile-seekers, space sensors, drones, fighter jets, electric vehicles, military communications, radars and jammers.
- The plant will include a testing centre, a centre of excellence, a design hub and two fabrication units. This initiative is part of India-US cooperation under the Indo-Pacific Economic Corridor (ICET) and the CHIPS Act, aimed at strengthening semiconductor manufacturing capabilities. **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

INDIA SEMICONDUCTOR MISSION (ISM)	
Objectives	➤ Strategy: Formulation of a comprehensive long-term strategy for developing semiconductors & display manufacturing facilities and semiconductor design ecosystem in the Country in consultation with Government ministries/departments/agencies, industry, and academia. ➤ Supply Chain: Facilitation in the adoption of trusted electronics through secure semiconductors and display supply chain, including raw materials, speciality chemicals, gases, and manufacturing equipment. ➤ Design & start up: Enabling a multi-fold growth of the Indian semiconductor design industry by providing requisite support in the form of Electronic Design Automation (EDA) tools, foundry services and other suitable mechanisms for early-stage startups. ➤ Intellectual Property: Promoting indigenous Intellectual Property (IP) generation and encouraging, enabling and incentivising Transfer of Technologies (ToT).

	➤ Partnership: Enabling collaborations and partnership programs with national and international agencies, industries and institutions for catalysing collaborative research, commercialisation and skill development.
SEMICON India	The Central Government has launched the SEMICON India Programme, implemented through the India Semiconductor Mission (ISM). ➤ SEMICON India brings together global industry leaders, policymakers, academia, and startups to foster investment, dialogue, and strategic partnerships. ➤ SEMICON India plays a catalytic role in advancing ISM's goals by enabling cross-border collaborations, promoting research commercialisation, enhancing skill development, and showcasing India's growing potential in the global semiconductor value chain. ➤ Three editions of SEMICON India have been held so far, in 2022 (Bangalore), 2023 (Gandhinagar), and 2024 (Greater Noida).
SEMICON India 2025	➤ SEMICON India 2025 was jointly organised by the India Semiconductor Mission (ISM) under the Ministry of Electronics and Information Technology (MeitY) and SEMI, the global semiconductor industry association. ➤ The SEMICON India 2025, the Country's largest semiconductor conference, in September 2025 at New Delhi, will mark a significant milestone in India's journey towards making India the next semiconductor powerhouse.

39. Recently, Bharat Sanchar Nigam Limited (BSNL) conducted the soft launch of BSNL Quantum 5G fixed-wireless-access (FWA). With reference to the Quantum 5G FWA, consider the following statements:

1. It is a SIM-less technology.
2. It delivers high-speed internet over 4G radio.
3. The service is based on BSNL's Direct-to-Device platform

How many of the above statements is/are correct?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Recently, Bharat Sanchar Nigam Limited (BSNL) soft-launched its Quantum 5G Fixed Wireless Access (FWA). This indigenous, SIM-less fixed-wireless-access solution delivers optical fibre-like speeds over 5G radio (Not Over 4G). **So, Statement 1 is correct, and Statement 2 is not correct.**

Features:

- **SIM-less Architecture:** Implemented on BSNL's Direct-to-Device platform, enabling the customer premises equipment (CPE) to automatically authenticate with the network without the need for a physical SIM card. BSNL is the first Indian telecom operator to demonstrate a production-grade SIM-less 5G service." **So, Statement 3 is correct.**
- **Fully Indigenous stack:** Core, Radio Access Network (RAN), and Customer Premises Equipment (CPE) designed and integrated by Indian vendors under the Atmanirbhar Bharat programme.
- **Gigabit-class speeds:** Recorded 980 Mbps Down Link (DL) / 140 Mbps Up-Link (UL) with sub-10 ms latency—ideal for Ultra High Definition (UHD) streaming, cloud gaming and remote work.

ADDITIONAL INFORMATION:

FIXED WIRELESS ACCESS (FWA)	
Recently in the News	State-owned telecom firm BSNL has forayed into 5G fixed wireless service to provide home broadband service with its Launch in Hyderabad. At present, Reliance Jio and Bharti Airtel have been providing 5G Fixed Wireless Service (FWA) by using their 5G spectrum.
About	Fixed Wireless Access (FWA) is an innovative use case that uses 4G and 5G radio spectrum (the same as used for mobile phone services) to provide wireless broadband connectivity between two fixed points. ➤ Advantages: • Available where fibre is not present. • It can be faster and more affordable to install than fibre or cable. • Download speeds comparable to fibre. • Generally, more weather-resistant than Satellite or Digital Subscriber Line (DSL) • Lower latency than Satellite or mobile broadband • Accessible anywhere with cellular service • Secondary connection as a backup during network outages ➤ Disadvantages: • Generally, it requires line of sight. In other words, the area between the cell tower and wireless access point in your fixed location needs to be clear of obstructions such as mountains or buildings. The good news is that some FWA providers have initiated wireless access that does not require line-of-sight radio connectivity. • Its Radiofrequency signal can be affected by heavy storms and extreme hail • Latency is higher than that of fibre.

40. Consider the following information:

S.no	Processing Unit	Description
1.	Central Processing Unit	A core can only handle one task at a time
2.	Graphics Processing Unit	Carries out parallel processing of tasks
3.	Tensor Processing Unit	Google's application-specific integrated circuits

Which of the rows given above are correctly matched?

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

EXPLANATION:

A CPU (Central Processing Unit) is the primary component of any computer or electronic device. It's responsible for carrying out the instructions given to it by the user. The CPU acts as the "brain" of the computer — it reads and interprets commands from software programs and uses them to control other components within the machine.

- A CPU core is the physical processing unit of a central processing unit (CPU). It is the component responsible for executing instructions and performing calculations.
- A CPU can have multiple cores, which allows it to run multiple tasks simultaneously. The more cores a CPU has, the more independent tasks the processor can run concurrently.

- A CPU core can only process one thread at a time. However, multi-core processors can run multiple threads at the same time efficiently. This is because each core can be working on a different instruction or thread.

Thus, a Single core can handle only one task at a time, and a multi-core can process multiple tasks at the same time. **So, Pair 1 is correct.**

A graphics processing unit (GPU) is an electronic circuit designed to speed up computer graphics and image processing on various devices. These devices include video cards, system boards, mobile phones and personal computers (PCs).

- GPU has high-speed parallel processing capabilities due to their large number of smaller, efficient cores.
- Parallel processing, or parallel computing, is a kind of computing that relies on two or more processors to accomplish different subsets of an overall computing task.
- Because of this parallel structure, GPUs can perform many calculations or tasks simultaneously, making them faster and more efficient than CPUs in older computers. **So, Pair 2 is correct.**

A TPU, or Tensor Processing Unit, is a type of specialised hardware designed specifically for accelerating machine learning and artificial intelligence workloads.

- It Google's custom-developed, application-specific integrated circuits (ASICs) used to accelerate machine learning workloads.
- It is specifically optimised for processing and executing complex mathematical operations that are commonly used in training and running AI models.
- This type of hardware is especially useful for tasks like image and speech recognition, natural language processing, and other forms of deep learning. It can significantly speed up AI processes and reduce the time and resources needed to train and run AI models.

Thus, the Tensor Processing Unit helps with quicker machine learning. **So, Pair 3 is correct.**

ADDITIONAL INFORMATION:

PROCESSING UNITS	
About	Processing units are essentially hardware units that are the brain of a computer. Like the human brain handles tasks such as reading and solving a math problem, processing units also perform tasks. These could be doing calculations, taking a picture, or sending a text.
CPU	➤ Developed in the 1950s, a Central Processing Unit (CPU) is a general-purpose processor that can handle various tasks. It is like a conductor in an orchestra, controlling all the other components of the computer — from GPUs to disk drives and screens — to perform different tasks. ➤ A CPU has at least a single core — the processing unit within the CPU that can execute instructions. ➤ In the initial years, CPUs used to have just one core, but today, they can contain from two to up to 16 cores. ➤ As each core of the CPU can handle one task at a time, the ability to multitask is determined by the number of cores in the hardware.
GPU	➤ A Graphic processing Unit (GPU) is a specialised processor (it is a type of application-specific integrated circuit, or ASIC) which has been designed to perform multiple tasks concurrently rather than sequentially (like in a CPU). ➤ Modern GPUs comprise thousands of cores, which break down complex problems into thousands or millions of separate tasks and work them out in parallel, a concept known as parallel processing. This makes GPUs far more efficient than CPUs.

TPU	➤ Google Cloud Tensor Processing Unit (TPUs) are custom-designed AI accelerators, which are optimised for training and inference of AI models. ➤ They are ideal for a variety of use cases, such as agents, code generation, media content generation, synthetic speech, vision services, recommendation engines, and personalisation models, among others. ➤ Cloud TPUs are designed to scale cost-efficiently for a wide range of AI workloads, spanning training, fine-tuning, and inference.
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41. Which of the following correctly describes high-band 5G?

1. It offers extremely high internet speeds, tested up to 20 Gbps.
2. It has minimal coverage and is not suitable for wide-area connectivity.
3. The signal penetration is weak, making it less effective at passing through obstacles.

Select the correct code using the options given below:

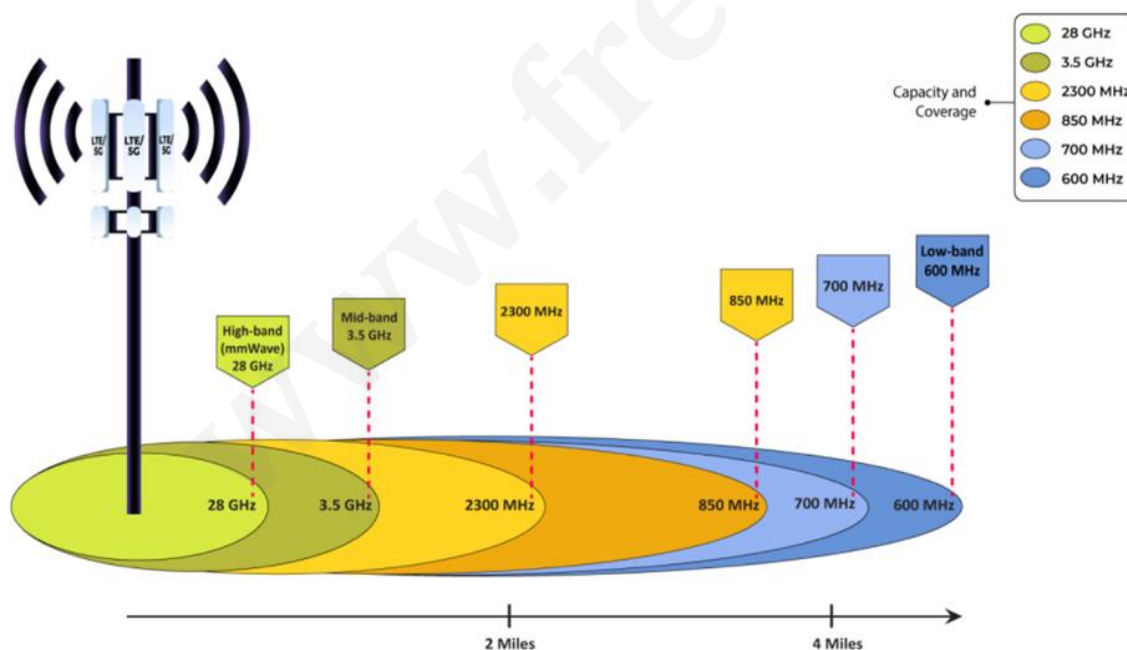
- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3**

EXPLANATION:

High-Band 5G (mmWave) offers the highest internet speeds among all 5G bands. Speeds have been tested up to 20 Gbps, whereas the maximum data speed in 4G is typically around 1 Gbps. **So, Statement 1 is correct.**

However, this high-band spectrum has very limited coverage. Its signals are effective only over short distances, making it suitable mainly for dense urban areas, stadiums, or hotspots. **So, Statement 2 is correct.**

Another limitation is weak signal penetration. High-frequency waves are easily blocked by walls, windows, and even trees, which restricts its effectiveness indoors and in obstructed areas. The high-band 5G provides ultra-fast speeds but suffers from limited range and poor penetration, making it ideal for short-range, high-capacity applications. **So, Statement 3 is correct.**



ADDITIONAL INFORMATION:

FIFTH-GENERATION MOBILE TECHNOLOGY	
About	5G, or fifth-generation mobile technology, is designed to provide high device connectivity, fast data transfer, low latency, high reliability, and reduced costs. It delivers three key communication services: ➤ Enhanced Mobile Broadband (eMBB): Offers gigabit-range speeds and high-quality internet, even in challenging conditions. ➤ Ultra-Reliable Low-Latency Communications (URLLC): Ensures latency below 4–5 ms, end-to-end security, and 99.99% reliability for mission-critical applications. ➤ Massive Machine Type Communications (mMTC): Supports large-scale IoT and non-human device communication with low-rate, uplink-focused transmission. These services are applied in smart cities, healthcare, industrial automation, autonomous vehicles, and entertainment, enabled by proper frequency allocation.
5G Frequency Bands	5G combines low, mid, and high-frequency bands to provide flexible coverage, high-speed connectivity, and low latency, enabling advanced applications across industries and urban environments. ➤ Low-Band (600 MHz–2.6 GHz): Provides wide coverage with low data speeds (~50 Mbps), ideal for IoT, industrial automation, and remote monitoring ➤ Mid-Band (1.7–2.5 GHz): Balances coverage and speed (100–900 Mbps), suitable for urban areas, smart cities, and continuous IoT connectivity. ➤ High-Band (24–40 GHz and beyond): Offers ultra-fast speeds (1–10 Gbps) over short distances, best for densely populated areas, high-data-rate business applications, and real-time IoT data. Typical mobile service frequencies include 26, 40, 50, and 60 GHz.

42. How many of the following applications can be effectively implemented using Blockchain technology?

1. Land title registration
2. Photosynthesis rate enhancement in crops
3. Peer-to-peer energy trading
4. Detection of blood pressure in a patient
5. Cryptocurrency payments
6. Real-time traffic light control based on vehicle count

Select the correct answer using the code given below:

(a) Only three

(b) Only four

(c) Only five

(d) All six

EXPLANATION:

Blockchain is a shared, immutable (unchangeable) ledger that facilitates the process of recording transactions and tracking assets across a business network. Anything of value — such as money, property, or information — can be tracked and traded on a Blockchain network.

- Essentially, a Blockchain is a distributed database shared across a network of computers. It stores information electronically in digital form, making transactions secure, transparent, and tamper-proof.
- Blockchain is a type of Distributed Ledger Technology (DLT). With the help of Blockchain, not only digital currencies but also other types of assets can be digitised and securely stored. The technology operates through a system of data blocks, where each block is linked to the previous one, forming a chain.
- Once data is recorded in a block and added to the chain, it cannot be altered, making Blockchain highly secure and resistant to hacking. Its main goal is to digitally secure and verify transactions and documents in a decentralised manner.

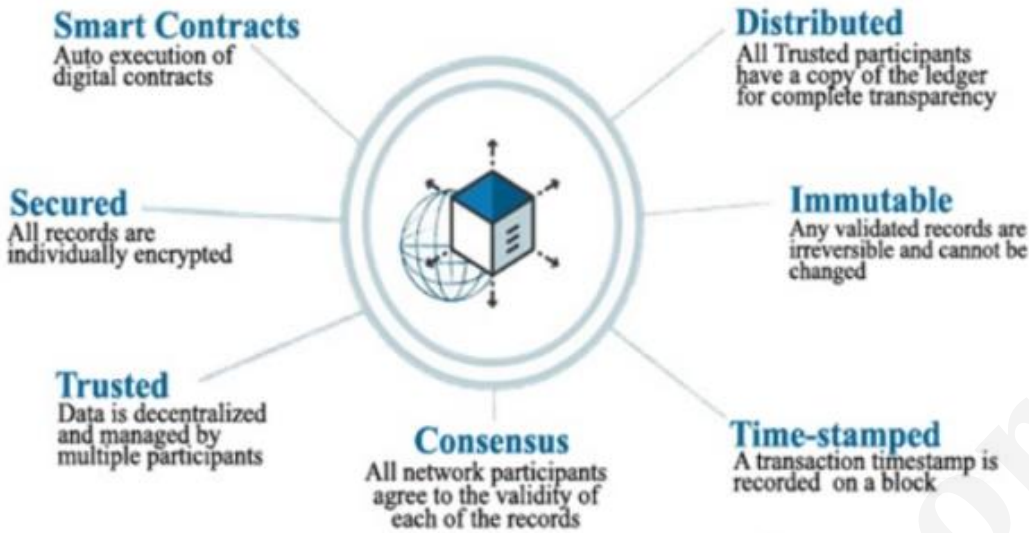
Applications that can be effectively implemented using Blockchain technology are:

- **Land title registration:** A blockchain-enabled land title registration system creates immutable records of land ownership that are digitised and stored permanently on the Blockchain. This ensures transparency, security, and tamper-proof recordkeeping.
 - Any change in ownership — such as a sale, transfer, or mutation of title — is recorded as a new transaction on the Blockchain. Each new record is linked to previous transactions, forming an unalterable chain of ownership history.
 - Because all data on the Blockchain is immutable and transparent, authorised stakeholders such as government agencies, utilities, insurance companies, and financial institutions can easily verify and track property details in real time. This reduces fraud, simplifies verification, and improves trust in the land registration process.
 - **Example:** In India, Andhra Pradesh and Telangana launched a blockchain system for land record management to prevent tampering and reduce land disputes. **So, Statement 1 is correct.**
- **Energy Trading:** Blockchain may enable a sustainable energy trading system by implementing smart PPAs (Purchase Power Agreements), smart microgrids, REC Certificates Issuance, etc. Making energy resources into digital assets that can be traded on a blockchain could open new investing and trading opportunities, allowing ease of entry to the new players and fostering innovations. It can also lead to a community-driven change that would solve the problem of last-mile access. **So, Statement 3 is correct.**
- **Cryptocurrency payments:** Blockchain technology serves as the foundation for cryptocurrencies such as Bitcoin and Ethereum. A cryptocurrency is a digital form of payment that operates on a blockchain network, allowing value to be transferred directly between users without the need for intermediaries like banks.
 - When a user sends cryptocurrency, credit is transferred in the form of computer code through a cryptographically signed transaction recorded on the Blockchain. These transactions are verified by multiple computers (nodes) in the network through a process known as consensus.
 - A transaction can only be authorised and processed by someone possessing a valid private (secret) key, which proves ownership of the funds. These keys are securely stored in a user's digital wallet.
 - Because Blockchain operates as a decentralised, borderless network, it enables faster and easier cross-border payments. This system bypasses traditional currency restrictions, exchange rate fluctuations, and banking infrastructure limitations, making global transactions more efficient, transparent, and cost-effective. **So, Statement 5 is correct.**

Blockchain technology does not have real-time applications in processes such as photosynthesis rate enhancement in crops, detection of blood pressure levels in patients, or real-time traffic light control based on vehicle count. **So, Statements 2, 4 and 6 are not correct.**

ADDITIONAL INFORMATION:

BLOCKCHAIN TECHNOLOGY	
About	➤ Blockchain allows digital information to be recorded and distributed. Blockchain is an irreversible record of transactions, which cannot be changed, deleted or destroyed. ➤ Blockchain was first proposed in 1991 as a research project, but in the year 2009, Blockchain was used in bitcoin. ➤ Bitcoin is a cryptocurrency which is built on the basis of Block technology. Blockchain has since been used in the creation of various cryptocurrencies, decentralised finance applications, non-fungible tokens and smart contracts.

Properties	Properties of Block Chain  Smart Contracts Auto execution of digital contracts Distributed All Trusted participants have a copy of the ledger for complete transparency Imutable Any validated records are irreversible and cannot be changed Time-stamped A transaction timestamp is recorded on a block Consensus All network participants agree to the validity of each of the records Trusted Data is decentralized and managed by multiple participants Secured All records are individually encrypted
Pros and Cons	Pros: ➤ Improved accuracy by removing human involvement in verification ➤ Cost reductions by eliminating third-party verification ➤ Decentralisation makes it harder to tamper with transactions are secure, private, and efficient ➤ Transparent technology ➤ Provides a banking alternative and a way to secure personal information for citizens of countries with unstable or underdeveloped governments Cons: ➤ Significant technology cost associated with blockchains ➤ Low number of transactions per second ➤ History of use in illicit activities, such as on the dark web ➤ Regulation varies by jurisdiction and remains uncertain ➤ Data storage limitations

43. Consider the following statements regarding GI Cloud (MeghRaj):

1. It is a Government of India initiative to provide a cloud computing platform for all central and state government departments.
2. The platform accelerates the deployment of identity verification and consent-based data sharing in e-Gov applications.

Which of the statements given above is/are correct?

- (a) 1 only
 (b) 2 only
 (c) **Both 1 and 2**
 (d) Neither 1 nor 2

EXPLANATION:

The GI Cloud (MeghRaj) initiative aims to provide Information and Communication Technology (ICT) services via Cloud to all Government Departments at the Centre and States/UTs, promoting the Cloud ecosystem nationwide. **So, Statement 1 is correct.**

- MeghRaj will ensure optimum utilisation of the infrastructure and speed up the development and deployment of eGov applications.
- The architectural vision of GI Cloud encompasses a set of discrete cloud computing environments spread across multiple locations, built on existing or new (augmented) infrastructure, following a set of common protocols, guidelines and standards issued by the Government of India.
- It ensures optimal use of IT infrastructure and accelerates the development and deployment of e-Gov applications such as digital payments, identity verification, and consent-based data sharing.
So, Statement 2 is correct.
- MeitY has initiated the empanelment of Cloud Service Providers (CSPs) to address the evolving Cloud needs of Government Departments.

ADDITIONAL INFORMATION:

GI CLOUD INITIATIVE - MEGHRAJ	
About	➤ Cloud Computing Services provide a new model of offering services (Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Software as a Service (SaaS) and Storage as a Service (STaaS)) to the users at a fast pace, which is also cost-effective. ➤ "GI Cloud" has been named as 'MeghRaj'. This initiative is to implement various components, including a governance mechanism, to ensure the proliferation of Cloud in the Government. The focus of this initiative is to accelerate the delivery of e-services in the Country while optimising the ICT spending of the Government.
Advantages	➤ Optimum utilisation of existing infrastructure ➤ Rapid deployment and Reusability: Any software made available by any government department in India can be made available to other departments as well without additional costs. ➤ Manageability and Maintainability: It provides a single point for maintaining Information & Communication Technology (ICT) infrastructure in India. ➤ Scalability: According to the demands from the citizens of India, the infrastructure of the Government can be increased accordingly. ➤ Efficient service delivery ➤ Security: A security framework for the entire GI Cloud will lead to less environmental complexity and less potential vulnerability. ➤ Increased user mobility ➤ Reduced effort in managing technology ➤ Ease of first-time IT solution deployment ➤ Cost reduction ➤ Standardisation: GI Cloud shall prescribe the standards around interoperability, integration, security, data security and portability, etc.
Services offered as part of the National Cloud	The National Informatics Centre (NIC) is providing National Cloud services under the initiative MeghRaj. The services offered are as follows: ➤ Infrastructure as a Service (IaaS): IaaS provides basic virtual compute infrastructure resources like CPU, Memory, Disk Storage attached to blank Virtual Machines (VMs), allowing you to install an OS, using ISOs, from scratch and customisation. ➤ Platform as a Service (PaaS): PaaS provides pre-installed web and database servers so that you can publish and run a web application without worrying about server setup. The servers are pre-configured and ready with basic security hardening. It can be used to deploy

	servers and publish web applications quickly. The OS & Application Software licenses are provided as part of the offering. ➤ Software as a Service (SaaS): This provides an on-demand software service. SaaS is a software delivery model where users are not responsible for supporting the application or any of its components. The server infrastructure, OS and Software are being managed by cloud services. If a web application is available and needs to be distributed to multiple users, SaaS can be used to deliver it efficiently. ➤ Storage as a Service (STaaS): STaaS provides a need-based storage solution. It provides an excellent alternative to the traditional on-site and dedicated storage systems and reduces the complexities of deploying and managing multiple storage tiers. It can be used to mitigate risks in disaster recovery, provide long-term retention for records and enhance both continuity and availability.
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44. Which of the following is **not** correct regarding Common Service Centres (CSCs)?
- They provide access to e-Governance, financial, and social sector services in rural areas.
 - It aims to strengthen digital infrastructure in Tier-1 and Tier-2 cities, while rural outreach was added only under CSC 2.0**
 - They are managed by the Common Services Centres Special Purpose Vehicle under the Ministry of Electronics and Information Technology.
 - They were introduced as part of the National e-Governance Plan approved in 2006.

EXPLANATION:

Common Services Centre (CSC) programme is an initiative of the Ministry of Electronics & IT (MeitY), Government of India. CSCs are the access points for the delivery of various electronic services to villages in India, thereby contributing to a digitally and financially inclusive society. ➤ CSCs are more than service delivery points in rural India. They are positioned as change agents, promoting rural entrepreneurship and building rural capacities and livelihoods. ➤ They are enablers of community participation and collective action for engendering social change through a bottom-up approach, with a key focus on the rural citizen. So, Option (a) is correct.
The Common Service Centres (CSCs) initiative was launched in 2006 as part of the National e-Governance Plan (NeGP). The primary objective was to establish a network of ICT-enabled service delivery points across rural and remote areas of India. These centres aimed to bridge the digital divide by providing e-Governance, financial, health, education, and social services to citizens in underserved regions. ➤ The Government of India has launched the CSC 2.0 Project in August 2015, under the Digital India Programme, to expand the outreach of the CSCs to all Gram Panchayats (GPs) across the Country. ➤ It has aimed to set up at least one CSC in every GP across the Country within a duration of 4 years (by August 2019), thereby envisaging the establishment of at least 2.5 lakh CSCs covering all Gram Panchayats of the Country over a period of four years. Therefore, the primary objective of the CSC is to strengthen digital infrastructure in rural areas and under CSC 2.0, the focus shifted to expanding the network to cover all Gram Panchayats (GPs) across the Country, ensuring no village is left without a CSC. So, Option (b) is not correct.
CSC e-Governance Services India Limited is a Special Purpose Vehicle (CSC SPV) incorporated under the Companies Act, 1956, by the Ministry of Electronics and Information Technology (MeitY), Government of India, to monitor the implementation of the Common Services Centres Scheme. It provides a centralised collaborative framework for the delivery of services to citizens through CSCs, besides ensuring systemic viability and sustainability of the scheme. So, Option (c) is correct.

The Common Service Centres (CSC) is a strategic cornerstone of the National e-Governance Plan (NeGP), approved by the Government in September, 2006, with an aim to cover all 6 lakhs census villages by one lakh CSCs, as per 1:6 ratio equitably spread across rural India, as part of its commitment in the National Common Minimum Programme to introduce e-governance on a massive scale. **So, Option (d) is correct.**

ADDITIONAL INFORMATION:

COMMON SERVICE CENTRES (CSC)	
Recently in the News	In a landmark stride for financial inclusion under the Digital India initiative, Common Services Centres, e-Governance Services India Limited, has crossed the significant milestone of disbursing three thousand crore rupees in loans since July 2023.
Functions	➤ Service Delivery Centres for – Government to Citizen (G2C), Business to Consumer (B2C), Utility Services, etc. ➤ Permanent Enrolment Centres (PEC) for Aadhaar, and Aadhaar Printing Centres ➤ Business Correspondent Agents (BCAs) under Financial Inclusion for Banking services and banking services under Prime Minister's Jan-Dhan Yojana ➤ Insurance service Centres ➤ Educational and Skill Development Centres ➤ Electoral Registration centres ➤ Information Centre for various schemes of the Government for creating awareness, leading to digital empowerment among the citizens ➤ Wi-Fi distribution centres (Wi-Fi e-Choupal).
Key services	➤ G2C Services • Central Government Services for: PAN card Application, Passport Applications, Income Tax Return, Employment Service, Swachh Bharat Abhiyan, Pradhan Mantri Awas Yojana (PMAY), Agriculture Service, Soil Health Card, etc. • State Government Services that can be accessed: e-District/State Service Delivery Gateway (SSDG) services, Land Record, Ration Card, Birth/Death Certificate, Income, Caste, Domicile certificate, etc. • UIDAI Aadhaar Service: Aadhaar Print, Mobile Updates, Demographic Updates, Enrolments, e-KYC (Electronic Know Your Customer), Authentication, Seeding, and printing of Aadhaar Card. • Election Commission Services: Electoral Registration, deletion of elector's details, Modification of elector's details, transposition, etc, Electoral Photo Identity Card (EPIC) Printing. ➤ B2C Services: Indian Railway Catering & Tourism Corporation (IRCTC) Services, e-Recharge, Tour & Travels, Sale & purchase of seeds & farmer equipment, e-Commerce, etc. ➤ Financial Services • Banking Services: Setting up of Business Correspondent Agents of various banks at CSCs. And providing the services like: New Account opening, Deposit, Withdrawal, and Remittance.

	• Insurance Services: Life Insurance (New Policy), Life Insurance (Renewal of Policies), General Insurance. • Aadhaar Enabled Payment System (AEPS) Services: Withdrawal of money only. • Pension: Providing the PFRDA services ➤ Educational Services • National Digital Literacy Mission (NDML) – Digital Saksharata Abhiyan (DISHA) / Pradhan Mantri Gramin (PMG) DISHA, CyberGram project, various courses through National Institute of Open Schooling (NIOS), National Institute of Electronics & Information Technology (NEILIT) Courses (Courses on Computer Concepts - CCC & Basic Computer Course -BCC), Tally, various coaching courses (IIT, Civil Services), Financial and Legal Literacy. ➤ Skill Development: Courses on electronics, motor mechanics, mobile repair, health adviser, etc, are being offered. ➤ Health Services: Telemedicine, JAN Aushadhi, Diagnostic Services
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45. SSI Mantra, recently seen in the news, in the context of :

- (a) Quantum computer
- (b) Earth observation satellite
- (c) Refractor telescope
- (d) **Surgical robotic system**

EXPLANATION:

Recently, combining cutting-edge technology with medical innovation, doctors used India's first indigenous surgical tele-robotic system, SSI Mantra, to successfully conduct two complex heart surgeries over a distance of 286 kilometres – the longest physical separation so far achieved in India between a patient and the operating surgeon. **So, Option (d) is correct.**

- The SSI Mantra surgical tele-robotic system developed by medical technology company, SSI Ltd, is the first-of-its-kind system in India. It conducted two surgeries, with a team stationed at the SSI's robotics control in Gurugram and another at a hospital in Jaipur.
- The first procedure was an internal mammary artery harvesting, which involves removing the artery for a coronary artery bypass grafting. The second was a total endoscopic coronary artery bypass, which is considered a complex cardiac surgery as the surgeon has to work on the artery while the heart is still beating.

ADDITIONAL INFORMATION:

SSI MANTRA SURGICAL ROBOTIC SYSTEM	
About	➤ The SSI Mantra Surgical Robotic System has two consoles: • A master surgeon console situated at a remote location and • A slave surgeon console located in an operation theatre. ➤ Both the surgeon consoles have a system controller, a pair of hand controllers, and various other control pedals/toggle switches, etc. ➤ In an operation theatre, multiple patient-side arm carts are arranged around an operating table. Multiple robotic arms (each having a robotic surgical instrument) are mounted on the patient-side arm carts. One of the patient-side arm carts is equipped with an endoscopic camera. ➤ The dual consoles are connected via a transmission network. ➤ During the telesurgery, the system control is with the master surgeon console. ➤ The remote expert surgeon manoeuvres the hand controllers to perform specific surgical actions, and these action/control signals are transmitted to a

network router via a network switch locally present near the master surgeon console. Then the control signals are sent over the chosen transmission network to the system controller of the slave surgeon console via a local network router. These action/control signals are then transmitted to the patient-side arm carts, present at the location of the patient.



46. Which one of the following countries recently conducted a 'Robot Olympics'?

- (a) India
- (b) China**
- (c) USA
- (d) Germany

EXPLANATION:

The first World Humanoid Robot Games have concluded in Beijing, China, with more than 500 androids alternating between jerky tumbles and glimpses of real power as they took part in events ranging from the 100m (109-yard) hurdles to kung fu. **So, Option (b) is correct.**

- Two hundred eighty robotics teams from 16 countries, including the United States, Germany and Brazil, with 192 representing universities and 88 from private enterprises such as China's Unitree and Fourier Intelligence, competed at the Chinese capital's National Speed Skating Oval, built for the 2022 Winter Olympics.
- Competing teams used robots from Chinese manufacturers such as Booster Robotics.
- Events included traditional sports such as athletics, football and basketball, as well as practical tasks such as medicine categorisation and cleaning.
- Organisers say the purpose of the event is to trial and refine current robotics. They say sports are a way to test a robot's decision-making, motor skills and controllers that could be later applied in real-life settings like factories and homes.
- It's all part of China's push to become a global leader in humanoid robotics. The Government has a national plan to build a world-class humanoid industry by 2027.



47. With reference to the defence sector, consider the following:

1. Artificial Intelligence-based warfare
2. Proxy warfare
3. Electro-magnetic warfare
4. Space warfare
5. Cyber attacks

How many of the above is/are frontier technologies used in new-age warfare?

- (a) Only two
- (b) Only three
- (c) Only four**
- (d) All five

EXPLANATION:

Frontier technologies in warfare refer to cutting-edge, disruptive innovations that transform the way military power is developed, deployed, and sustained. They draw on advances in fields such as artificial intelligence, robotics, quantum science, biotechnology, space systems, cyber operations, and advanced materials, and are characterised by their ability to alter the speed, precision, reach, and autonomy of combat operations.

- AI is set to rapidly transform the landscape of warfare, with deep tech being deployed for tasks ranging from autonomous weapons systems to intelligence gathering and cybersecurity. This includes the development of autonomous weapons systems that can select and engage targets without human intervention; analysing vast amounts of data to identify potential threats, tracking enemy movements, and forecasting future attacks; and creating realistic battlefield simulations to enable field evaluation trials, as well as allowing soldiers to train in virtual environments to prepare for real-world combat scenarios.
- AI use in warfare is also spreading rapidly, with reports suggesting that Ukraine has equipped its long-range drones with AI that can autonomously identify terrain and military targets, using them to launch successful attacks against Russian refineries.

Therefore, Artificial Intelligence-based warfare is a frontier technology used in new-age warfare. **So, Statement 1 is correct.**

Proxy war, a military conflict in which one or more third parties directly or indirectly support one or more state or nonstate combatants in an effort to influence the conflict's outcome and thereby to advance their own strategic interests or to undermine those of their opponents. It is an unconventional type of warfare.

- Third parties in a proxy war do not participate in the actual fighting to any significant extent, if at all. Proxy wars enable major powers to avoid direct confrontation with each other as they compete for influence and resources.
- Direct means of support by third parties consist of military aid and training, economic assistance, and sometimes limited military operations with surrogate forces.
- Indirect means of support have included blockades, sanctions, trade embargoes, and other strategies designed to thwart a rival's ambitions.

The Ongoing Ukraine-Russia war consists of a proxy war launched by the United States, with economic sanctions such as tariffs on countries that support Russia in the war. **So, Statement 2 is not correct.**

Electronic warfare is any strategic use of the electromagnetic spectrum, or of tactics related to the use of the electromagnetic spectrum, against an enemy in a military conflict.

- The most commonly practised types of electronic warfare are jamming, which falls under the category of electronic countermeasures (ECM), and eavesdropping on enemy communications, which is known as signals intelligence (SIGINT) gathering.
- The purpose of jamming is to limit an enemy's ability to exchange information by overriding radio transmissions or by sending signals to prevent radar detection or convey false information.

Example: Russia uses systems like the Krasukha-4 and Leer-3 to jam Ukrainian communications, GPS, and drone control signals in the ongoing war.

Therefore, Electromagnetic warfare is a frontier technology used in new-age warfare. **So, Statement 3 is correct.**

Space warfare means military actions that attack, deny, degrade, or defend space systems (satellites, ground-to-space links, and the services they provide). It includes kinetic strikes (anti-satellite missiles), non-kinetic attacks (jamming, blinding lasers, cyberattacks), electronic and cyber warfare, and combinations of those.

In 2019, India conducted an Anti-Satellite (ASAT) missile test, named Mission Shakti, becoming the fourth Country in the world to demonstrate the capability to shoot down satellites in orbit. So far, only the United States, Russia and China have this prowess.

Therefore, the world powers are gearing up for the neo-age warfare based on frontier technology, which was science fiction a decade ago. **So, Statement 4 is correct.**

A cyberattack is a deliberate attempt to gain unauthorised access to a computer network, computer system or digital device. The goal is to steal, expose, alter, disable or destroy data, applications or other assets.

Today's threat actors range from lone hackers and organised cybercriminals to state-sponsored groups engaged in long-term cyberwarfare. Their tactics span an ever-growing arsenal—malware attacks, social engineering scams, zero-day exploits and self-replicating worms included.

Example: Iran's nuclear enrichment facilities (Natanz) cyberattack by the US and Israel (Suspected) in 2010.

Therefore, Cyber attacks are a neo-frontier technology used in new-age warfare. **So, Statement 5 is correct.**

48. Consider the following:

1. Rustom -1
2. Heron
3. TAPAS-BH-201
4. Nag astra
5. Warmate

Which of the above are surveillance and reconnaissance drones?

- (a) 1, 2, 3 and 5 only**
(b) 2, 3 and 4 only
(c) 1, 2, 3 and 4 only
(d) 1, 2, 3, 4 and 5

EXPLANATION:

Rustom-1, a medium-altitude and long-endurance Unmanned Aerial Vehicle (UAV), was developed by the DRDO with the Aeronautical Development Establishment, Bangalore, as the nodal laboratory in 2010.

- The UAV has an endurance of 12 to 15 hours and can carry payloads up to 75 kg.
- It has an altitude ceiling of 25,000 feet.
- This UAV is a "MALE" or medium altitude long endurance type.
- Rustom will be able to see the enemy territory up to a distance of 250 km and carry a variety of cameras and radar for surveillance. **So, Statement 1 is correct.**

The Heron is a Medium-Altitude Long Endurance (MALE) unmanned aerial system (UAS) developed by Israel Aerospace Industries (IAI). With the capability to conduct continuous operations for up to 45 hours at altitudes of up to 35,000 feet, the Heron is a robust and combat-proven platform.

- It boasts hundreds of thousands of operational flight hours and is entrusted by over 22 global leaders across a diverse spectrum of mission types.
- The multi-mission system of the Heron UAS is engineered to manage up to six different mission payloads concurrently, enabling the execution of complex intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) missions over varied terrains, including mountains, forests, jungles, swamps, maritime environments, or urban areas. **So, Statement 2 is correct.**

The indigenously-developed Tactical Aerial Platform for Advanced Surveillance (TAPAS) 201 Medium Altitude Long Endurance (MALE) unmanned aerial vehicle (UAV) is designed and developed by the Bengaluru-based Aeronautical Development Establishment (ADE). It is a multi-mission UAV to carry out the intelligence, surveillance and reconnaissance roles for the armed forces with an endurance of 24 to 30 hours.

Dubbed the Indian version of the US Predator drones, TAPAS 201 is capable of carrying different combinations of payloads like Medium Range Electro Optic, Long Range Electro Optic, Synthetic Aperture Radar, Electronic Intelligence, Communication Intelligence and Situational Awareness Payloads to perform missions during day and night. This MALE UAV was earlier referred to as Rustom-II UAV. **So, Statement 3 is correct.**

The Nagastra-1 is a UAV-based loitering munition designed to act as an aerial ambush system. Its primary function is to hover above targets and execute precision strikes with GPS-enabled accuracy, achieving a remarkable precision of 2 meters.

- **Precision Strike Capability:** In "Kamikaze mode," Nagastra-1 can neutralise hostile threats by directly striking the target and destroying itself in the process.
- **High Altitude Operation:** The drone can fly at altitudes over 4,500 meters, making it difficult to detect by radar.
- **Endurance and Range:** The fixed-wing electric UAV can operate for 60 minutes, with a man-in-loop control range of 15 kilometres and an autonomous mode range of 30 kilometres.
- **Recovery Mechanism:** The Nagastra-1 has an abort, recover, and reuse feature. Suppose the target is not detected or the mission is aborted. In that case, it can be called back and safely landed using a parachute system, making it superior to similar systems developed by advanced countries.

The primary objective and capacity of Nagastra UAV is to do precision aerial strikes. **So, Statement 4 is not correct.**

Recently, Poland's largest private defence technology firm, WB Group, showcased its battle-tested Warmate Tube-Launched (TL) Loitering Munition System for the first time at Aero India 2025.

- The Warmate TL Loitering Munition, originally developed as a cost-effective alternative to traditional guided missiles, has emerged as a versatile, precision-strike solution.
- It is a canister-based pneumatic launch system, allowing integration across land vehicles, naval vessels, and aerial platforms. Once deployed, its folding wings extend mid-flight, enabling it to loiter over a target area with pinpoint accuracy before executing an attack.

- Equipped with daylight and infrared cameras, the Warmate TL can perform real-time reconnaissance, surveillance, and target acquisition, feeding live intelligence back to operators. The fully automated attack capability allows for engagement even in GPS-denied environments, reducing reliance on traditional targeting infrastructure. **So, Statement 5 is correct.**

49. With reference to the Gandiva missile, consider the following statements:

1. It is part of the Astra series of missiles.
2. It has a range of over 500 kilometres.
3. It doesn't need an onboard oxidiser.

How many of the above statements is/are correct?

- (a) Only one
(b) Only two
 (c) All three
 (d) None

EXPLANATION:

Defence Research and Development Organisation (DRDO) has made significant strides in advancing India's air-to-air missile technology with the Astra MK-3, now officially named "Gandiva" after the legendary bow of Arjuna from the Mahabharata.

- Gandiva missile is a culmination of the Astra series, building upon the success of its predecessors, the Astra MK-1 and MK-2, which had ranges of 80–110 km and 140–160 km, respectively. **So, Statement 1 is correct.**
- The Gandiva missile is powered by a Solid Fuel Ducted Ramjet (SFDR) propulsion system, a cutting-edge technology that utilizes atmospheric oxygen as an oxidizer. This eliminates the need for onboard oxidizers, resulting in a lighter and more efficient design. **So, Statement 3 is correct.**
- The SFDR system allows the missile to sustain supersonic speeds, reportedly up to Mach 4.5, over extended ranges of 300–350 kilometres, depending on launch conditions.
- The Gandiva missile has been designed with a remarkable ability to strike enemy aerial targets from a range of 340 kilometers when the target is at an altitude of 20 kilometers, and 190 kilometers when the target is at a lower altitude of 8 kilometers. It doesn't have a range of over 500 kilometres. **So, Statement 2 is not correct.**
- One of the hallmark features of the Gandiva is its throttle-able solid fuel ducted ramjet. Unlike conventional solid rocket motors that burn at a fixed rate, the SFDR's ramjet engine can modulate thrust during flight. This capability, achieved through a hot gas flow controller, enables the missile to dynamically adjust its speed and trajectory.



ADDITIONAL INFORMATION:

AIR-TO-AIR MISSILE	
Recently in the News	India's new Astra MK-III missile, renamed Gandiva, significantly increases its aerial combat capabilities with a range of 340 kilometres, surpassing rivals like China's PL-15 and the U.S. AIM-174. India's defence exports have also surged to a record high of Rs 21,083 crore for the fiscal year 2023-24.
About	Modern air combat has evolved with the rise of beyond-visual-range (BVR) engagements, betterment in missiles and their guidance systems, which highlights the importance of advanced air-to-air missiles like Meteor and Astra.
Missiles	For India, equipping fighter jets with the best Air-to-Air Missile (AAMs) ensures maintaining an edge in aerial combat against our adversaries. Indian Air Force and Indian Navy use a wide range of air-to-air missiles, and here is a list of those missiles. ➤ Astra Mk-I, Astra Mk-II and Astra Mk-III ➤ Python-5: It is an advanced air-to-air missile developed by Israel's Rafael Advanced Defence Systems. It features an infrared homing seeker, high manoeuvrability, and a lock-on-after-launch capability, allowing engagement of targets effectively. (Up to 20 km, Solid-fuel rocket motor) ➤ Derby: Also developed by Rafael, Derby is a medium-range active radar-guided air-to-air missile with beyond-visual-range capabilities and a fire-and-forget system. ➤ R-73: The R-73 is a short-range infrared-guided air-to-air missile developed by the Soviet Union. Known for its off-boresight capability and compatibility with helmet-mounted sight systems, it can engage targets in close combat scenarios with high manoeuvrability, making it dangerous in close combat dogfights. ➤ R-77: The R-77 is a modern Russian active radar-guided BVRAAM (Beyond Visual Range Air-to-Air Missile), often compared to the AIM-120 AMRAAM. It features a unique lattice fin design for high agility and a range of approximately 80 km. ➤ MICA: The MICA is a French air-to-air missile developed by MBDA (a European company), available in infrared and active radar-guided variants. It is compatible with various platforms like Rafale and Mirage 2000, and successful test firings have already been conducted from SU30MKI aircraft. ➤ Meteor: BVRAAM developed by MBDA, featuring a unique ramjet propulsion system for sustained thrust and long-range capability of over 150 km. With high-speed and high-no-escape-zone, it establishes the superiority of IAF in BVR combat over our adversaries.

50. Consider the following information:

S. no	Defence technology in the news	Description
1.	Multi-Influence Ground Mine	It is an underwater mine that could improve naval warfare capabilities
2.	Akashteer	It is an automated Air Defence Control and Reporting System
3.	Barak-8 Missile System	It is a surface-to-air missile system that offers all-weather protection.

Which of the above pairs are correctly matched?

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

EXPLANATION:

Recently, the Indian Navy and the Defence Research and Development Organisation have successfully undertaken combat firing of the indigenously designed and developed Multi-Influence Ground Mine (MIGM).

MIGM system is an advanced underwater naval mine, and it is designed to enhance the Indian Navy's capabilities against modern stealth ships and submarines.

- Multi-Influence Ground Mine is equipped with multiple sensors for recording of influences like acoustic, magnetic, and pressure generated by marine vessels.
- It has a built-in electronics system that comprises data acquisition electronics with ARM processors, along with peripheral devices for processing the data and generating commands to initiate the desired course of action. This system would further enhance the undersea warfare capabilities of the Indian Navy. **So, Pair 1 is correct.**



Recently, India had deployed 'Akashteer' during Operation Sindoor, launched against nine terror sites in Pakistan and Pakistan-occupied Kashmir.

Akashteer is India's fully indigenous, automated Air Defence Control and Reporting System, which intercepted and neutralised every inbound projectile.

- The system provides a common, real-time air picture to all involved parties (control room, radars and Defence Gun), enabling coordinated air defense operations.
- It is a system designed to automate detection, tracking and engagement of enemy aircraft, drones and missiles.
- It integrates various radar systems, sensors and communication technologies into a single operational framework.

Akashteer gathers data from multiple sources, processes it and allows for automated, real-time engagement decisions. **So, Pair 2 is correct.**



The Barak-8 missile system played a crucial role in India's Operation Sindoor, successfully neutralising Pakistan's aerial threats, including missiles and drones, and contributing to the operation's success.

- The Barak-8 missile system was developed as a joint project between India's Defence Research and Development Organisation (DRDO) and Israel Aerospace Industries.
- The Barak-8 is a medium-range surface-to-air missile (MR-SAM) designed to counter a wide array of threats. It is capable of targeting enemy fighter aircraft, drones, surveillance planes, helicopters, and even incoming missiles. The missile has a range between 70 to 100 kilometres and can travel at speeds up to Mach 2, which is twice the speed of sound.
- The Barak-8 missile system provides 360-degree protection against multiple threats simultaneously, utilising a multi-mission radar system, flexible control, and command capabilities.
- It can target and destroy multiple objectives at once, thanks to its multi-function surveillance tracking and guidance radar, ensuring precise targeting.

Additionally, the system is effective in all weather conditions and can operate both day and night.

So, Pair 3 is correct.



51. Which of the following is related to 'India's Analogue Space Mission' that was recently in the news?
- (a) A field testing of lunar rover prototypes in desert-like environments on Earth.
 - (b) A ground-based simulation of extraterrestrial conditions to train astronauts and test technologies.**
 - (c) To Conduct microgravity experiments aboard stratospheric balloons.
 - (d) To test cryogenic propulsion systems for deep-space exploration.

EXPLANATION:

Indian Space Research Organisation (ISRO) has started the country's first analogue space mission at Leh in Ladakh, where the space agency will simulate life in an interplanetary habitat. The mission is a collaborative effort by the Human Spaceflight Centre (ISRO), AAKA Space Studio, University of Ladakh, IIT Bombay, and supported by the Ladakh Autonomous Hill Development Council.

- Ladakh is chosen for its dry, cold climate, barren land, high-altitude terrain, and extreme isolation, which closely resemble Martian and lunar landscapes.
- The mission aims to simulate extraterrestrial conditions and provide valuable data for long-duration space missions to the Moon, Mars, and beyond.

Highlights:

- Located at an elevation of over 3,000 meters with oxygen levels only about 40% of sea level, Ladakh allows researchers to evaluate life support systems under low-pressure and low-oxygen conditions similar to those on Mars.
- A compact, inflatable habitat named Hab-1 has been set up for the mission.
- It is equipped with essentials such as a hydroponics farm, kitchen, and sanitation facilities, creating a self-sustaining environment that allows researchers to test daily life and survival in space-like conditions. **So, Option (b) is correct.**

52. Consider the following Pairs

S. no	Missions	Details
I	XPoSat	Indigenous in-space docking demonstration by ISRO
II	INSAT-3DS	Meteorological satellite mission for weather forecast
III	Chang'e-6	World's first far-side lunar sample return mission
IV	Nova-C (Odysseus)	First U.S. Moon landing in decades using methalox propulsion

How many of the pairs given above is/are correctly matched?

- (a) Only one
- (b) Only two
- (c) Only three**
- (d) All four

EXPLANATION:

XPoSat (X-ray Polarimeter Satellite) is India's first dedicated polarimetry mission aimed at studying the dynamics of bright astronomical X-ray sources under extreme conditions. It is not related to in-space docking.

The spacecraft carries two scientific payloads in low Earth orbit:

- **POLIX** (Polarimeter Instrument in X-rays): Measures polarisation parameters (degree and angle of polarisation) in the medium X-ray energy range of 8–30 keV.
- **XSPECT** (X-ray Spectroscopy and Timing): Provides spectroscopic information in the energy range of 0.8–15 keV. **So, Pair 1 is not correct.**

INSAT-3DS is a meteorological satellite launched on February 17, 2024, by ISRO. It provides advanced weather forecasting, disaster warning, and oceanographic observations. The INSAT-3DS satellite is designed with a set of primary objectives aimed at comprehensive Earth observation and meteorological services:

- The satellite monitors the Earth's surface and observes the oceans using various spectral channels essential for meteorological analysis.
- It provides detailed vertical profiles of meteorological parameters, contributing to a better understanding of atmospheric conditions.
- It facilitates the collection and dissemination of data through dedicated platforms, ensuring timely access to vital information.
- INSAT-3DS is equipped to provide satellite-aided search and rescue services, enhancing safety and emergency response capabilities. **So, Pair 2 is correct.**

Chang'e-6 is China's lunar sample-return mission and became the first mission to collect samples from the far side of the Moon and return them to Earth.

The mission involves landing a spacecraft on the lunar surface, collecting soil and rock samples, and safely returning them to Earth for scientific study. **So, Pair 3 is correct.**

Nova-C (Odysseus) is a lunar lander developed by Intuitive Machines. It is the first US spacecraft to use methalox propulsion (liquid methane and liquid oxygen) for lunar missions. The Lander has a hexagonal cylindrical design with six legs, about 4 meters tall, and can produce up to 4,000 N of thrust.

This enables precise landings and relocation to secondary sites. The first mission, IM-1 Odysseus, successfully landed on the Moon in February 2024, marking the first US soft landing since Apollo 17.

So, Pair 4 is correct.

53. Which of the following measures was implemented by the Indian government to enhance border security against drone threats?

- (a) **Deployment of anti-drone systems along the Pakistan border.**
- (b) Implementation of mandatory drone pilot licensing for all recreational users.
- (c) Establishment of a centralised drone control centre in Delhi.
- (d) Mandatory drone registration for all foreign-made drones.

EXPLANATION:

Recently, Punjab government deployed Punjab anti-drone system (ADS) named 'Baaj Akh'. The anti-drone system has been launched to eliminate the supply of drugs from across the border.

To strengthen border security and tackle the challenges posed by drone-based smuggling, nine anti-drone units are being set up along the international border.

In the year 2023, the Indian government also deployed the Anti-drone systems in border areas of Punjab to counter the drone threats. Further, an anti-rogue drone SOP has been formulated and circulated to field units and is being followed. **So, Option (a) is correct.**

To operate a drone in India, one need to obtain a drone license from the Directorate General of Civil Aviation (DGCA). This license is mandatory and applies to both commercial and recreational drone operators. The DGCA has implemented strict guidelines to ensure the safe operation of drones in Indian airspace.

Drone licensing has been made mandatory in India primarily to ensure the safe and regulated operation of drones, rather than for enhancing border security or countering drone threats. **So, Option (b) is not correct.**

No official announcement or implementation of a centralised drone control centre has been made. **So, option (c) is not correct.**

- India mandates registration for all drones under the Digital Sky platform, but no separate rule for foreign-made drones exists.
- Mandatory registration of all foreign-made drones was not a measure implemented by the Indian government to enhance border security against drone threats. **So, Option (d) is not correct.**

54. Consider the following statements regarding AdFalcivax Vaccine:

1. It is India's first indigenous malaria vaccine.
2. The vaccine maintains its potency at normal temperatures.
3. The vaccine prevents parasite development inside mosquitoes during the mating stage.

Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 1 and 3 only
- (c) 2 and 3 only
- (d) **1, 2 and 3**

EXPLANATION:

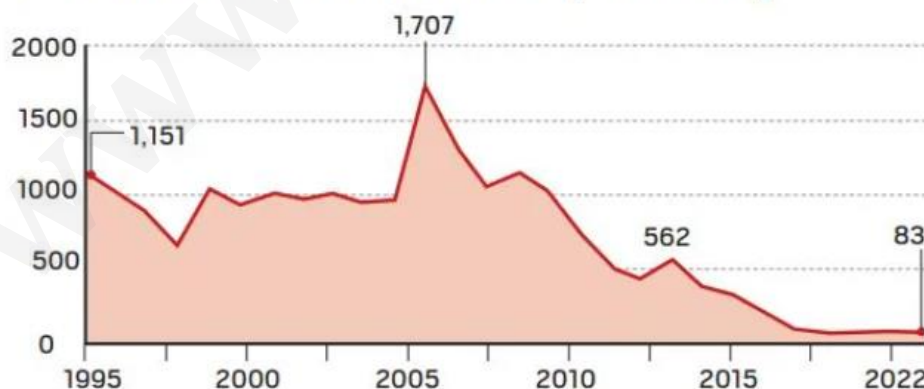
India is developing a Multi-Stage Malaria Vaccine Candidate named AdFalcivax. The vaccine aims to provide protection against human infection while also reducing vector-borne community transmission of the parasite.

- AdFalcivax is the first indigenous recombinant chimeric malaria vaccine specifically designed to target two critical stages of Plasmodium falciparum, the parasite responsible for the most lethal form of malaria. **So, Statement 1 is correct.**
- Alum in AdFalcivax can remain stable at room temperature for at least nine months. This might make it possible to “transport the vaccines without maintaining the cold chain. **So, Statement 2 is correct.**
- The vaccine prevents parasite development inside mosquitoes during the mating stage, which decreases the number of new infections mosquitoes can transmit to humans. **So, Statement 3 is correct.**
- The vaccine distribution network extends its reach to all population segments, including remote areas.

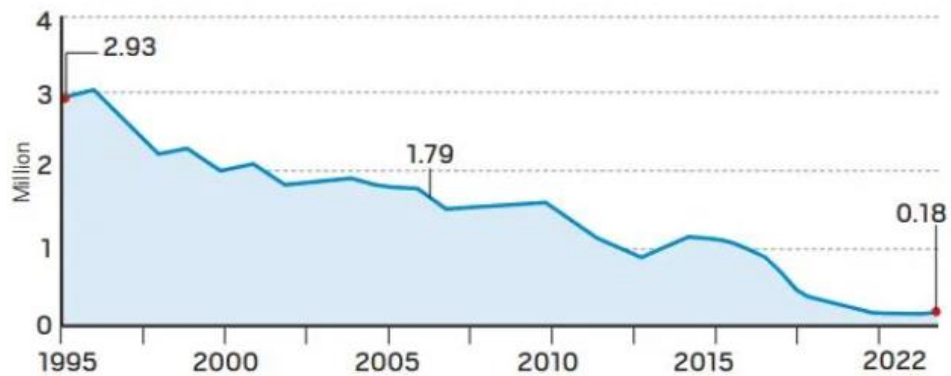
ADDITIONAL INFORMATION:

MALARIA IN INDIA	
About	➤ Malaria continues to affect India significantly, but the nation has achieved substantial success in lowering both disease occurrences and mortality rates. ➤ The World Malaria Report 2024 shows India has reduced its malaria cases from 6.4 million in 2017, to 2 million in 2023. ➤ The number of deaths from malaria decreased from 11,100 to 3,500 between 2017 and 2023. ➤ The current trajectory indicates India will reach its goal of eliminating native malaria cases by 2027, while working toward complete malaria elimination by 2030. ➤ The year 2023 brought a significant triumph when 122 districts throughout the country reported no malaria cases. ➤ The National Framework for Malaria Elimination (2016-2030) and National Strategic Plan for Malaria (2023-2027), serve as guidelines for these initiatives through their focus on early diagnosis, treatment, vector control and vaccination programs.

REPORTED MALARIA DEATHS IN INDIA (1995-2022)



REPORTED MALARIA CASES IN INDIA (1995-2022)



55. Consider the following statements about Free-Space Quantum Communication:

1. It sends quantum signals through the air using laser light, without optical fibre.
2. It allows Quantum Key Distribution that can catch any attempt at eavesdropping.
3. It has been successfully demonstrated over a distance of more than one kilometre.

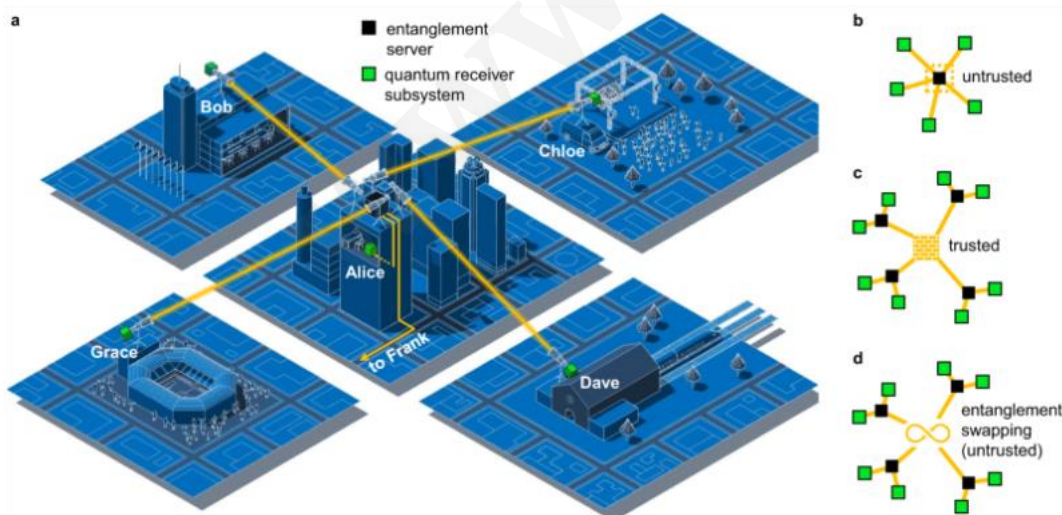
Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3**

EXPLANATION:

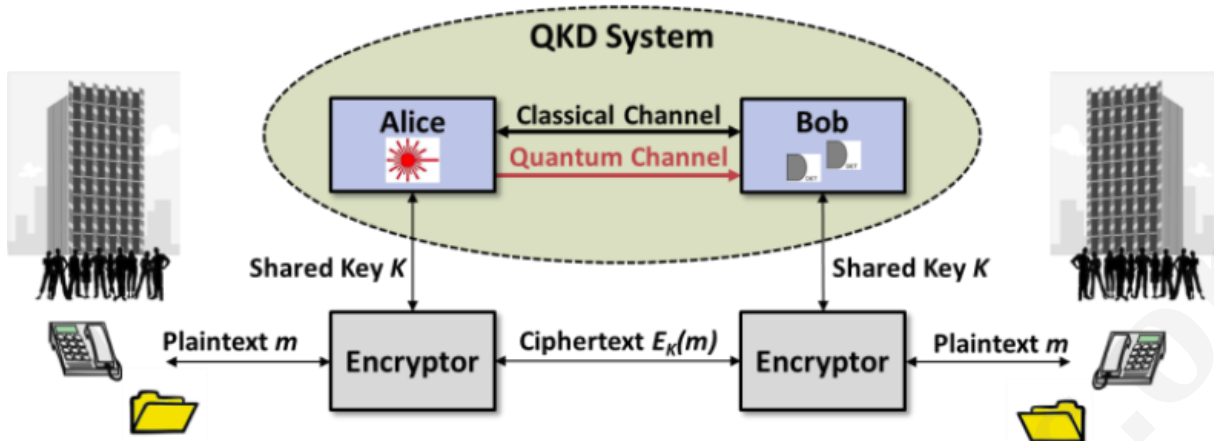
Quantum communication provides fundamentally unbreakable encryption, making it a dual-use technology with applications in securing data in strategic sectors such as defence, finance, and telecommunications, as well as in protecting national security-related communications.

- Free-space quantum communication uses lasers to send quantum signals through the air, typically with entangled photons. This technology supports the Quantum Key Distribution (QKD) technology.
- Free-space QKD eliminates the need to lay optical fibers, which can be both disruptive and expensive, especially in challenging terrains and dense urban environments. **So, Statement 1 is correct.**



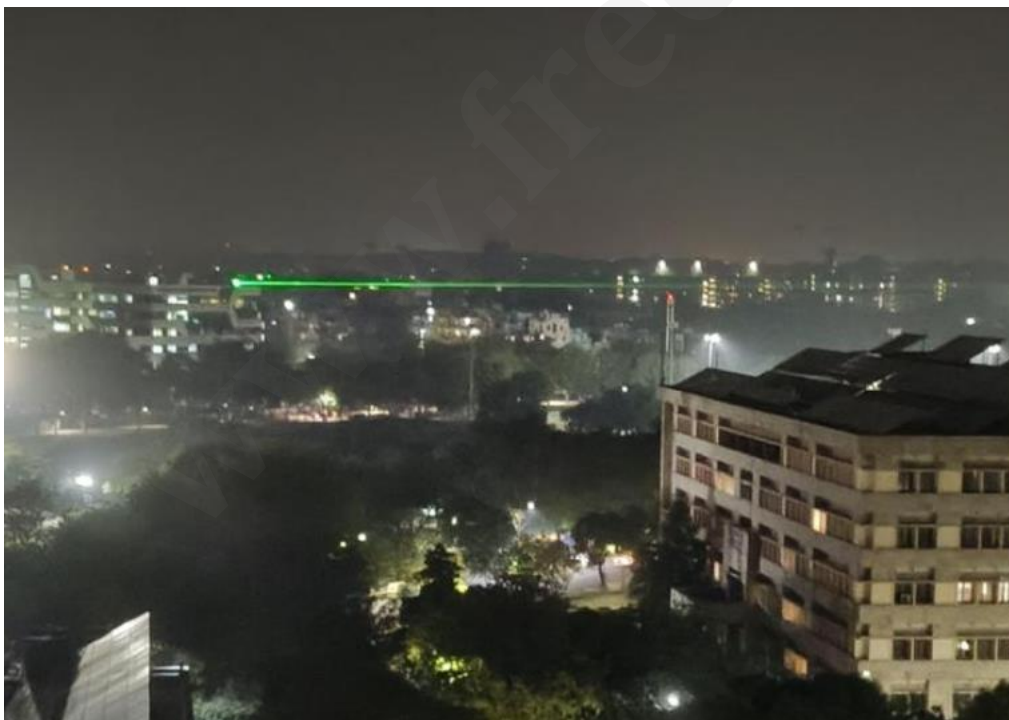
The Quantum Key Distribution (QKD) underpins Quantum Communication technology that ensures unconditional data security by virtue of the principles of quantum mechanics, which is not possible with the conventional encryption systems.

- Even if devices are compromised or imperfect, the use of quantum entanglement ensures the security of key distribution. Any attempt to measure or intercept the entangled photons disturbs the quantum state, allowing authorised users to detect the presence of an eavesdropper (is the act of intercepting and secretly monitoring communications). **So, Statement 2 is correct.**



Recently, DRDO-Industry-Academia Centre of Excellence (DIA-CoE), IIT Delhi successfully demonstrating an experimental advancement that the free-space quantum secure communication using quantum entanglement over a distance of more than one km was achieved via a free-space optical link established on the IIT Delhi campus.

The experiment attained a secure key rate of nearly 240 bits per second with a quantum bit error rate of less than 7 per cent. **So, Statement 3 is correct.**



56. Consider the following space missions:

1. Axiom -4
2. SpaDeX
3. Gaganyaan

How many of the above missions use docking technology to connect with the International Space Station?

- (a) Only one
 (b) Only two
 (c) All three
 (d) None

EXPLANATION:

The International Space Station Program brings together international flight crews, multiple launch vehicles, globally distributed launch and flight operations, training, engineering, and development facilities, communications networks, and the international scientific research community.

Space docking refers to the process of connecting two spacecraft in orbit.

- The Ax-4 mission “realized the return” to human spaceflight for India, Poland, and Hungary. While Ax-4 marks these countries' second human spaceflight mission in history, it became the first time all three nations executed a mission on board the International Space Station.
 - The Ax-4 crew will arrive and dock to the International Space Station begins their 14-day mission on the orbiting laboratory conducting microgravity research, technology demonstrations, and outreach engagements.
 - This historic mission underscores how Axiom Space is redefining the pathway to low-Earth orbit and elevating national space programs globally. **So, Statement 1 is correct.**



SpaDeX mission is a cost-effective technology demonstrator mission for the demonstration of in-space docking using two small spacecraft launched by PSLV. This technology is essential for India's space ambitions such as Indian on Moon, sample return from the Moon, the building and operation of Bharatiya Antariksh Station (BAS), etc.

- The primary objective of the SpaDeX mission is to develop and demonstrate the technology needed for rendezvous, docking, and undocking of two small spacecraft (SDX01, which is the Chaser, and SDX02, the Target, nominally) in a low-Earth circular orbit.

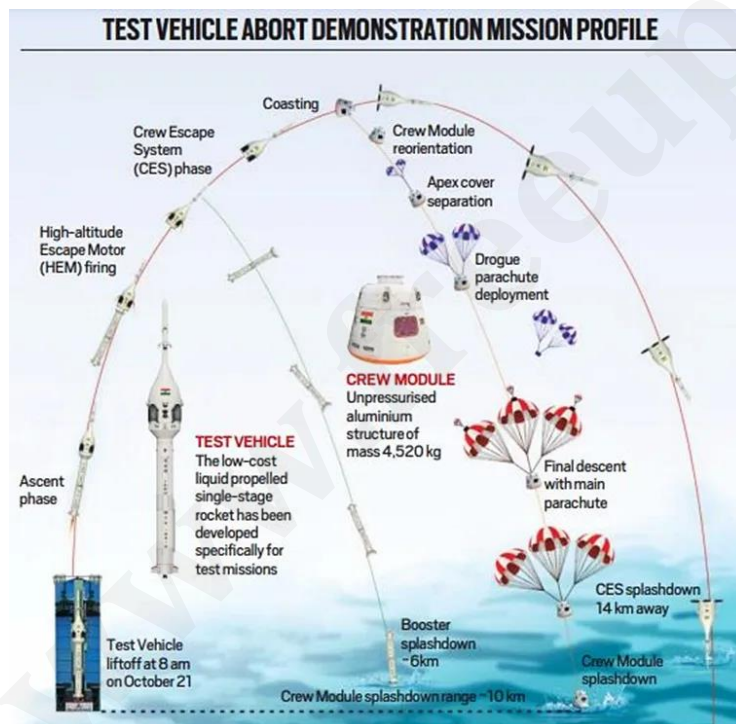
Here, SpaDeX missions do not connect with the International Space Station (ISS). **So, Statement 2 is not correct.**



Gaganyaan mission of India envisages demonstration of human spaceflight capability by launching crew of 3 members to an orbit of 400 km for a 3-day mission and bring them back safely to earth, by landing in Indian sea waters.

- It constitutes important components for future sustained human space flight activities like rendezvous and docking, space station building and interplanetary collaborative manned missions to Moon/Mars and near-earth asteroids.

Although Gaganyaan employs docking technology, it is not currently intended to dock with the International Space Station (ISS). **So, Statement 3 is not correct.**



57. Which one of the following is **not** the objective of the SpaDeX Mission?

- (a) Demonstration of the transfer of electric power between the docked spacecraft
- (b) Rendezvous of two small spacecraft in low-Earth orbit
- (c) Docking and undocking of the two spacecraft in low-Earth orbit
- (d) Conduct biological experiments aboard the docked spacecraft**

EXPLANATION:

SpaDeX mission is a cost-effective technology demonstrator mission for the demonstration of in-space docking using two small spacecraft launched by PSLV.

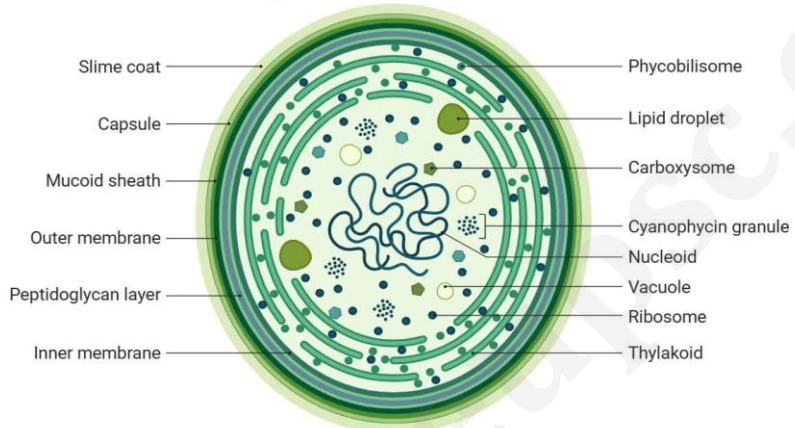
- The primary objective of the SpaDeX mission is to develop and demonstrate the technology needed for rendezvous, docking, and undocking of two small spacecraft SDX01 the Chaser and SDX02 the Target, nominally in a low-Earth circular orbit.
- Secondary objectives include:
 - Demonstration of the transfer of electric power between the docked spacecraft, which is essential for future applications such as in-space robotics,
 - Composite spacecraft control, and
 - Payload operations after undocking.

Conducting biological experiments aboard the docked spacecraft is not the objective of the SpaDeX Mission. India is set to conduct its first-ever biological experiments aboard the International Space Station (ISS) to study the sustainability of human life in space, Science and Technology. **So, Option (d) is correct.**



ADDITIONAL INFORMATION:

SPACE BIOLOGICAL EXPERIMENTS	
About	India to conduct first biological experiments aboard International Space Station (ISS) will examine the impact of microgravity and space radiation on the growth of edible microalgae, a nutrient-rich potential food source for long-duration space missions. ➤ An important initiative under the BioE3 (Biotechnology for Economy, Environment, and Employment), these unique experiments, spearheaded by the Indian Space Research Organisation (ISRO) in collaboration with the Department of Biotechnology (DBT), will be carried out as part of the upcoming International Space Station (ISS) mission AXIOM-4, with Indian astronaut Group as a crew member. ➤ This project is a joint initiative of ISRO, NASA, and DBT and aims to analyse key growth parameters and changes in transcriptomes, proteomes, and metabolomes of different algal species in space, as compared to Earth-based controls. ➤ The results will help identify the most suitable microalgal species for use in space environments.

	➤ Microalgae offer several key advantages that make them ideal candidates for sustaining life in space. They have an extremely short life cycle, with some species growing in as little as 26 hours, allowing for rapid biomass production.
Cyanobacteria	➤ The second experiment at the ISS will study the growth and proteomic responses of cyanobacteria, such as Spirulina and Synechococcus, under microgravity conditions using urea- and nitrate-based media. ➤ The need to recycle carbon and nitrogen from human waste during prolonged space travel to achieve self-sustainability in spacecraft and future extraterrestrial colonies. Cyanobacteria, due to their fast growth and efficient photosynthesis, are ideal agents for such recycling systems. ➤ the experiment aims to explore Spirulina as a "superfood" due to its high protein and vitamin content, compare the growth of cyanobacterial cells in urea versus nitrate environments, and study the effect of space conditions on their metabolic profiles. Cyanobacteria 

58. Consider the following:

1. HANSA - 3 (NG)
2. Chinook Helicopter
3. Boeing 787
4. Advanced Light Helicopter Rudra

How many of the listed above aircraft/helicopters can be used for Combat operations?

- (a) Only one
- (b) **Only two**
- (c) Only three
- (d) All four

EXPLANATION:

Hansa-3 NG is India's first home-grown civil aircraft, designed and developed by National Aerospace Laboratories (NAL), Bengaluru, a unit of the Council of Scientific and Industrial Research (CSIR).

It is a twin-seater, all-composite light trainer aircraft.

Designed as an ab-initio flying trainer for flying clubs in India.

Provides a cost-effective option for Flight Training Organisations

The original Hansa-3 was certified in 2000 to meet the need for an advanced trainer aircraft.

Recently, Hansa-3 NG has been handed over to a private firm for commercial manufacturing. Thus, HANSA - 3 (NG) is a trainer aircraft, it is not used for Combat operations. **So, Statement 1 is not correct.**



The CH-47 Chinook is the U.S. Army's heavy-lift cargo helicopter, known for its twin engines and tandem rotors. It is considered the "workhorse" of the Army's helicopter fleet.

It can carry large, underslung loads, making it valuable for combat, disaster relief, and humanitarian missions.

Capable of lifting up to 48,000 pounds at 4,000 feet and 95°F.

Its versatility makes it suitable for combat operations as well as support missions. Thus, Chinook Helicopter can be used for Combat operations. **So, Statement 2 is correct.**



The Boeing 787 Dreamliner is a family of long-range, midsize wide-body, twin-engine jet airliners that can seat 242–335 passengers in a typical three-class seating configuration.

This aircraft, the world's first major commercial airliner to use composite materials as the primary material in its airframe, is Boeing's most fuel-efficient airliner. Thus, Boeing 787 is a passenger flight which cannot be used for Combat operations. **So, Statement 3 is not correct.**



Rudra is the weaponized version of the Advanced Light Helicopter (Dhruv), designed and developed by Hindustan Aeronautics Limited (HAL) to meet the requirements of the Indian Army and Air Force.

This multi-role helicopter of the 5.8-ton class is powered by two Shakti engines.

The HAL Rudra can be deployed in a wide range of missions, including reconnaissance, troop transport, anti-tank warfare, and close air support.

Therefore, the Advanced Light Helicopter Rudra can be used for combat operations. **So, Statement 4 is correct.**



59. Consider the following reactions:

1. Respiration
2. Evaporation of water
3. Decomposition of calcium carbonate
4. Photosynthesis
5. Condensation of steam into water
6. Combustion of Fuels

How many of the reactions given above absorb heat or energy from the surroundings?

- (a) Only three
 (b) Only four
 (c) Only five
 (d) All six

EXPLANATION:

When a chemical reaction happens, energy is transferred to or from the surroundings. The chemical reactions are Endothermic reactions and Exothermic reactions.

- Endothermic reactions absorb energy from the surroundings. This energy is usually absorbed as heat, so the surroundings get colder.
 - **Evaporation of water:** Evaporation is an endothermic process that changes a liquid to a gas. Consider a puddle of water on the ground. As water in the puddle absorbs thermal energy from its environment (i.e., heat from the Sun), it begins to heat up. **(2)**
 - **Decomposition of calcium carbonate:** Calcium carbonate, calcium oxide and calcium hydroxide are all made from limestone. When limestone is heated strongly, the calcium carbonate it contains absorbs heat (endothermic) and decomposes to form calcium oxide. **(3)**
 - **Photosynthesis:** It is an endothermic reaction because plant leaves absorb light energy. **(4)**
- Exothermic reactions are chemical reactions which release energy from the chemicals into the surroundings. This energy is usually released as heat, so the surroundings get hotter and not all exothermic reactions release energy as heat.
 - **Respiration:** Respiration is a chemical process that takes place inside the cells of all living organisms. Respiration releases energy for the organism to use to stay alive. **(1)**
 - **Condensation of steam into water:** Condensation is an exothermic process that changes a gas to a liquid. When water vapor in the atmosphere makes contact with the cool surface of the glass, it loses some of its heat to the surrounding environment. As a result, the water vapor cools and condenses into a liquid. **(5)**
 - **Combustion of fuels:** Combustion is another name for burning. In a combustion reaction, fuel is burned and reacts with oxygen to release energy. **(6)**

Thus, exactly 3 of listed processes absorb heat (are endothermic) i.e., evaporation of water, decomposition of calcium carbonate and Photosynthesis and the rest are exothermic. **So, Option (a) is correct.**

ADDITIONAL INFORMATION:

ENDOTHERMIC AND EXOTHERMIC PROCESSES	
Endothermic Processes	An endothermic process takes in heat to cause a physical change in matter. Melting (fusion), evaporation, and sublimation are endothermic processes. ➤ Melting (Fusion): • Melting is an endothermic process that changes a solid to a liquid. Ice, or frozen water, is a solid. When ice absorbs heat from its environment, it begins to melt. • Over time, melting causes ice to change from a solid to a liquid. Although the physical properties of the ice change, the liquid water that results remains unchanged chemically. ➤ Sublimation: • Sublimation is an endothermic process that changes a solid into a gas. A good example of sublimation is dry ice, which is a solid form of carbon dioxide. As dry ice absorbs heat from its surrounding environment, its temperature increases. • At room temperature, dry ice readily changes from a solid to a gas and escapes into the atmosphere. Although the physical properties of the dry ice change, the carbon dioxide gas that results from sublimation is chemically the same as the dry ice.
Exothermic Processes	Exothermic processes release heat to cause physical changes in matter. Examples of exothermic processes are freezing, condensation, and deposition. ➤ Freezing: • Freezing is an exothermic process that changes a liquid to a solid. Water, at room temperature, is a liquid. In cold temperatures, water loses heat to its environment and eventually freezes. • Over time, the freezing process causes water to change from a liquid to a solid. Although the physical properties of the water change, the ice that results remains unchanged chemically. ➤ Deposition: • Deposition is an exothermic process that changes a gas into a solid. A good example of sublimation is frost that forms on a car windshield on a cold day. Frost is a type of ice, which is a solid form of water. • In subfreezing temperatures, water vapor in the atmosphere, a gas, loses heat so quickly that it freezes and turns to ice, a solid, without first condensing into liquid water. Although the physical properties of the water vapor change, the frost that results from deposition is chemically the same as the water vapor.

60. Which among the following are the benefits of placing satellites in Polar Orbit?

1. Useful for remote sensing, meteorology and environmental studies of the earth.
2. These satellites can view polar and equatorial regions at close distances with good resolution.
3. A constellation of satellites over this orbit provides telecommunication services.

Select the correct code using the options given below

- (a) 1 and 2 only**
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

EXPLANATION:

Polar orbits pass over the Earth's polar regions from north to south. The orbital track of the satellite does not have to cross the poles exactly for an orbit to be called polar, an orbit which passes within 20 to 30 degrees of the poles is still classed as a polar orbit.

Polar orbits are used for reconnaissance and Earth observation. If a satellite is in polar orbit at an altitude of 800 km, it will be travelling at a speed of approximately 7.5 km per second. These orbits mainly take place at low altitudes of between 200 to 1000 km. Satellites in polar orbit look down on the Earth's entire surface and can pass over the North and South Poles several times a day.

Satellites placed in this orbit can view polar and equatorial regions at close distances with good resolution. Information gathered from such satellites is extremely useful for remote sensing, meteorology as well as for environmental studies of the earth. **So, Statement 1 and 2 are correct.**

Telecommunications satellites are usually placed in geostationary Earth orbit (GEO). Satellites in GEO allow permanent communication links to be established by transmitting radio-frequency signals from fixed antennas. These signals are not very different from the signals that are used to broadcast terrestrial television, but usually have a frequency 3–50 times higher. The signal is received by the satellite, amplified and transmitted back to Earth, allowing communications between points thousands of kilometres apart. **So, Statement 3 is not correct.**



ADDITIONAL INFORMATION:

TYPES OF SATELLITES	
Polar Orbiting satellites	➤ Polar orbiting satellites travel in a circular orbit moving from pole to pole. These satellites collect data in a swath beneath them as the earth rotates on its axis. In this way, a polar orbiting satellite can “see” the entire planet twice in a 24 hour period. The basic operational mode deploys two polar orbiting satellites continuously, one passing north to south (descending) and the other passing south to north (ascending), circling the earth every 12 hours. ➤ Polar Orbiting Satellites are inserted into sun-synchronous orbits which place the spacecraft in a relatively constant relationship to the sun so that the ascending node will remain at a constant solar time, permitting images and data to be received by direct broadcast at the same time each day.
Geostationary Orbit (GEO) Satellites	➤ This type of satellites is perfect for always-on communication services like TV and phones.

	➤ This satellite can be used in meteorology to keep an eye on the weather in particular regions and track the development of local patterns. ➤ The downside of GEO type of spacecraft for real-time communication is the longer signal delay caused by their great distance from Earth.
Sun-Synchronous Orbit (SSO) Satellites	➤ The Sun-synchronous orbit type of satellites goes from north to south across the polar regions at an altitude of 600 to 800 km above the Earth. The orbital inclination and altitude of SSO spacecraft are calibrated so that they always cross any given location at precisely the same local solar time. Thus, the lighting conditions are consistent for imaging, making this type of satellite ideal for earth observation and environmental monitoring.

61. Consider the following missile types:

1. Intercontinental Ballistic Missile (ICBM)
2. Hypersonic Glide Missile (HGV)
3. Fractional Orbital Bombardment System (FOBS)

Which of the missile types uses low Earth orbit in its journey?

- (a) 1 only
- (b) 3 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

EXPLANATION:

A low Earth orbit (LEO) is, as the name suggests, an orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth, which is low compared to other orbits, but still very far above Earth's surface.

An intercontinental ballistic missile (ICBM) is a Land-based, nuclear-armed ballistic missile with a range of more than 3,500 miles (5,600 km).

An ICBM is a suborbital device. It doesn't go into orbit. It is defined as a missile which is capable of striking a target on the surface of the Earth across intercontinental distances. **So, Statement 1 is not correct.**

Most ICBMs don't enter Earth's orbit. Instead, they travel in high, arc-like paths, similar to the way a football flies when chucked far downfield by a quarterback.

A Hypersonic Glide Vehicle (HGV) is a sophisticated system typically mounted on a booster, such as a ballistic missile, which propels it to the edge of Earth's atmosphere.

- Once detached, the HGV glides toward its target at hypersonic speeds (Mach 5 or higher).
- The key advantage of an HGV lies in its manoeuvrability during flight, enabled by the lift generated as it transitions from the thin air of the upper atmosphere to the denser air closer to the target. This combination of hypersonic speed and manoeuvrability allows the vehicle to evade missile defence systems and strike targets with precision, even beyond its original trajectory.
- In August 2021, China launched a Long March rocket carrying a hypersonic glide vehicle (HGV) into low Earth orbit (160 to 2,000 km). China tested two hypersonic weapons where 'a payload was sent into low-Earth orbit, which travelled partially around the globe and released a HGV that travelled through the atmosphere to a target site in Chinese territory'.

Thus, the Hypersonic Glide Vehicle (HGV) uses low Earth orbit. **So, Statement 2 is correct.**

A Fractional Orbital Bombardment System (FOBS) weapon system, unlike a ballistic trajectory, enters an orbit around the planet, de-orbits through a retrograde engine burn and re-enters the atmosphere just before reaching its target, only then entering a ballistic trajectory.

This warhead delivery system uses a low Earth orbit towards its target destination and de-orbits before completing a full orbit. **So, Statement 3 is correct.**

62. Which one of the following missile systems works on a Scramjet propulsion system?

- (a) Agni-V
- (b) Agni Prime
- (c) BrahMos**
- (d) Akash

EXPLANATION:

India is set to fast-track the development of its next-generation hypersonic cruise missile, BrahMos-II, following the success of BrahMos strikes on Pakistan's terror and military infrastructure during Operation Sindoor.

BrahMos-II, being developed as a joint venture between India and Russia under BrahMos Aerospace, is designed to reach speeds of Mach 6 to Mach 8 — six to eight times the speed of sound — with a strike range of up to 1,500 kilometres.

The missile will be powered by a scramjet engine, an upgrade over the current BrahMos missile's ramjet propulsion system. The design of BrahMos-II is reportedly inspired by Russia's 3M22 Zircon, a scramjet-powered missile already inducted into the Russian Navy and capable of reaching speeds of Mach 9. **So, Option (c) is correct.**

ADDITIONAL INFORMATION:

MISSILE	
Agni-V	Recently, India successfully tested another of its Agni-5, an intermediate-range ballistic missile capable of carrying a nuclear warhead into China. ➤ The surface-to-surface Agni-V uses a three-stage solid-fuelled engine and can strike targets up to 5,000 kilometres away with a high degree of accuracy. ➤ Designed and developed by the Defence Research and Development Organisation (DRDO), Agni-V is a canister-launched system transported by truck. With its range, it is viewed as a deterrent against China. ➤ Broadly classified as an intercontinental ballistic missile, it can carry a payload of 1.5 tonnes and weighs about 50 tonnes. India is the eighth country with ICBM capability after the United States, United Kingdom, Russia, China, France, Israel and North Korea. ➤ The Agni series ranges from Agni-I to Agni-V, with the latter the most advanced and first tested in 2012. Other missiles in the series include Agni-I (700 km range), Agni-II (2,000 km), and Agni-III and IV (2,500–3,500 km).
Agni Prime	Recently, the Defence Research and Development Organisation (DRDO), in collaboration with the Strategic Forces Command (SFC), has successfully test-fired the Agni-P missile from a rail-based mobile launcher for the first time. ➤ It is a nuclear-capable new-gen advanced variant of the Agni class of missiles. ➤ Developed under the Integrated Guided Missile Development Program (IGMDP). ➤ Type – Medium range, surface-to-surface ballistic Missile. ➤ Designed by the Defence Research and Development Organisation (DRDO). ➤ Propulsion - Two-stage, canisterised, solid propellant. ➤ Operational range – Between 1,000 km to 2,000 km. ➤ Warhead – Manoeuvrable Multiple independently targetable re-entry vehicle (MIRV) (high explosive, thermobaric and nuclear) ➤ Warhead weight - 1,500 kg – 3,000 kg

	➤ Guidance system - Advanced ring laser gyro-based inertial navigation system (INS) (more accurate) + GPS and NavIC satellite navigation systems. ➤ Road-mobile version of Agni-P – It has already been inducted into the armed forces after a series of successful trials.
Akash	Akash is a Surface-to-Air Missile System currently in service with the Indian Army and IAF. ➤ It was jointly developed by DRDO and other PSUs. It is a medium-range missile capable of intercepting aerial targets up to 30 Kms. ➤ The Missile can be launched from both tracked and wheeled platforms. After the initial success of the Akash missile, DRDO is developing the Akash NG Missile. ➤ Akash is a two-stage SAM Missile. The Initial Propulsion of the Akash Missile is a Solid Rocket Motor Booster. After the initial motor burnout, the ramjet-rocket propulsion system provides sustained thrust for the Missile throughout its flight until interception. The use of a ramjet propulsion system enables sustained speeds without deceleration throughout its flight. ➤ Akash flies at supersonic speed, reaching around Mach 2.5.

63. Consider the following statements regarding Naegleria fowleri:

1. It is a single-cell organism known as a brain-eating amoeba.
2. The amoeba enters the body through the roof of the nasal cavity, leading to a severe, fatal brain infection.
3. The organism can survive in saline conditions and is not found in freshwater bodies.

How many of the statements given above is/are correct?

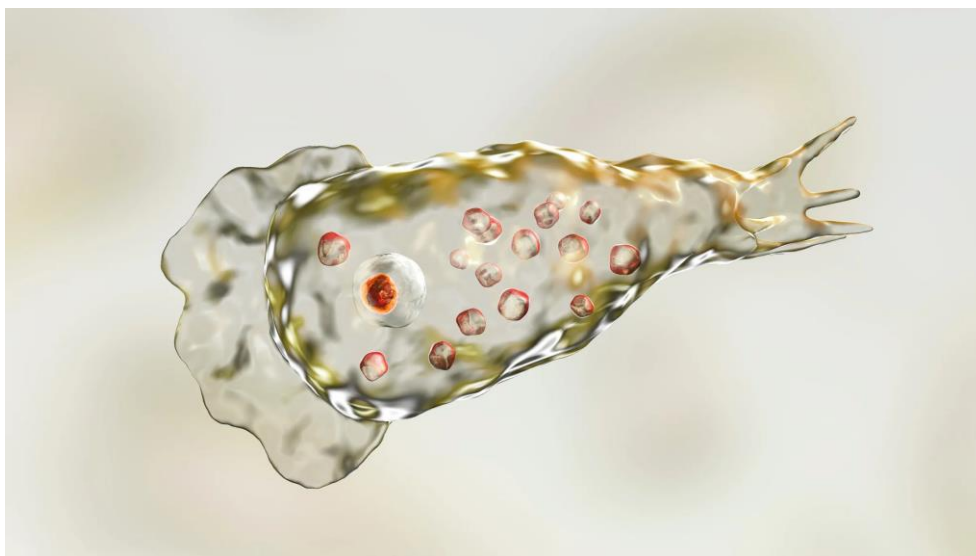
- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Primary amoebic meningoencephalitis or PAM is caused by Naegleria fowleri, an amoeba that thrives in warm freshwater lakes, ponds and rivers. It can also survive in poorly maintained swimming pools in rare cases. It is a one-celled organism, also called a 'brain-eating amoeba', as it can infect the brain and destroy the tissues there. **So, Statement 1 is correct.**

- Naegleria fowleri infections can happen after water containing the amoeba gets into the nose. It can then travel up the nasal cavity to the brain. There, it can cause an infection, primary amoebic meningoencephalitis (PAM). A PAM infection is almost always deadly because it kills brain tissue quickly. **So, Statement 2 is correct.**
- The infection does not spread from person to person. Swallowing water containing the amoeba does not lead to it either.
- Naegleria fowleri thrives in heat and grows best at temperatures up to 115 degrees. It is found in warm freshwater environments such as lakes and rivers, naturally hot water such as hot springs, warm-water discharge from industrial or power plants, geothermal well water, poorly maintained or minimally chlorinated swimming pools, water heaters, and soil, where it lives by feeding on

bacteria and other microbes in the environment. This type of amoeba doesn't survive in saline conditions and hence is not found in salt water. **So, Statement 3 is not correct.**



ADDITIONAL INFORMATION:

NAEGLERIA FOWLERI	
Recently in the News	A rare and deadly brain-eating amoeba infection has been reported in Kerala over the past two months.
About	➤ Naegleria fowleri is a free-living, eukaryotic amoeba belonging to the genus Naegleria and is commonly known as the "brain-eating amoeba." ➤ It is a facultative parasite, meaning it does not require a host to complete its life cycle and reproduces by mitosis. ➤ After entering the nose, the amoeba migrates along the olfactory nerves, crosses the cribriform plate, and invades the Central Nervous System (CNS), resulting in PAM. The infection is characterised by cerebral edema, hemorrhagic necrosis, brain herniation, and, in most cases, death. ➤ The life cycle of N fowleri consists of 3 stages: trophozoites, flagellates, and cysts. • The trophozoite stage is the reproductive and invasive form responsible for human infection. As a thermophilic organism, it is most active during the warm summer when human exposure is more likely. Trophozoites are long and slender, approximately 22 µm long, equipped with pseudopodia for movement and bacterial ingestion, and capable of forming large colonies. • Under poor nutritional conditions, trophozoites transition into flagellates by developing flagella. • If unfavourable conditions persist, they further transform into metabolically inactive cysts, measuring 7 to 12 µm. These cysts are highly resistant, capable of withstanding low temperatures, and can survive during winter. Trophozoites feed on bacteria and fungi in warm waters and can encyst and settle into sediments when water temperatures drop during winter.
Symptoms	➤ Early symptoms of Primary amoebic meningoencephalitis PAM can include headache, fever, nausea, and vomiting. PAM progresses rapidly. ➤ Most people with PAM die within 1 to 18 days after symptoms begin. It usually leads to coma and death after 5 days. ➤ As PAM progresses, symptoms can include stiff neck, confusion, lack of attention to people and surroundings, loss of balance, and hallucinations.

Treatment	➤ Experts are still trying to find the best medicines to treat PAM. It's hard to know what works well because PAM is so rare, and it develops so fast. ➤ Right now, PAM is treated with a combination of medications including: Amphotericin B (Anti-fungal), Azithromycin, Fluconazole, Rifampin, Miltefosine, and Dexamethasone.
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64. Recently, which country launched the Global Observing Satellite for Greenhouse gases and the Water cycle (GOSAT-GW)?

- (a) Russia
- (b) India
- (c) China
- (d) Japan**

EXPLANATION:

Recently, the Japan Aerospace Exploration Agency (JAXA) launched the Global Observing Satellite for Greenhouse gases and the Water cycle (GOSAT-GW) satellite to monitor greenhouse gases like carbon dioxide and methane.

It helps the Global Greenhouse Gas Watch (G3W) initiative by providing accurate global data.

- The satellite orbits the Earth at 666 km in a sun-synchronous path, covering the whole globe every three days.
- GOSAT-GW is equipped with a grating imaging spectrometer, known as the Total Anthropogenic and Natural emissions mapping Spectrometer (TANSO-3), which offers higher spatial resolution compared to GOSAT-1 and GOSAT-2.
- It features a selectable swath width:
 - A wide mode covering 911 km, with a 10 km footprint, enabling global coverage every three days.
 - A focus mode covering 90 km, with a footprint of 1–3 km, suitable for analysing localised emission sources.
- This is the third GOSAT satellite, offering better resolution and supporting research on climate change and greenhouse gas emissions. **So, Option (d) is correct.**

ADDITIONAL INFORMATION:

SIMILAR SPACE PROJECTS	
GOSAT-1 & GOSAT-2 (Japan)	➤ GOSAT and GOSAT-2 are the only satellites in the world that can measure both the solar reflection from the Earth's surface and the thermal radiation from the atmosphere using their high-resolution spectrometers. ➤ This allows them to observe carbon dioxide (CO₂) and methane (CH₄) in both the lower and upper atmosphere. ➤ These measurements provide detailed information on regional differences, seasonal changes, and yearly increases of these major greenhouse gases, helping to monitor local emissions and improve our understanding of the global carbon cycle.
MicroCarb (France/ESA)	➤ Launched in 2024 to measure atmospheric CO₂ concentrations and identify global carbon sources and sinks. ➤ Serves as a precursor to the EU's CO₂M mission for enhanced greenhouse gas monitoring.

GHGSat-C12 & C13 (Canada)	➤ Launched in 2025 to monitor methane emissions from industrial facilities worldwide. ➤ Offers daily high-resolution observations to track localised emissions and support climate mitigation.
Tanager-1 (USA)	➤ Launched in 2024 to detect and quantify CO₂ and methane emissions from individual sites. ➤ Uses advanced imaging spectrometer technology developed by NASA's Jet Propulsion Laboratory.
Sentinel-4A (Europe)	➤ Launched in 2025 by the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EOEMS) to monitor air quality and atmospheric composition from geostationary orbit. ➤ Provides high temporal resolution observations, allowing near-real-time tracking of pollutants and greenhouse gases.

65. Consider the following statements about Amoeba:

1. No Amoeba remains in a fixed shape.
2. No Amoeba can survive in a dry environment.
3. No Amoeba is multicelled.

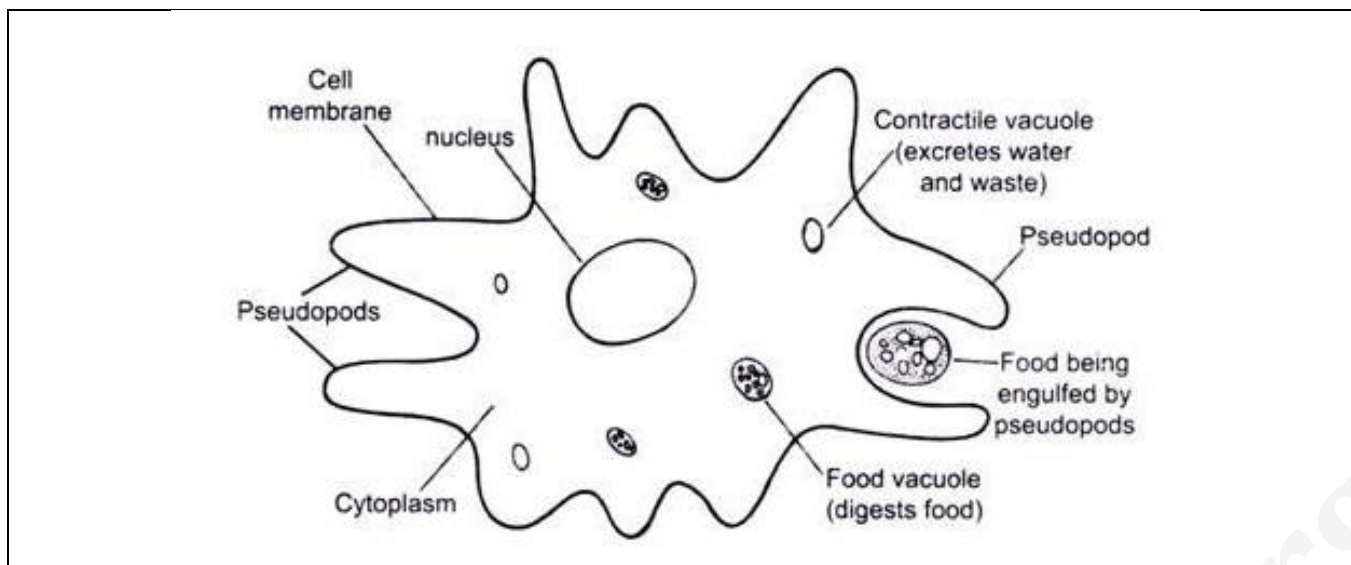
How many of the statements given above is/are correct?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Amoebas belong to the Kingdom of the protists (a protist is any eukaryotic organism that is not an animal, plant, or fungus).

- Under the microscope, it appears as irregular, jelly-like tiny mass of hyaline protoplasm. Amoeba has no fixed shape, and the outline of body continues changing due to formation of small finger like outgrowths called pseudopodia. **So, Statement 1 is correct.**
- Amoeba is commonly found in the mud, in freshwater ponds and ditches containing decaying leaves. Amoeba has no nerves; it reacts to its surroundings. With its whole body it responds by moving toward or away from stimuli. It retreats from strong light, or from water that is too hot or too cold.
- An amoeba may survive extremely unfavorable circumstances such as a dry spell by rolling into a ball, losing most of its water, and secreting a protective coat called a cyst membrane. Once the surroundings are again suitable, the coat opens and the amoeba comes out. **So, Statement 2 is not correct.**
- Amoeba is a single-celled organism, meaning one Amoeba consists of only one giant cell. **So, Statement 3 is correct.**
- Amoeba belongs to eukaryotic cells, which means that their genetic material (or DNA) is well organized and enclosed within a membrane by forming a "nucleus". In this aspect, Amoeba is closer to our human beings (also eukaryotes) than bacteria (prokaryotes).
- Sexual reproduction is uncommon in Amoeba. Asexual reproduction is by binary fission.



66. Which of the following statements about catenation is/are correct?

1. Catenation is the ability of an element to form chains or networks through bonding with itself.
2. Carbon exhibits the maximum degree of catenation among all elements.
3. Silicon, despite being in the same group as carbon, shows significantly less catenation due to its larger atomic size and weaker Si-Si bonds

Select the correct answer using the codes given below:

- (a) 1 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

EXPLANATION:

Catenation, chemical linkage into chains of atoms of the same element, occurs only among the atoms of an element that has a valence of at least two and that forms relatively strong bonds with itself.

- The property is predominant among carbon atoms, significant among sulfur and silicon atoms, and slightly present among germanium, nitrogen, selenium, and tellurium atoms.
- Carbon atoms have the tendency to link with one another through covalent bonds to form chains and rings. This property is called catenation. This is because C—C bonds are very strong. **So, Statement 1 is correct.**

Carbon has the unique ability to form bonds with other atoms of carbon, giving rise to large molecules. This property is called catenation. These compounds may have long chains of carbon, branched chains of carbon or even carbon atoms arranged in rings.

- No other element exhibits the property of catenation to the extent seen in carbon compounds.
- The bonds that carbon forms with most other elements are very strong, making these compounds exceptionally stable. One reason for the formation of strong bonds by carbon is its small size. This enables the nucleus to hold on to the shared pairs of electrons strongly. The bonds formed by elements with bigger atoms are much weaker. Thus, due to its small size and strong C-C bond, carbon exhibits the maximum degree of catenation among all elements. **So, Statement 2 is correct.**

Although silicon and carbon both belong to Group 14, their ability to form chains of atoms—catenation—differs greatly. This difference arises mainly from two factors:

- **Atomic size:** Silicon atoms are larger than carbon atoms. Larger atoms have their valence electrons farther from the nucleus, which reduces the effectiveness of orbital overlap when forming bonds.

- **Bond strength:** The Si-Si bond is significantly weaker than the C-C bond. Weaker bonds are more easily broken, making long silicon chains unstable and highly reactive. As a result, silicon can only form short chains of 7–8 atoms in compounds like silanes, whereas carbon can form long, stable chains and rings, giving rise to thousands of organic compounds. **So, Statement 3 is correct.**

67. Consider the following statements regarding the CEREBO device:

1. It is a portable and non-invasive brain injury diagnostic tool.
2. It is safe for infants and pregnant women.
3. It was developed using advanced near-infrared spectroscopy technology.

How many of the statements given above is/are correct?

- (a) Only one
- (b) Only two
- (c) All three**
- (d) None

EXPLANATION:

CEREBO is a portable non-invasive brain injury diagnostic tool, developed through a collaboration between the Indian Council of Medical Research (ICMR), the Medical Device & Diagnostics Mission Secretariat (MDMS), AIIMS Bhopal, NIMHANS Bengaluru, and Bioscan Research. **So, Statement 1 is correct.**

- The device is to be used for Traumatic Brain Injuries (TBIs) and can detect intracranial bleeding and edema within a minute.
- It is safe for infants and pregnant women, and can be used by paramedic staff as well as unskilled personnel. **So, Statement 2 is correct.**

TBI is a condition caused by a sudden trauma or injury to the head, which disrupts normal brain function. This injury can range from mild (concussion) to severe, often resulting in long-term physical, cognitive, emotional, and behavioural impairments.

TBIs are a significant public health challenge, particularly in emergency settings, rural areas, and underserved populations. Traditional diagnostic methods, such as the Glasgow Coma Scale (GCS), are prone to errors and subjective interpretations, while imaging techniques require specialised infrastructure, trained personnel, and are cost-intensive. It is to address this issue that CEREBO has been developed using advanced near-infrared spectroscopy technology powered by machine learning.

So, Statement 3 is correct.

68. With reference to a solenoid, consider the following statements:

1. It can be used to make electromagnets.
2. The magnetic field inside a solenoid is highest at its midpoint.

Which of the statements given above is/are correct?

- (a) 1 only**
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

EXPLANATION:

Electromagnets are magnets that use electric current to generate magnetic fields. A solenoid is a type of electromagnet that consists of a coil of wire wrapped around a ferromagnetic or ferrimagnetic core.

- When the ends of the copper wires are attached to the ends of a battery (+ and –), current starts flowing through the coil, which starts functioning as a bar magnet. When the flow of current is stopped from the battery, then its magnetic property ceases

- . If the +ve and -ve terminals of the battery are reversed, then the poles of the magnet are also reversed. To increase the magnetic field, put soft iron, such as iron nails, inside the core.

So, the current-carrying solenoid with a soft iron core inside it forms an electromagnet. An electromagnet may be made as strong as one may desire. Electromagnets are widely used as components in electrical devices such as motors, generators, electrical bells, MRI machines, etc. **So, Statement 1 is correct.**

The pattern of the magnetic field lines around a current-carrying solenoid. Compare the pattern of the field with the magnetic field around a bar magnet. In fact, one end of the solenoid behaves as a magnetic north pole, while the other behaves as the south pole. The field lines inside the solenoid are in the form of parallel straight lines.

This indicates that the magnetic field is the same at all points inside the solenoid. That is, the field is uniform inside the solenoid, not concentrated at any single point. A strong magnetic field produced inside a solenoid can be used to magnetise a piece of magnetic material, like soft iron, when placed inside the coil. **So, Statement 2 is not correct.**

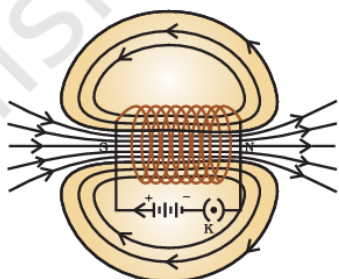


Figure 12.10
Field lines of the magnetic field through and around a current carrying solenoid.

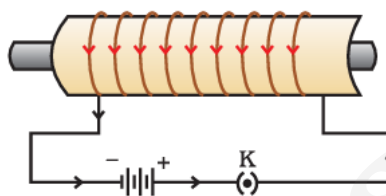
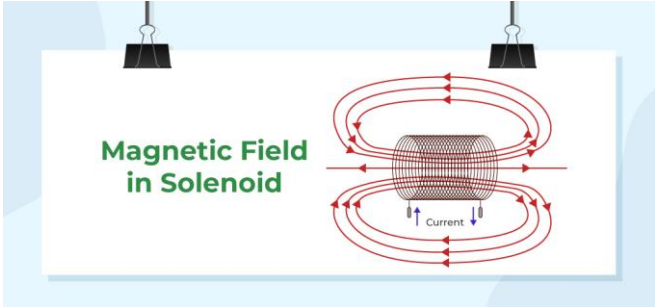


Figure 12.11
A current-carrying solenoid coil is used to magnetise steel rod inside it – an electromagnet.

ADDITIONAL INFORMATION:

SOLENOID	
about	A solenoid is an electromagnetic device made out of a coil of wire wound around a cylindrical or elongated core, usually comprised of ferromagnetic material like iron or steel. When an electric current flows through a wire coil, it generates a magnetic field surrounding it, which can exert force on objects in the field or cause mechanical motion.
Working	When an electric current is passed through a circular wire, a magnetic field is generated around it. ➤ We know that a magnetic field is directional; in simpler terms, if we place another circular wire with an electric current passing in the opposite direction to that of the first wire, the magnetic fields of both wires will cancel each other out. ➤ However, if the wires have currents passing in the same direction, the magnetic fields around both wires will add up. ➤ Now, a solenoid is like a collection of multiple circular wires, all of which have current passing in the same direction. Its helix-like structure allows for the summing up of all the magnetic fields. As a result, a strong magnetic flux is generated when an electric current is passed through this wire

Magnetic Field	The magnetic field inside the solenoid is parallel to the axis of the core. Beyond the solenoid, the magnetic field is very weak. The purpose of a solenoid is to generate a magnetic field, so studying it is very important to understand how magnetic fields are distributed around a current-carrying solenoid.  Magnetic Field in Solenoid Inside the current-carrying solenoid, the magnetic field is parallel to the axis of the solenoid. That is another way of saying that the magnetic field is the same at all the points inside a current-carrying solenoid, that is, uniform inside a solenoid. Beyond the solenoid, at a very large distance, the magnetic field is nearly zero.
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69. Consider the following information:

S. no	Type of thermometer	Use
1.	Maximum – minimum thermometer	In meteorology, to find the diurnal range of temperature
2.	Laboratory thermometer	To find temperatures in science experiments
3.	Thermocouple thermometer	In processes that require measuring temperatures as low as -200°C

How many of the above statements is/are correctly matched?

- (a) Only one
 (b) Only two
(c) All three
 (d) None

EXPLANATION:

The Maximum Minimum Thermometer or Six's thermometer, invented in 1780 by British scientist James Six. It has found widespread use across various fields due to its ability to record temperature extremes reliably without continuous monitoring.

One of its primary applications is in meteorology, where it is used to record the daily maximum and minimum air temperatures at weather stations. This data is crucial for understanding weather patterns, climate monitoring, and forecasting. **So, Pair 1 is correct.**

A laboratory thermometer measures the boiling and freezing points in science experiments. It is also used to determine the temperature of various substances. Its temperature range extends from -10 degrees Celsius to 110 degrees Celsius.

- They are used to measure melting, boiling, and freezing points.
- To check the temperature of solvents and chemicals during sample preparation.
- Determine the temperature inside the furnaces used in the laboratory.
- Regulating the temperature of transition from solid to gas, gas to liquid, solid to liquid, liquid to solid, and liquid to gas.
- For scaling the physical features of a material based on its temperature. **So, Pair 2 is correct.**

Thermocouples are the most commonly used temperature sensors in the world because they can measure a wide range of temperatures, are durable, and are relatively inexpensive. Thermocouples can come in multiple different calibrations or combinations of metals. The following are the applications of thermocouples.

Food and Industrial Applications:

Thermocouples are used in many areas of the food and drink industry to measure temperature. Common uses include:

- Clean-in-place systems – Monitor cleaning process temperatures
- Penetration probes – Measure internal food temperatures
- Oven control – Keep oven temperatures consistent
- Food chain monitoring – Track food temps during processing
- Hotplate control – Regulate surface temperatures
- Steam kettles – Control cooking temperatures
- Extruders – Measure high pressure and high temperature in plastics

Measuring Low Temperatures:

Thermocouple types E, K, T, and N can measure very low temperatures (down to -200°C), but:

- The metals used need to be specially chosen for accurate readings
- Some sensors are only calibrated for 0°C and above, so accuracy may vary below that
- Individual calibrations can help adjust for these differences. **So, Pair 3 is correct.**

Molten Metal Applications:

Measuring molten metal is tough due to extreme heat and conditions. Thermocouple options include:

- Type K or N – Base metal types with thick wires and ceramic protection
- Type R, S, B – Platinum types, better for very high temperatures

70. Consider the following:

1. Ultrasound sonography
2. Monitor tornadoes
3. Communication between satellites and ground stations
4. Tsunami detection

How many of the above is/are applications of the Doppler effect?

- (a) Only one
- (b) Only two
- (c) Only three
- (d) All four**

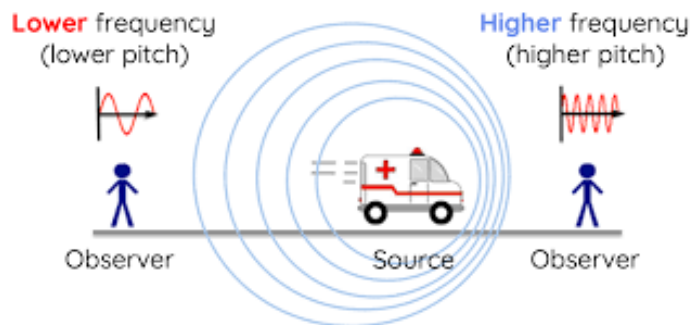
EXPLANATION:

The Doppler effect is a phenomenon that occurs when a source of sound or light is moving relative to an observer. It causes the frequency of the sound or light to change, depending on whether the source is moving towards or away from the observer.

When the source is moving towards the observer, the waves are compressed, resulting in a higher frequency. Conversely, when the source is moving away from the observer, the waves are stretched out, resulting in a lower frequency.

The amount of change in frequency depends on the speed of the source and the distance between the source and the observer. The faster the source is moving, the greater the change in frequency. Additionally, the closer the source is to the observer, the greater the change in frequency.

The Doppler effect is commonly observed in everyday life. For example, the siren of an approaching ambulance sounds higher in pitch than when it is receding. Similarly, the light from a moving star can be shifted towards the blue end of the spectrum if the star is moving towards us, or towards the red end of the spectrum if the star is moving away from us.



Applications of the Doppler effect:

- **Ultrasound Sonography** - Doppler sonography play important role in medicine. Sonography can be enhanced with Doppler measurements, which employ the Doppler effect to assess whether structures (usually blood) are moving towards or away from the probe, and its relative velocity. This is particularly useful in cardiovascular studies (sonography of the vasculature system and heart) and essential in many areas such as determining reverse blood flow in the liver vasculature in portal hypertension. **So, Statement 1 is correct.**
- **Monitor tornadoes** - By monitoring the Doppler shift in radar signals, forecasters can predict severe weather events such as tornadoes and hurricanes. Doppler radar data helps authorities issue timely warnings and alerts to communities in the path of severe weather. **So, Statement 2 is correct.**
- **Communication between satellite and ground station** - Doppler navigation systems use the Doppler effect to determine the velocity and position of aircraft relative to the ground. Doppler compensation techniques are used in satellite communication to account for frequency shifts caused by the relative motion between satellites and ground stations. **So, Statement 3 is correct.**
- **Tsunami detection** - Doppler radar systems can also measure the frequency shift of ocean waves, providing data on wave height and direction. Doppler sensors are deployed in tsunami detection buoys to monitor sea surface movements and detect potential tsunamis. **So, Statement 4 is correct.**

71. With reference to periscopes, consider the following statements:

1. They use plain mirrors.
2. They are used by soldiers in bunkers.
3. They can be used during the maintenance of nuclear reactors.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

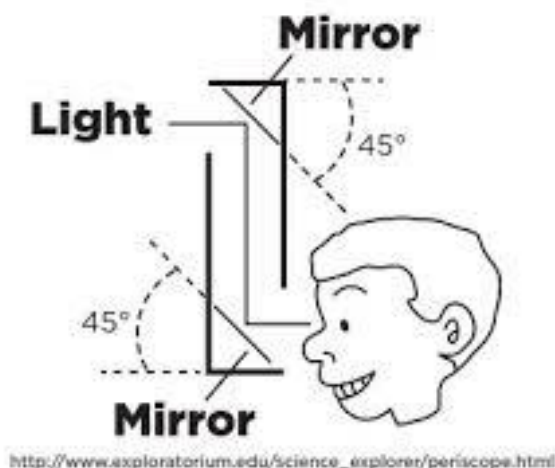
EXPLANATION:

A periscope is an optical device that allows observation from a concealed or protected position. It consists of a tube with mirrors at each end, arranged so that light can travel through the tube and be reflected up to the observer's eye.

Periscopes work on the principle of reflection. Light from the object being observed enters the periscope and strikes the first mirror, which is angled at 45 degrees. The light is then reflected up the tube to the second mirror, which is also angled at 45 degrees. The light is then reflected back down the tube and out to the observer's eye.

- The periscope makes use of two plain mirrors. It includes two mirrors or reflecting prisms to change the direction of the light coming from the scene observed. **So, Statement 1 is correct.**

- Periscopes are used in submarines, tanks and also by soldiers in bunkers to see things outside.
So, Statement 2 is correct.
- Optical periscope has been used as an in-service inspection instrument for the visual inspection of Prototype Fast Breeder Reactor's (PFBR). It is capable of working under the conditions of high temperature and radiation and has facilities for scanning the area of interest, image zooming, image relay, image focusing and image rotation, which are motorized. The instrument will be used for critical inspection of the components installed inside the reactor core under shut down condition.
So, Statement 3 is correct.



ADDITIONAL INFORMATION:

<u>USES OF PERISCOPE</u>	
Military Uses	Periscopes are essential for military operations, providing a way for soldiers to observe enemy positions without exposing themselves to danger. They are used in a variety of military vehicles, including: ➤ Submarines: Periscopes allow submarines to remain submerged while still being able to observe the surface. ➤ Tanks: Periscopes allow tank crews to see over obstacles and around corners, giving them a better view of the battlefield. ➤ Other armored vehicles: Periscopes are also used in other armored vehicles, such as armored personnel carriers and self-propelled artillery.
Civilian Uses	Periscopes also have a variety of civilian uses, including: ➤ Periscopes are not typically used in construction to inspect hard-to-reach areas, such as inside walls or underground pipes. ➤ Marine exploration: Periscopes are not used in marine exploration to observe underwater life without disturbing it. Submersibles and remotely operated vehicles (ROVs) are the primary tools used for observing underwater life without disturbing it. ➤ Sports: Periscopes are sometimes used in sports, such as sailing and fishing, to get a better view of the surroundings. ➤ Security: Periscopes are used in security applications to observe areas without being seen, such as in prisons or at border crossings.

72. Consider the following statements:

Statement-I:

Solid carbon dioxide can be directly converted into gaseous state at high pressure.

Statement II:

The level of pressure applied to a substance can influence its state of matter.

Which of the following is correct with respect to the above statements?

- (a) Both Statement-I and Statement-II are correct and Statement-II is the correct Explanation for Statement-I.
- (b) Both Statement-I and Statement-II are correct and Statement-II is not the correct Explanation for Statement-I
- (c) Statement I is correct, but Statement II is incorrect
- (d) **Statement I is incorrect, but Statement II is correct**

EXPLANATION:

Solid carbon dioxide is stored under high pressure. Solid gets converted directly into a gaseous state on a decrease in pressure to 1 atmosphere without coming into the liquid state. This is the reason that solid carbon dioxide is also known as dry ice. Thus, we can say that pressure and temperature determine the state of a substance, whether it will be solid, liquid or gas. i.e., solid carbon dioxide (dry ice) converts directly from solid to gas at low pressure. **So, Statement I is not correct.**

Water exists as a solid (ice), a liquid (water) and a gas (steam) under different conditions of temperature and pressure. The difference between these three states of matter is due to the difference in their intermolecular distances and intermolecular forces. In addition to these, temperature and pressure also play an important role in deciding the states of matter. **So, Statement II is correct.**

ADDITIONAL INFORMATION:

MATTER IN OUR SURROUNDINGS	
About	➤ Matter is made up of small particles. ➤ The matter around us exists in three states-solid, liquid and gas. ➤ The forces of attraction between the particles are maximum in solids, intermediate in liquids and minimum in gases. ➤ The spaces in between the constituent particles and kinetic energy of the particles are minimum in the case of solids, intermediate in liquids and maximum in gases. ➤ The arrangement of particles is most ordered in the case of solids, in the case of liquids layers of particles can slip and slide over each other while for gases, there is no order, particles just move about randomly. ➤ The states of matter are inter-convertible. The state of matter can be changed by changing temperature or pressure. ➤ Sublimation is the change of solid state directly to gaseous state without going through liquid state. ➤ Deposition is the change of gaseous state directly to solid state without going through liquid state. ➤ Boiling is a bulk phenomenon. Particles from the bulk (whole) of the liquid change into vapour state. ➤ Evaporation is a surface phenomenon. Particles from the surface gain enough energy to overcome the forces of attraction present in the liquid and change into the vapour state.

	➤ The rate of evaporation depends upon the surface area exposed to the atmosphere, the temperature, the humidity and the wind speed. ➤ Evaporation causes cooling. ➤ Latent heat of vaporisation is the heat energy required to change of a liquid to gas at atmospheric pressure at its boiling point. ➤ Latent heat of fusion is the amount of heat energy required to change of solid into liquid at its melting point.
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73. Consider the following statements:

1. The echo of a sound occurs only if multiple surfaces reflect a sound.
2. Successive reflections cause the rolling of thunder.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2**
- (d) Neither 1 nor 2

EXPLANATION:

Sound propagates through a medium at a finite speed. The sound of thunder is heard a little later than the flash of light is seen. So, we can make out that sound travels at a speed which is much less than the speed of light. The speed of sound depends on the properties of the medium through which it travels. The speed of sound decreases when we go from a solid to a gaseous state. In any medium, as we increase the temperature, the speed of sound increases.

If we shout or clap near a suitable reflecting object, such as a tall building or a mountain, we will hear the same sound again a little later. This sound, which we hear, is called an echo. The total distance covered by the sound from the point of generation to the reflecting surface and back should be at least $(344 \text{ m/s}) \times 0.1 \text{ s} = 34.4 \text{ m}$. Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, 17.2 m.

This distance will change with the temperature of the air. Echoes may be heard more than once due to successive or multiple reflections. **So, Statement 1 is correct.**

The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds and the land. **So, Statement 2 is correct.**

ADDITIONAL INFORMATION:

SOUND	
About	Sound is a mechanical disturbance from a state of equilibrium that propagates through an elastic medium. A purely subjective definition of sound is also possible, as that which is perceived by the ear, but such a definition is not particularly illuminating and is unduly restrictive, for it is useful to speak of sounds that cannot be heard by the human ear, such as those that are produced by dog whistles or by sonar equipment.
Reflection of Sound	Sound bounces off a solid or a liquid like a rubber ball bounces off a wall. Like light, sound gets reflected at the surface of a solid or liquid and follows the same laws of reflection as you have studied in earlier classes. ➤ The directions in which the sound is incident and is reflected make equal angles with the normal to the reflecting surface at the point of incidence, and the three are in the same plane.

	➤ An obstacle of large size, which may be polished or rough, is needed for the reflection of sound waves.
Reverberation	A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. ➤ In an auditorium or big hall, excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound-absorbent materials like compressed fibreboard, rough plaster or draperies. ➤ The seat materials are also selected on the basis of their sound-absorbing properties.
Uses Of Multiple Reflection Of Sound	➤ Megaphones or loudhailers, horns, musical instruments such as trumpets and shehanais, are all designed to send sound in a particular direction without spreading it in all directions. ➤ A stethoscope is a medical instrument used for listening to sounds produced within the body, mainly in the heart or lungs. In stethoscopes, the sound of the patient's heartbeat reaches the doctor's ears by multiple reflections of sound. ➤ Generally, the ceilings of concert halls, conference halls and cinema halls are curved so that sound after reflection reaches all corners of the hall. Sometimes, a curved soundboard may be placed behind the stage so that the sound, after reflecting from the soundboard, spreads evenly across the width of the hall.

74. With reference to properties of a colloid, consider the following statements:

1. Its particles are uniformly spread.
2. It is a homogeneous mixture.
3. It can cause the Tyndall effect.
4. It is a stable solution.

Which of the statements given above are correct?

- (a) 1, 2 and 3 only
(b) 2, 3 and 4 only
(c) 1, 3 and 4 only
(d) 1, 2, 3 and 4

EXPLANATION:

Colloid, any substance consisting of particles substantially larger than atoms or ordinary molecules but too small to be visible to the unaided eye; more broadly, any substance, including thin films and fibres, having at least one dimension in this general size range, which encompasses about 10^{-7} to 10^{-3} cm. Colloidal systems may exist as dispersions of one substance in another—for example, smoke particles in air—or as single materials, such as rubber or the membrane of a biological cell.

Properties of a colloid:

- The particles of a colloid are uniformly spread throughout the solution. **So, Statement 1 is correct.**

- Due to the relatively smaller size of particles, as compared to that of a suspension, the mixture appears to be homogeneous. But actually, a colloidal solution is a heterogeneous mixture, for example, milk. **So, Statement 2 is not correct.**
- Because of the small size of colloidal particles, we cannot see them with naked eyes. But, these particles can easily scatter a beam of visible light as observed. This scattering of a beam of light is called the Tyndall effect. Tyndall effect can also be observed when a fine beam of light enters a room through a small hole. This happens due to the scattering of light by the particles of dust and smoke in the air. Tyndall effect can be observed when sunlight passes through the canopy of a dense forest. In the forest, mist contains tiny droplets of water, which act as particles of colloid dispersed in air. **So, Statement 3 is correct.**

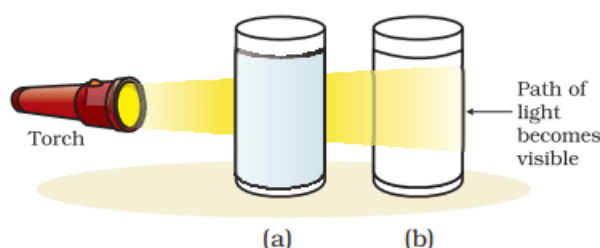


Fig. 2.3: (a) Solution of copper sulphate does not show Tyndall effect, (b) mixture of water and milk shows Tyndall effect.

- Colloids do not settle down when left undisturbed, that is, a colloid is quite stable. **So, Statement 4 is correct.**

ADDITIONAL INFORMATION:

COLLOIDS																																																	
About	All colloidal systems can be either generated or eliminated by nature as well as by industrial and technological processes. The colloids prepared in living organisms by biological processes are vital to the existence of the organism. Those produced with inorganic compounds in Earth and its waters and atmosphere are also of crucial importance to the well-being of life-forms.																																																
Types	<table border="1"> <thead> <tr> <th>S.No.</th><th>Dispersed Phase</th><th>Dispersion Medium</th><th>Type of Colloidal Solution</th><th>Examples</th></tr> </thead> <tbody> <tr> <td>1.</td><td>Solid</td><td>Solid</td><td>Solid sol.</td><td>Gemstones,</td></tr> <tr> <td>2.</td><td>Solid</td><td>Liquid</td><td>Sol</td><td>Paints, muddy water, gold sol, starch sol, arsenious sulphide sol.</td></tr> <tr> <td>3.</td><td>Solid</td><td>Gas</td><td>Aerosol of solids</td><td>Smoke, dust in air</td></tr> <tr> <td>4.</td><td>Liquid</td><td>Solid</td><td>Gel</td><td>Jellies, Cheese</td></tr> <tr> <td>5.</td><td>Liquid</td><td>Liquid</td><td>Emulsion</td><td>Milk, Cream</td></tr> <tr> <td>6.</td><td>Liquid</td><td>Gas</td><td>Aerosol</td><td>Mist, fog, cloud</td></tr> <tr> <td>7.</td><td>Gas</td><td>Solid</td><td>Solid foam</td><td>Foam rubber, pumice stone</td></tr> <tr> <td>8.</td><td>Gas</td><td>Liquid</td><td>Foam</td><td>Froth, whipped cream</td></tr> </tbody> </table>				S.No.	Dispersed Phase	Dispersion Medium	Type of Colloidal Solution	Examples	1.	Solid	Solid	Solid sol.	Gemstones,	2.	Solid	Liquid	Sol	Paints, muddy water, gold sol, starch sol, arsenious sulphide sol.	3.	Solid	Gas	Aerosol of solids	Smoke, dust in air	4.	Liquid	Solid	Gel	Jellies, Cheese	5.	Liquid	Liquid	Emulsion	Milk, Cream	6.	Liquid	Gas	Aerosol	Mist, fog, cloud	7.	Gas	Solid	Solid foam	Foam rubber, pumice stone	8.	Gas	Liquid	Foam	Froth, whipped cream
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Applications of colloidal solutions	Colloids play a very important role in our daily life. Some of these applications are : ➤ Sewage disposal : Colloidal particles of dirt, etc. carry electric charge. When sewage is allowed to pass through metallic plates kept at a high potential, the colloidal particles move to the oppositely charged electrode and get precipitated there. Hence sewage water is purified. ➤ Purification of Water in Wells : When alum is added to muddy water, the negatively charged particles of the colloid are neutralized by Al^{3+} ions. Hence the mud particles settle down and the water can be filtered and used. ➤ Photography : A colloidal solution of silver bromide in gelatin is applied on glass plates or celluloid films to form photo-sensitive plates in photography. ➤ Clotting of Blood : Blood is a colloidal solution and is negatively charged. On applying a solution of $FeCl_3$ bleeding stops and clotting of the colloidal particles of blood takes place. ➤ Rubber Plating : Latex is a colloidal solution of negatively charged rubber particles. The object to be rubber plated is made the anode in the rubber plating bath. The negatively charged rubber particles move towards the anode and get deposited on it.
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75. Consider the following statements:

1. They can harvest water from the air.
2. They can remove polyfluoroalkyl substances from water.
3. They can facilitate safe storage of hydrogen.

How many of the above statements is/are applications of Metal-Organic Frameworks?

- (a) Only one
- (b) Only two
- (c) **All three**
- (d) None

EXPLANATION:

The 2025 Nobel Prize in Chemistry has been awarded to Susumu Kitagawa, Richard Robson and Omar Yaghi, for their work on metal-organic frameworks (often called MOFs).

MOFs are a class of materials composed of metal ions connected by organic molecules, forming a three-dimensional network with large, porous cavities. This design allows gases and liquids to flow through, making MOFs highly adaptable for various applications.

The unique properties of MOFs have led to their application in various fields:

- Water harvesting: MOFs can extract water from dry air, offering a potential solution for water-scarce regions. **So, Statement 1 is correct.**
- Pollutant Removal: They can filter out harmful substances like Per- and polyfluoroalkyl substances (PFAS) from water, addressing environmental contamination. **So, Statement 2 is correct.**
- Carbon capture: MOFs are effective in capturing carbon dioxide, aiding in efforts to mitigate climate change.
- Hydrogen storage: Their porous nature allows for the safe storage of hydrogen, crucial for clean energy applications. **So, Statement 3 is correct.**

Nobel Prize in Chemistry 2025

Susumu Kitagawa

for the development of metal-organic frameworks



Ill. Niklas Elmehed © Nobel Prize Outreach

Richard Robson

for the development of metal-organic frameworks



Ill. Niklas Elmehed © Nobel Prize Outreach

Omar M. Yaghi

for the development of metal-organic frameworks



Ill. Niklas Elmehed © Nobel Prize Outreach

ADDITIONAL INFORMATION:

NOBEL PRIZE 2025

About

The Nobel Prize is a prestigious prize awarded separately in six different fields “to those who, during the preceding year, have conferred the greatest benefit to humankind”. Originally, the prize was awarded in the fields of Physics, Chemistry, Physiology or Medicine, Literature, and Peace.

- The Peace Prize was characterised as “to the person who has done the most or best to advance fellowship among nations, the abolition or reduction of standing armies, and the establishment and promotion of peace congresses”.
- Later in 1968, a sixth prize was added in the field of economic sciences.
- The Prize is officially not a Nobel Prize but it is called as "The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel".
- It was established by Sveriges Riksbank (Sweden’s central bank).
- The first Nobel Prize was given on 10 December, 1901.

Nobel Prize in Physics 2025

John Clarke

for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit



Ill. Niklas Elmehed © Nobel Prize Outreach

Michel H. Devoret

for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit



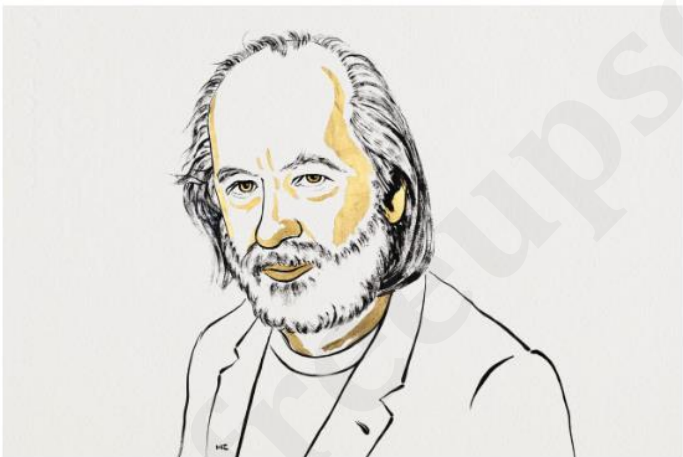
Ill. Niklas Elmehed © Nobel Prize Outreach

John M. Martinis

for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit



Ill. Niklas Elmehed © Nobel Prize Outreach

Nobel Prize in Physiology or Medicine 2025	Mary E. Brunkow for their discoveries concerning peripheral immune tolerance  Ill. Niklas Elmehed © Nobel Prize Outreach Fred Ramsdell for their discoveries concerning peripheral immune tolerance  Ill. Niklas Elmehed © Nobel Prize Outreach Shimon Sakaguchi for their discoveries concerning peripheral immune tolerance  Ill. Niklas Elmehed © Nobel Prize Outreach
Nobel Prize in Literature 2025	László Krasznahorkai for his compelling and visionary oeuvre that, in the midst of apocalyptic terror, reaffirms the power of art  Ill. Niklas Elmehed © Nobel Prize Outreach
Nobel Peace Prize 2025	Maria Corina Machado for her tireless work promoting democratic rights for the people of Venezuela and for her struggle to achieve a just and peaceful transition from dictatorship to democracy  Ill. Niklas Elmehed © Nobel Prize Outreach

Indians who have won the Nobel Prize so far	➤ Rabindranath Tagore (Literature, 1913) – Awarded for Gitanjali, a collection of poems that brought Indian spirituality and lyricism to world literature. With this, Tagore became the first Asian Nobel laureate. ➤ CV Raman (Physics, 1930) – Honoured for discovering the Raman Effect, explaining how light changes wavelength when it passes through a transparent material. ➤ Har Gobind Khorana (Physiology or Medicine, 1968) – Shared the prize for decoding how genetic information in DNA controls protein synthesis. He also built the world's first synthetic gene. ➤ Mother Teresa (Peace, 1979) – Recognised for her humanitarian work through the Missionaries of Charity, caring for the poor and sick in Kolkata. ➤ Subrahmanyan Chandrasekhar (Physics, 1983) – Awarded for his theory on the structure and evolution of stars, including the “Chandrasekhar limit.” ➤ Amartya Sen (Economic Sciences, 1998) – Honoured for his contributions to welfare economics and his “capability approach” to measuring poverty and development. ➤ Venkatraman Ramakrishnan (Chemistry, 2009) – Shared the prize for mapping the atomic structure of the ribosome, a discovery crucial to medical science. ➤ Kailash Satyarthi (Peace, 2014) – Recognised for his decades-long fight against child labour and advocacy for children's education. ➤ Abhijit Banerjee (Economic Sciences, 2019) – Shared the prize for pioneering the use of field experiments to study and reduce global poverty.
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76. Consider the following statements regarding the Hyperspectral Imaging Satellite:

1. It can provide information on which nutrients are missing from the soil.
2. It can also distinguish between different species and subspecies of crops.
3. It can be used to detect invisible leaks of compounds such as methane in oil and gas.

How many of these are actually possible through Hyperspectral Imaging Satellites?

- (a) Only one
- (b) Only two
- (c) All three**
- (d) None

EXPLANATION:

ISRO (Indian Space Research Organisation) developed HySIS (HyperSpectral Imaging Satellite), a full-fledged hyperspectral EO (Earth Observation) satellite for launch in 2018. The primary goal of HysIS is to study the Earth's surface in the visible, near-infrared and shortwave infrared regions of the electromagnetic spectrum.

Hyperspectral imaging satellites have significant potential in sectors such as agri-business, oil and gas, and mining.

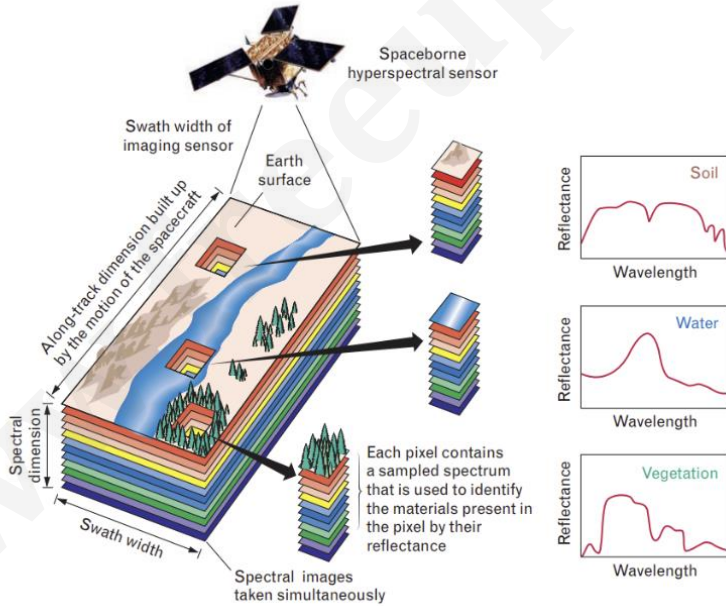
- **Soil Nutrient Assessment:** Hyperspectral images can tell which nutrients are missing from the soil, helping farmers optimise fertiliser application.

So, Statement 1 is correct.

- **Crop Variety Discrimination:** These images can also distinguish between different species and subspecies of crops, which is not possible with many other Earth observation satellites. This detailed data can help companies, say, predict their yields better. **So, Statement 2 is correct.**

- **Methane and Gas Leak Detection:** When it comes to the oil and gas sector, hyperspectral images can be used to detect invisible leaks of compounds such as methane or underground leaks that cannot be easily spotted. In the mining sector, it can be used to remotely map the minerals that are available in an area. **So, Statement 3 is correct.**

ADDITIONAL INFORMATION:

HYPERSENSPECTRAL IMAGING	
recently in news	Google-backed Indian space tech startup Pixxel has successfully launched three of its six hyperspectral imaging satellites, marking a significant milestone for both the company and the country's growing private space sector.
About	Hyperspectral imaging is a non-invasive imaging technique that combines the power of spectroscopy and traditional imaging. Unlike conventional imaging systems that capture images in three or four spectral bands, hyperspectral imaging records data in hundreds of narrow, contiguous spectral bands. ➤ In conventional imaging, the human eye sees the colour of visible light in mostly three bands: long wavelengths (perceived as red), medium wavelengths (perceived as green), and short wavelengths (perceived as blue). ➤ Spectral imaging divides the spectrum into many more bands. This technique of dividing images into bands can be extended beyond the visible spectrum range. ➤ In hyperspectral imaging, the recorded spectra have fine wavelength resolution and cover a wide range of wavelengths. ➤ Hyperspectral imaging measures continuous spectral bands, as opposed to multispectral imaging, which measures spaced spectral bands. Hyperspectral imaging systems acquire images in over one hundred contiguous spectral bands, whereas multispectral imaging does so in under ten bands. 
Application / Uses	➤ Early detection: Hyperspectral imaging can identify subtle spectral differences in tissues, aiding in the early detection of various cancers. ➤ Skin lesion analysis: Dermatologists use hyperspectral imaging to assess skin lesions, aiding in the diagnosis of conditions such as melanoma. ➤ Enhanced visualisation: Hyperspectral imaging enhances the visualisation of brain structures and abnormalities, offering valuable insights for neurosurgeons and researchers.

	➤ Gastrointestinal imaging: Hyperspectral endoscopy can detect and classify abnormalities in the gastrointestinal tract with enhanced sensitivity. ➤ Early disease detection: Hyperspectral imaging can identify subtle changes in the spectral signatures of plants affected by diseases or pests. Early detection allows for timely intervention, reducing crop losses. ➤ Precision agriculture: Yield prediction: Hyperspectral data can be used to predict crop yields by assessing plant health and growth throughout the growing season. ➤ Soil composition: Hyperspectral imaging can determine soil composition and properties, including moisture content, organic matter, and mineral content, helping farmers make informed decisions about soil management. ➤ Mineral identification: Hyperspectral imaging can accurately identify minerals based on their unique spectral signatures. This is particularly useful for prospecting valuable minerals such as gold, copper, and rare earth elements. ➤ Terrain analysis: Hyperspectral data can be used to create detailed geological maps by distinguishing between different rock types, formations, and geological structures based on their spectral characteristics. ➤ Hydrocarbon detection: Hyperspectral imaging can assist in the identification of hydrocarbon deposits by detecting hydrocarbon-related absorption features in the spectral data. ➤ Natural hazard assessment: Landslide prediction: Hyperspectral imaging can be used to detect potential landslide-prone areas by analysing terrain and soil conditions.
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77. Which among the Launch vehicles uses the Cryogenic upper stage for its launch?

- (a) **Launch Vehicle Mark-3**
 (b) Polar Satellite Launch Vehicle
 (c) Reusable Launch Vehicle – Technology Demonstrator
 (d) Small Satellite Launch Vehicle

EXPLANATION:

LVM3(Geosynchronous Satellite Launch Vehicle Mk III) is configured as a three-stage vehicle with two solid strap-on motors (S200), one liquid core stage (L110) and a high-thrust cryogenic upper stage (C25).

- The S200 solid motor is among the largest solid boosters in the world with 204 tonnes of solid propellant.
- The liquid L110 stage uses a twin liquid engine configuration with 115 tonnes of liquid propellant.
- The C25 Cryogenic upper stage is configured with the fully indigenous high thrust cryogenic engine (CE20) with a propellant loading of 28 tons. The overall length of the vehicle is 43.5 m with a gross lift-off weight of 640 tonnes and a 5m-diameter payload fairing. **So, option (a) is correct.**

Polar Satellite Launch Vehicle (PSLV) is the third generation launch vehicle of India. It is the first Indian launch vehicle to be equipped with liquid stages. After its first successful Launch in October 1994, PSLV emerged as a reliable and versatile workhorse launch vehicle of India.

- PSLV uses an Earth storable liquid rocket engine for its second stage, known as the Vikas engine, developed by Liquid Propulsion Systems Centre.
- The third stage of PSLV is a solid rocket motor that provides the upper stages high thrust after the atmospheric phase of the Launch.

- The PS4 is the uppermost stage of PSLV, comprising two Earth storable liquid engines. **So, option (b) is not correct.**

Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) is one of the most technologically challenging endeavors of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low-cost access to space. The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft. RLV-TD consists of a fuselage (body), a nose cap, double delta wings and twin vertical tails. It also features symmetrically placed active control surfaces called Elevons and Rudder. This technology demonstrator was boosted to Mach no: 5 by a conventional solid booster (HS9) designed for low burn rate. Thus, RLV-TD does not use the Cryogenic upper stage. **So, option (c) is not correct.**

Small Satellite Launch Vehicle (SSLV) is a 3-stage Launch Vehicle configured with three Solid Propulsion Stages and a liquid propulsion-based Velocity Trimming Module (VTM) as a terminal stage. SSLV is 2m in diameter and 34m in length with a lift-off weight of ~120 tonnes. SSLV is capable of launching a ~500kg satellite in a 500km planar orbit from SDSC/SHAR. The key features of SSLV are Low cost, with low turnaround time, flexibility in accommodating multiple satellites, Launch on demand feasibility, minimal launch infrastructure requirements, etc. Thus, SSLV does not use the Cryogenic upper stage. **So, option (d) is not correct.**

78. Consider the following statements:

Statement I: Alkanes are hydrocarbons used as fuels.

Statement II: On complete combustion, alkanes produce carbon dioxide and water along with the release of heat.

Statement III: During incomplete combustion of alkanes with a lack of air, carbon black is formed. Which one of the following is correct with respect to the above statements?

- (a) Both Statement II and Statement III are correct, and both explain Statement I
(b) **Both Statement II and Statement III are correct, but only one of them explains Statement I**
(c) Only one of the Statements II and III is correct, and that explains Statement I
(d) Neither Statement II nor Statement III is correct

EXPLANATION:

Hydrocarbons are organic compounds that contain only hydrogen and carbon atoms. Hydrocarbons are found in a wide variety of sources, including petroleum, natural gas, and coal.

- Alkanes are a class of hydrocarbons, saturated hydrocarbons, meaning all carbon atoms are bonded to four other atoms (either carbon or hydrogen). They have the general formula C_nH_{2n+2} , where n is the number of carbon atoms. Alkanes are named according to the number of carbon atoms in the chain. For example, methane, ethane, propane, and so on. Alkanes are nonpolar and have low reactivity due to the strong carbon-carbon and carbon-hydrogen bonds. Alkanes are hydrocarbon chains that make up fuels. **So, Statement I is correct.**
- On Combustion, Alkanes, on heating in the presence of air or dioxygen, are completely oxidised to carbon dioxide and water with the evolution of a large amount of heat. Due to the evolution of a large amount of heat during combustion, alkanes are used as fuels.
➤ **So, Statement II is correct.**
- During incomplete combustion of alkanes with an insufficient amount of air or dioxygen, carbon black is formed, which is used in the manufacture of ink, printer ink, black pigments and as filters. **So, Statement III is correct.**
- Only Statement II explains why alkanes are used as fuels.

Both Statement II and Statement III are correct but only one of them explains Statement I.

ADDITIONAL INFORMATION

HYDROCARBONS	
About	Hydrocarbons are of different types. Depending upon the types of carbon-carbon bonds present, they can be classified into three main categories: (i) saturated, (ii) unsaturated and (iii) aromatic hydrocarbons.
Types	Alkenes ➤ Alkenes are unsaturated hydrocarbons that contain at least one carbon-carbon double bond. ➤ Alkenes are named by adding the suffix "-ene" to the root name of the alkane with the same number of carbon atoms. For example, ethylene, propene, and so on. ➤ Alkenes are more reactive than alkanes due to the presence of the double bond, which can undergo various addition reactions. Alkynes ➤ Alkynes are unsaturated hydrocarbons that contain at least one carbon-carbon triple bond. ➤ Alkynes are named by adding the suffix "-yne" to the root name of the alkane with the same number of carbon atoms. For example, acetylene, propyne, and so on. ➤ Alkynes are the most reactive type of hydrocarbon due to the presence of the triple bond, which can undergo a variety of addition and substitution reactions. Cycloalkanes ➤ Cycloalkanes are saturated hydrocarbons that form a ring structure. ➤ Cycloalkanes are named by adding the prefix "cyclo" to the root name of the alkane with the same number of carbon atoms. For example, cyclopropane, cyclobutane, and so on. ➤ Cycloalkanes are less reactive than alkanes due to the ring structure, which restricts the movement of the carbon atoms. Aromatic Hydrocarbons ➤ Aromatic hydrocarbons are unsaturated hydrocarbons that contain at least one benzene ring. ➤ Benzene is a six-membered carbon ring with alternating double bonds. ➤ Aromatic hydrocarbons are named according to the number and arrangement of benzene rings in the molecule. For example, benzene, toluene, and naphthalene. ➤ Aromatic hydrocarbons are relatively stable and unreactive due to the resonance stabilisation of the benzene ring.
Uses	Hydrocarbons are used in a wide variety of products, including: ➤ Fuels: Hydrocarbons are the primary fuel for most vehicles and power plants. ➤ Plastics: Hydrocarbons are used to make a variety of plastics, including polyethene, polypropylene, and polystyrene. ➤ Solvents: Hydrocarbons are used to dissolve other substances, such as paints, oils, and greases. ➤ Lubricants: Hydrocarbons are used to lubricate moving parts in machinery. ➤ Fertilisers: Hydrocarbons are used to make fertilisers, which help plants grow.

79. Consider the following statements:

1. The total linear momentum of a system of particles is constant if the total external force acting on the system is zero.
2. The internal force of particles does not affect the velocity of the centre of mass of the system if the external force on the system is zero.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2**
- (d) Neither 1 nor 2

EXPLANATION:

Linear momentum is defined as the momentum of an object moving in a straight line, calculated as the product of its mass and velocity. The linear momentum of a particle can be defined in equation as:

$$\mathbf{p} = m\mathbf{v}$$

- 'P' is momentum, which represents a moving object's quantity of motion,
- 'm' is the object's mass (its resistance to acceleration), and
- 'v' is its velocity (the rate of change of its position, including direction).

If the sum of all external forces acting on a system of particles is zero, then the total linear momentum of the system remains constant. In other words, when no net external force acts on a system, its total linear momentum neither increases nor decreases with time.

This principle is known as the law of conservation of linear momentum for a system of particles. **So, Statement 1 is correct.**

Internal forces are the forces that particles within a system exert on each other. These forces may change the motion of individual particles, but they always occur in equal and opposite pairs (Newton's Third Law). Because of this, their effects cancel out when looking at the system as a whole.

If the total external force on the system is zero, there is nothing to accelerate or slow down the centre of mass. Therefore, the velocity of the centre of mass remains constant, moving in a straight line just like a free particle.

Therefore, the internal forces between particles do not affect the velocity of the center of mass of the system when the net external force is zero. but only external forces can change the motion of the system's centre of mass. **So, Statement 2 is correct.**

80. Consider the following statements regarding Guillain-Barré Syndrome (GBS):

- I. It is an autoimmune disorder in which the body's immune system attacks the peripheral nervous system.
- II. Intravenous immunoglobulin (IVIG) therapy is one of the standard treatments for this syndrome.
- III. It spreads rapidly from person to person through respiratory droplets.

Which of the statements given above are correct?

- (a) I and II only**
- (b) II and III only
- (c) I and III only
- (d) I, II and III

EXPLANATION:

Guillain-Barré Syndrome (GBS) is an autoimmune neurological disorder in which a person's immune system attacks their peripheral nerves, leading to muscle weakness that can progress to paralysis. It can develop over a few days or several weeks. People of any age can be affected, but it is more common in adults and males. The condition is rare, with an estimated incidence of 1/2 per 100,000 population.

So, Statement I is correct.

Two treatments are commonly used to interrupt immune-related nerve damage. Both are equally effective if started within two weeks of GBS symptoms.

Plasma exchange (PE), also called plasmapheresis, involves removing some blood through a catheter. Plasma (the liquid part of the blood) is separated from the blood cells. These cells, along with replacement fluid, are returned to the body. PE may work by removing the bad antibodies in the plasma that have been damaging the nerves.

Intravenous immunoglobulin therapy (IVIg) involves injections of immunoglobulins—proteins that your immune system naturally makes to attack infecting organisms. The immunoglobulins are developed from a pool of thousands of healthy donors. **So, Statement II is correct.**

Guillain-Barré Syndrome (GBS) does not spread from person to person through respiratory droplets. It is not contagious. Instead, it is a post-infectious disease in which the body's immune system attacks the peripheral nervous system, leading to muscle weakness, paralysis, and, in severe cases, respiratory failure.

GBS itself is not contagious and does not directly spread from person to person or through environmental exposure, such as bathing or drinking contaminated water. However, there are indirect links between GBS and environmental factors, particularly bacterial or viral infections associated with contaminated water. **So, Statement III is not correct.**

GUILLAIN-BARRE SYNDROME

AN **AUTOIMMUNE DISORDER** WHERE THE
IMMUNE SYSTEM ATTACKS....

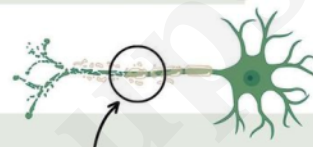
THE PERIPHERAL NERVOUS SYSTEM AND CRANIAL NERVES

SOMATIC: VOLUNTARY FUNCTION
AUTONOMIC: INVOLUNTARY FUNCTION

@stephaneebeggs

PATHOPHYSIOLOGY

In the human body, the immune system attacks invading organisms (like a cold).
↓
In Guillain-Barre, the immune system acts in overdrive and mistakenly attacks the myelin sheaths of nerves



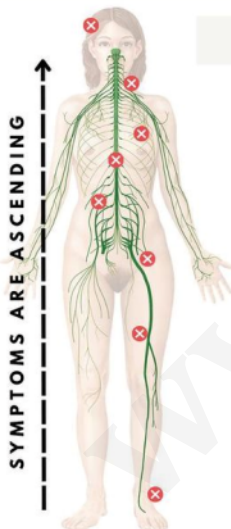
COMPLICATIONS: PARASTHESIA > PARALYSIS

1st SIGN: Paresthesia starts in the feet
(symmetrical) and ascends upward over time

LATE SIGN: Paralysis of major muscles in vital organs!

- Renal - constipation or incontinence
- Lungs - trouble breathing, respiratory failure
- Heart - dysrhythmias and blood pressure changes
- Neuro - cranial nerves affected, paralysis of the face
 - Trouble swallowing or speaking
 - Temperature irregularities

**MOST SEVERE FORM:
MEDICAL EMERGENCY!**



SYMPTOMS ARE ASCENDING

TREATMENT: NO CURE; WILL REMAIN DORMANT

GOAL: Decrease recovery time and improve signs and symptoms!
To do this, interventions must take place within 2 weeks of onset

- Immunoglobulin therapy
- Plasmapheresis

**After 2 weeks, symptoms start to subside. 1-2 years later, pt should return to baseline

NURSING CONSIDERATIONS

- Assess swallowing and respiratory effort! We worry about a gradual paralysis that reaches the lungs
- Monitor EKG's
- Listen for bowel sounds
- Monitor urinary output
- If intubated: Watch for infection, pressure injuries and blood clots

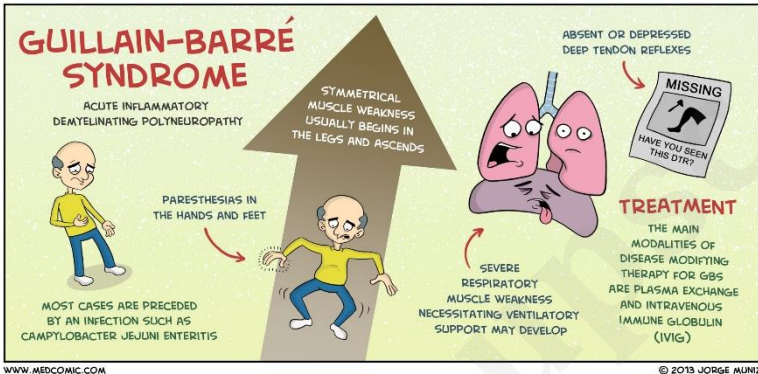


Memory Trick

GRADUAL
BLOCK
SENSATION



ADDITIONAL INFORMATION:

GUILLAIN-BARRÉ SYNDROME (GBS)	
Recently in news	Data collected by Pune Municipal Corporation (PMC) health department has revealed that the Guillain-Barré Syndrome (GBS) caseload in the first two months of 2025 is similar to the annual GBS cases reported in 2023 and 2024.
About	Guillain-Barré syndrome (GBS) is a rare condition in which a person's immune system attacks the peripheral nerves. ➤ People of all ages can be affected, but it is more common in adults and in males. ➤ Most people recover fully from even the most severe cases of Guillain-Barré syndrome. ➤ Severe cases of Guillain-Barré syndrome are rare but can result in near-total paralysis and problems breathing. ➤ Guillain-Barré syndrome is potentially life-threatening. People with Guillain-Barré syndrome should be treated and monitored as quickly as possible; some may need intensive care. Treatment includes supportive care and some immunological therapies. 

81. Which of the following best illustrates the role of friction?

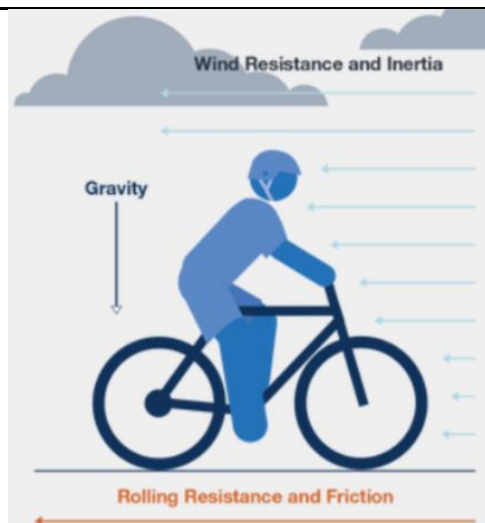
- (a) A cyclist pedaling continuously to keep the cycle moving.
 (b) A swimmer floating on still water.
 (c) A magnet attracting iron filings.
 (d) An apple falling from a tree.

EXPLANATION:

Friction is the force that opposes the relative motion of two objects in contact. It arises due to microscopic irregularities on the surfaces of the objects. Generally, the greater the force applied, the greater the friction.

Examples of friction:

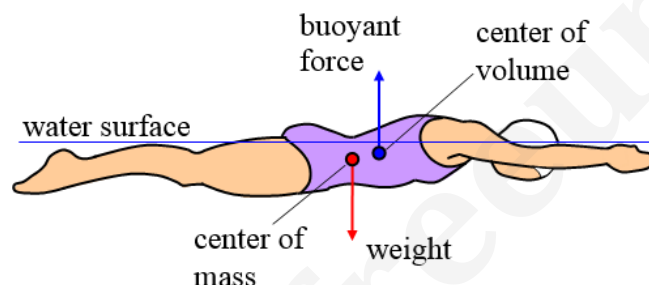
- Friction prevents slipping when we walk and slows down a cyclist when they stop pedaling. The cyclist must pedal continuously to overcome friction and keep moving. **So, Option (a) is correct.**
- Friction between car tires and the road allows the vehicle to accelerate, brake, and turn safely.
- Rubbing hands together generates heat due to friction.



Buoyant force is the upward force exerted by a fluid (liquid or gas) on an object submerged in it or floating on its surface. A swimmer floating on still water is one of the best examples of Buoyant force. Other examples are:

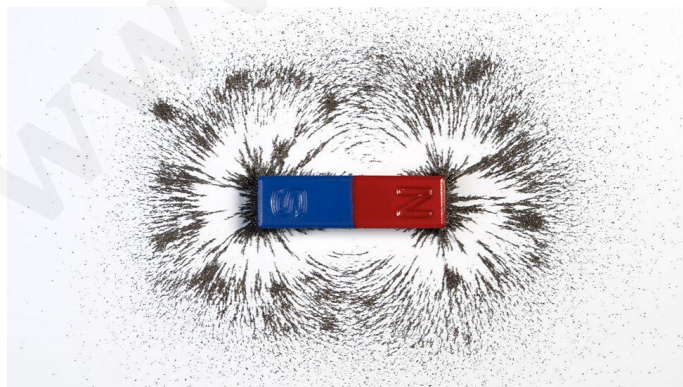
- Boats and submarines: Boats and submarines float on water because the buoyant force exerted by the water is greater than their weight.
- Hot air balloons: Hot air balloons rise because the hot air inside the balloon is less dense than the cooler air outside, creating a buoyant force that lifts the balloon.

Thus, a swimmer floating on still water involves buoyancy, not Friction. **So, Option (b) is not correct.**



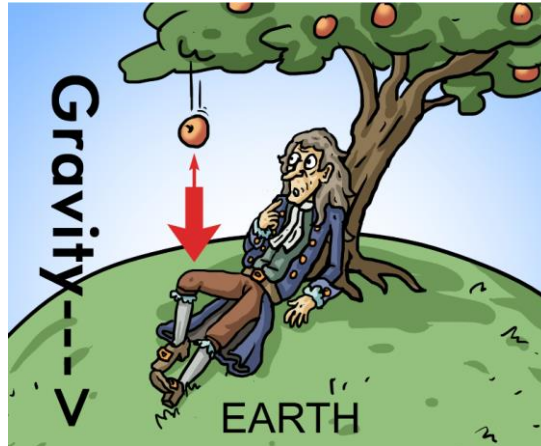
Magnetic force is an invisible force that draws in or pushes away objects, similar to how magnets pull metals like iron. This occurs because of the magnetic characteristics of tiny particles within materials. Iron filings are tiny bits of iron that can be sprinkled around the magnet. These will line up with the magnetic field, showing its shape. A magnet attracting iron filings involves magnetic force, not Friction.

So, Option (c) is not correct.



Gravity is a force that attracts objects towards each other. The weight of an object is the gravitational force between the object and the Earth. The weight of an object depends upon its mass and the

gravitational field strength. An apple that falls from a tree is because of the gravitational attraction between the earth and the apple (not friction). **So, Option (d) is not correct.**



82. Consider the following statements regarding the PARAS-2 Spectrograph:

- I. It is an advanced astronomical instrument to detect and study exoplanets.
- II. It is primarily used for detecting gravitational waves from distant galaxies.
- III. It has been jointly developed by ISRO and the European Southern Observatory (ESO).

Which of the statements given above is/are correct?

- (a) I and III only
- (b) I only**
- (c) II and III only
- (d) I, II and III

EXPLANATION:

The PRL Advanced Radial-velocity All-sky Search-2 (PARAS-2) is a cutting-edge fibre-fed spectrograph integrated with the PRL 2.5m telescope, constituting a significant advancement over its predecessor, PARAS, situated on the PRL 1.2m telescope. Distinguished as the first highly stabilised spectrograph of its kind within the nation and one of the select few globally, PARAS-2 was conceived with the primary objective of achieving sub-m/s precision in radial velocity (RV), a crucial capability for the detection and characterisation of super-Earths or massive planets orbiting G and K dwarf stars.

- Recently, Indian researchers have identified a new exoplanet, TOI-6038A b, which is approximately 78.5 times the mass of Earth and has a radius 6.41 times that of our planet. This marks the second exoplanet discovery using the advanced PARAS-2 spectrograph, attached to the 2.5-meter telescope at PRL's Mount Abu Observatory in Gurushikhar, Mount Abu.
- PARAS-2 is an advanced version of PARAS designed to detect and study exoplanets.

So, Statement I is correct.

PARAS-2 spectrograph is the highest-resolution stabilised radial velocity (RV) spectrograph in Asia. Precise Radial-Velocity data from PARAS-2, which was used to measure the mass of the planet, along with high-spatial resolution speckle imaging from the PRL's 2.5-meter telescope, were thus absolutely crucial in validating the planetary nature of the transit signal and hence the discovery.

- PARAS-2 is not used for gravitational wave detection. Instead, LIGO, which stands for "Laser Interferometer Gravitational-wave Observatory", is used to detect and understand the origins of gravitational waves (GW). **So, Statement II is not correct.**

The state-of-the-art PARAS-2 spectrograph, developed by the Physical Research Laboratory (PRL) in Ahmedabad, was not jointly developed by ISRO and the European Southern Observatory (ESO). **So, Statement III is not correct.**

83. Consider the following statements:

Statement I: The human eye can focus on objects at varying distances by adjusting the curvature of its lens.

Statement II:

The curvature of the cornea changes during this process to alter the focal length.

Statement III:

This process of changing the focal length of the lens is called accommodation.

Which of the following is correct with respect to the above statements?

- (a) Both Statement II and Statement III are correct, and both of them explain Statement I.
- (b) Both Statement II and Statement III are correct, but only one of them explains Statement I.
- (c) Only one of Statements II and III is correct, and that explains Statement I.**
- (d) Neither Statement II nor Statement III is correct.

EXPLANATION:

The human eye is one of the most sensitive sense organs of the human body. It functions much like a camera, with its lens system forming an image on a light-sensitive screen called the retina. Light enters the eye through a thin membrane called the cornea, which forms a transparent bulge on the front surface of the eyeball.

The human eye can focus on objects at varying distances by adjusting the curvature of its lens through a process called accommodation. **So, Statements I and III are correct.**

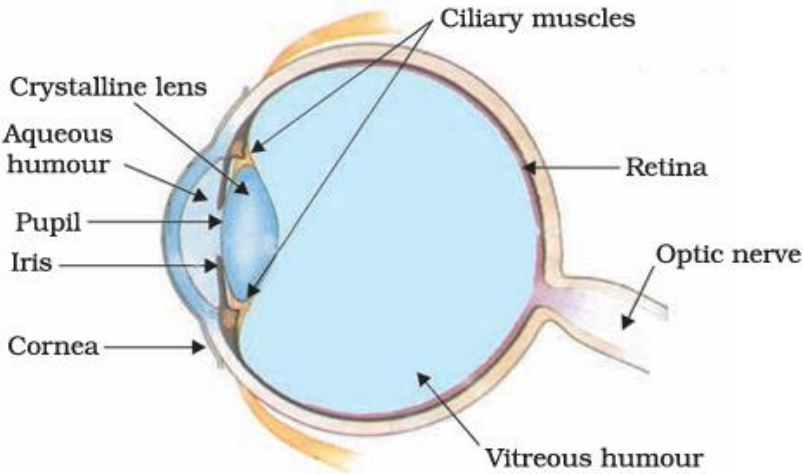
The eye lens is composed of a fibrous, jelly-like material. Its curvature can be modified to some extent by the ciliary muscles.

- When the ciliary muscles are relaxed, the lens becomes thinner, and its focal length increases. This enables us to see distant objects clearly.
- When looking at objects closer to the eye, the ciliary muscles contract. This increases the curvature of the eye lens, making it thicker. Consequently, the focal length of the eye lens decreases, allowing us to see nearby objects clearly.

Therefore, the process of changing the focal length of the (lens not cornea) is called accommodation, through which the human eye can focus on objects at varying distances by adjusting the curvature of its lens. **So, Statement II is not correct. Thus, only one of Statements II and III is correct, and that explains Statement I.**

ADDITIONAL INFORMATION:

THE HUMAN EYE	
About	➤ In the human eye, the lens system forms an image on a light-sensitive screen called the retina. ➤ Light enters through the cornea, a transparent bulge on the front of the approximately 2.3 cm spherical eyeball. ➤ Most refraction occurs at the cornea, while the crystalline lens makes finer adjustments to focus on objects at different distances. ➤ Behind the cornea lies the iris, a dark muscular diaphragm that controls the size of the pupil, regulating the amount of light entering the eye. ➤ The lenses form an inverted real image on the retina, which contains numerous light-sensitive cells. ➤ These cells convert light into electrical signals, transmitted to the brain through the optic nerves. ➤ The brain then interprets these signals, enabling us to perceive the objects.

	
Ability of human eye	➤ The ability of the eye lens to adjust its focal length is called accommodation. However, this focal length cannot be reduced beyond a certain minimum. ➤ If you try to read a printed page very close to your eyes, the image appears blurred or causes eye strain. ➤ For clear and comfortable vision, an object should be held at about 25 cm from the eyes. ➤ This minimum distance is called the least distance of a distinct vision or the nearest point of the eye. For a young adult with normal vision, it is about 25 cm. ➤ The far point of the eye is the farthest distance at which objects can be seen clearly — infinity for a normal eye. A normal eye can therefore see objects clearly between 25 cm and infinity. ➤ In some older people, the crystalline lens becomes milky or cloudy, a condition known as cataract, which causes partial or complete loss of vision. Cataract surgery can restore clear vision.

84. With reference to simple microscopes, consider the following statements:

1. They have a lens that acts as both the objective and the eyepiece.
2. They always use a concave lens.
3. They have higher magnifying power when the focal length is shorter.

How many of the above statements is/are correct?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

A simple microscope is a fundamental optical device comprised of a single lens that magnifies objects when they are placed close to the lens.

- This lens is a single, high-powered converging lens that produces virtual images by magnification, which cannot be projected on a screen like a real image. Therefore, a Simple microscope has a single lens which is convex type (Not Concave). **So, Statement 1 is correct, and Statement 2 is not correct.**
- Simple microscopes are commonly used for various applications such as reading small text, examining specimens, or inspecting details in crafts and artwork. They are portable, easy to use,

and provide moderate levels of magnification suitable for everyday tasks requiring enhanced visual clarity. A reading or magnifying glass is the most well-known example from today.

Simple microscopes have the magnification power which is given by:

$$M = 1 + D/f$$

Where M = Magnification power of the simple microscope.

D = Least distance of distinct vision, generally 25cm for a normal human eye.

f = Focal length of the convex lens.

- For example, we have a convex lens of focal length 10 cm.

$$M = 1 + \frac{25}{10} = 1 + 2.5 = 3.5$$

So, the magnification power is **3.5x**.

- While taking another lens of focal length 5 cm. For **Lens B**:

$$M = 1 + \frac{25}{10} = 1 + 5 = 6$$

So, the magnification power = **6x**.

From the above illustration, it can be deduced that the shorter the focal length of the lens, the higher its magnification power. **So, Statement 3 is correct.**

ADDITIONAL INFORMATION:

DIFFERENCE BETWEEN A SIMPLE AND A COMPOUND MICROSCOPE	
Optical System	➤ Simple Microscope: Consists of a single lens, typically convex in shape, which magnifies objects when they are placed close to the lens. ➤ Compound Microscope: Utilises multiple lenses and complex optical systems, including an objective lens near the specimen and an eyepiece lens near the viewer's eye. Light passes through the specimen and is magnified by the objective lens before passing through the eyepiece lens, resulting in higher magnification.
Magnification	➤ Simple Microscope: Provides lower magnification compared to compound microscopes. Typically used for moderate levels of magnification suitable for everyday tasks. ➤ Compound Microscope: Offers higher magnification capabilities, allowing for detailed examination of microscopic specimens and structures.
Applications	➤ Simple Microscope: Commonly used for tasks such as reading small text, examining specimens, or inspecting details in crafts and artwork. ➤ Compound Microscope: Widely used in scientific research, medical diagnostics, and educational settings for observing cells, bacteria, tissues, and other microscopic structures in greater detail.

85. Consider the following statements:

1. Gravitation is a strong force when the masses involved are small.
2. Gravitational force increases with altitude.
3. Gravitational force is stronger at the equator than at the poles.

How many of the above statements is/are correct?

- (a) Only one
(b) Only two
(c) All three
(d) **None**

EXPLANATION:

The law of gravitation states that the force of attraction between any two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them. The law applies to objects anywhere in the universe. Such a law is said to be universal.

- The force of gravitation between objects of ordinary mass is very weak. However, when large masses are involved, this force becomes appreciably stronger. The gravitational force due to earth is known as gravity. **So, Statement 1 is not correct.**
- Gravitation is a weak force unless large masses are involved. The force of gravity decreases with altitude. **So, Statement 2 is not correct.**
- It also varies on the surface of the earth, decreasing from poles to the equator. Thus, Gravitational force is stronger at the poles than at the equator. **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

THE FUNDAMENTAL FORCES	
About	The universe is governed by four fundamental forces: gravity, electromagnetism, and the strong and weak nuclear forces. These forces are the basic interactions that determine how matter behaves, how structures form, and how energy is transferred across the cosmos.
Gravitational Force	➤ Gravity is the familiar force that keeps our feet on the ground and Earth in orbit around the Sun. ➤ According to general relativity, gravity is the bending of space-time caused by mass, which attracts objects toward each other. ➤ Its strength increases with the masses of the objects but decreases with the square of the distance between them. Example: If the Moon were twice as far from Earth, the gravitational pull would be one-fourth as strong. ➤ Gravity is the weakest fundamental force but acts over infinite distances, shaping the structure of the universe.
Electromagnetic Force	➤ Electromagnetism combines electricity and magnetism, where a moving electric field produces a magnetic field and vice versa. ➤ Like gravity, its strength decreases with the square of the distance, but it only affects charged objects. ➤ Like charges repel; opposite charges attract. ➤ Electromagnetism is much stronger than gravity, but large objects often appear neutral because positive and negative charges cancel. Example: Earth's magnetic field arises from electric currents in its liquid core, though the planet is electrically neutral overall.
Strong Nuclear Force	➤ The strong nuclear force binds atomic nuclei together, holding protons and neutrons in place. ➤ It also binds quarks inside protons and neutrons. ➤ It is the strongest fundamental force: • 100 times stronger than electromagnetism • 10^{40} times stronger than gravity ➤ Its effect is limited to extremely small distances which is roughly the size of an atomic nucleus. Beyond this, other forces dominate.
Weak Nuclear Force	➤ The weak force governs interactions between subatomic particles, such as protons, neutrons, and electrons. ➤ It can change one quark type into another, e.g., turning a neutron's down quark into an up quark, converting the neutron into a proton. ➤ These processes:

- Drive energy production in the Sun
- Cause radioactive decay in atoms
- The weak force acts at even smaller distances than the strong force (about 1,000 times smaller) and is about a million times weaker than the strong force, but still much stronger than gravity.

86. Hypo used in photography is chemically known as:

- (a) Silver bromide
- (b) Sodium phosphate
- (c) Sodium thiosulphate**
- (d) Silver nitrate

EXPLANATION:

Hypo used in photography is chemically known as sodium thiosulphate. Sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) is a white, crystalline solid that is soluble in water. Sodium thiosulfate is used in a variety of applications, including:

- **Photography:** It is used as a fixing agent in photography to develop negatives and prints. It removes unexposed silver halide crystals from photographic film and paper, making the image permanent. **So, Option (c) is correct.**
- **Textile industry:** It is used as a reducing agent in the textile industry. It helps to remove excess dye from fabrics and to improve the colorfastness of dyes.
- **Water treatment:** Sodium thiosulfate is used to remove chlorine from water. Chlorine is a disinfectant that is used to kill bacteria in water, but it can also react with organic matter to form harmful disinfection byproducts. Sodium thiosulfate reacts with chlorine to form harmless compounds, such as sodium chloride and sodium sulfate.
- **Food industry:** It is used as a preservative in some foods, such as canned fruits and vegetables. It helps to prevent the growth of bacteria and fungi.
- **Medicine:** It is used to treat a variety of medical conditions, including cyanide poisoning, heavy metal poisoning, and skin conditions such as eczema and psoriasis.

87. With reference to deepfakes, consider the following statements:

1. It employs deep learning techniques.
2. It uses face-swapping technologies.
3. It is always created in the format of videos.
4. It can alter medical scans.

How many of the above statements is/are correct?

- (a) Only one
- (b) Only two
- (c) Only three**
- (d) All four

EXPLANATION:

Deepfake technology is a type of artificial intelligence used to create convincing fake images, videos and audio recordings.

- The term Deepfake is an amalgamation of the words “deep learning” and “fake” and it means fabricated videos generated from existing face-swapping techniques and technology. **So, Statement 2 is correct.**
- They are called deepfakes because they use deep learning technology, a branch of machine learning that applies neural net simulation to massive data sets, to create fake content. It employs a branch

of artificial intelligence where if a computer is fed enough data, it can generate fakes that behave much like a real person. **So, Statement 1 is correct.**

- Deepfakes constitute fake content often in the form of videos but also other media formats such as pictures or audio created using powerful artificial intelligence (AI) tools. **So, Statement 3 is not correct.**
- The application of a technology called Generative Adversarial Networks (GAN), which uses two AI algorithms where one generates the fake content and the other grades its efforts, teaching the system to be better has helped come up with more accurate deepfakes.

Concerns associated with deepfake:

- **Threat to Privacy:** Deepfake poses an alarming threat to the personal security and privacy of millions through audio-visual manipulation tactics. This includes the usage of deepfakes for purposes of identity theft and synthetic pornography. Deepfakes directly violate the fundamental right to privacy under Article 21 of the Constitution.
- **Threat to healthcare and national security:** According to the World Economic Forum (WEF), Deepfake technology can be employed to alter medical scans, create fake tumours or remove real ones, or manipulate satellite images to fabricate entire geographical features or deepfake geography. Thus, the implications are profound, posing risks not only to personal privacy but also to various sectors, including healthcare and national security. **So, Statement 4 is correct.**
- **Political misuse:** Another equally worrying ramification is the creation and dissemination of morphed videos of elected representatives and public figures in a political sphere already reeling from an avalanche of disinformation and polarization.

ADDITIONAL INFORMATION:

DEEPFAKES	
Recently in news	Recently, the Union Finance minister flags deepfake videos of herself, urges fintechs to strengthen AI defences and trust safeguards.
About	Deepfakes are digital media - video, audio, and images edited and manipulated using Artificial Intelligence. It is basically hyper-realistic digital falsification. Deepfakes are created to inflict harm on individuals and institutions. Deepfakes are made using two algorithms: ➤ Generator – creates fake content. ➤ Discriminator – checks if it looks real or fake. Together, they form a Generative Adversarial Network (GAN). GANs learn patterns from real images or videos and use them to make realistic fakes. For photos, GANs study the person from many angles and for videos, they also analyze movement, behavior, and speech. Deepfake videos are made in two ways: • Altering a video of someone to make them say or do things they never did. • Face swapping – putting someone’s face onto another person’s video.
Global initiatives related to deepfakes	Bletchley Declaration: ➤ Agreed by 28 countries, including the US, UK, and China. ➤ First global pact on frontier AI risks. ➤ Promotes transparency from AI developers and scientific collaboration to understand AI risks. Operation Minerva: ➤ Detects deepfakes by comparing media with a catalogue of digitally fingerprinted videos. ➤ Alerts users if a potentially doctored version of media is detected. European Union’s AI Law: ➤ Comprehensive regulation for AI technologies in the EU.

	➤ Requires transparency for general-purpose AI systems, including: • Compliance with EU copyright law. • Publishing summaries of training data. ➤ For high-risk models, additional safeguards include mandatory evaluations and incident reporting.
Initiative by Indian government	The Ministry of Electronics and Information Technology (MeitY) has selected five projects under the Safe & Trusted AI program of the IndiaAI Mission. These projects focus on deepfake detection, preventing gender bias in AI, and ensuring the security of generative AI. ➤ Saakshya – Being developed by IIT Jodhpur and IIT Madras, this multi-agent, RAG-enhanced framework focuses on deepfake detection and governance. ➤ AI Vishleshak – A joint initiative by IIT Mandi and the Directorate of Forensic Services, Himachal Pradesh, this project aims to enhance detection of audio-visual deepfakes and handwritten signature forgeries with adversarial robustness, explainability and domain generalisation. ➤ Real-Time Voice Deepfake Detection System – Led by IIT Kharagpur, this solution aims to counter emerging threats from synthetic voice manipulation. ➤ Evaluating Gender Bias in Agricultural LLMs – A collaboration between Digital Futures Lab and Karya, this project focuses on creating Digital Public Goods (DPG) for benchmarking and fair data work. ➤ Anvil – A penetration testing and evaluation tool for generative AI systems, developed by Globals ITES Pvt Ltd in partnership with IIIT Dharwad.

88. Consider the following statements:

1. Mission Fram2 is a geostationary orbit human spaceflight mission by the European Space Agency.
2. Geostationary satellites move around the Earth from west to east.
3. Telecommunication satellites are generally placed in geostationary orbit.

How many of the above statements is/are correct?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Recently, SpaceX launched the Fram2 mission, the first human spaceflight over Earth's polar regions, capturing unprecedented views of the Arctic and Antarctic from space. The mission, launched from NASA's Kennedy Space Center, aims to advance research for future Mars travel and involves various scientific experiments, including space X-ray imaging and microgravity mushroom cultivation. The privately funded Fram2 mission, was launched by SpaceX not by the European Space Agency. **So, Statement 1 is not correct.**

A geostationary orbit is a high-altitude, circular orbit above the Earth's equator where a satellite remains fixed relative to the planet's surface.

It has an orbital period that exactly matches Earth's rotation and an altitude of approximately 35,786 km (22,236 miles).

This positioning allows satellites to provide continuous coverage for communication, weather monitoring, and other applications.

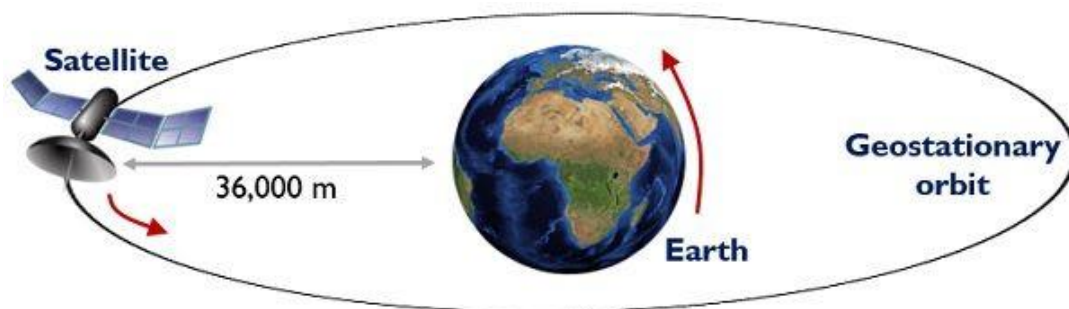
Satellites in geostationary orbit (GEO) fly above Earth's equator, moving from west to east, exactly matching Earth's rotation: taking 23 hours 56 minutes and 4 seconds to complete one full orbit. **So, Statement 2 is correct.**

GEO is ideal for satellites that need to stay fixed above a specific location, such as telecommunication satellites, allowing antennas on Earth to stay in a constant position, always pointing at the satellite.

So, Statement 3 is correct.

It is also valuable for weather satellites, enabling continuous monitoring of specific regions to track evolving weather patterns over time and see how weather trends emerge.

Satellites in GEO can cover a large portion of Earth; just three evenly spaced satellites can provide near-global coverage.



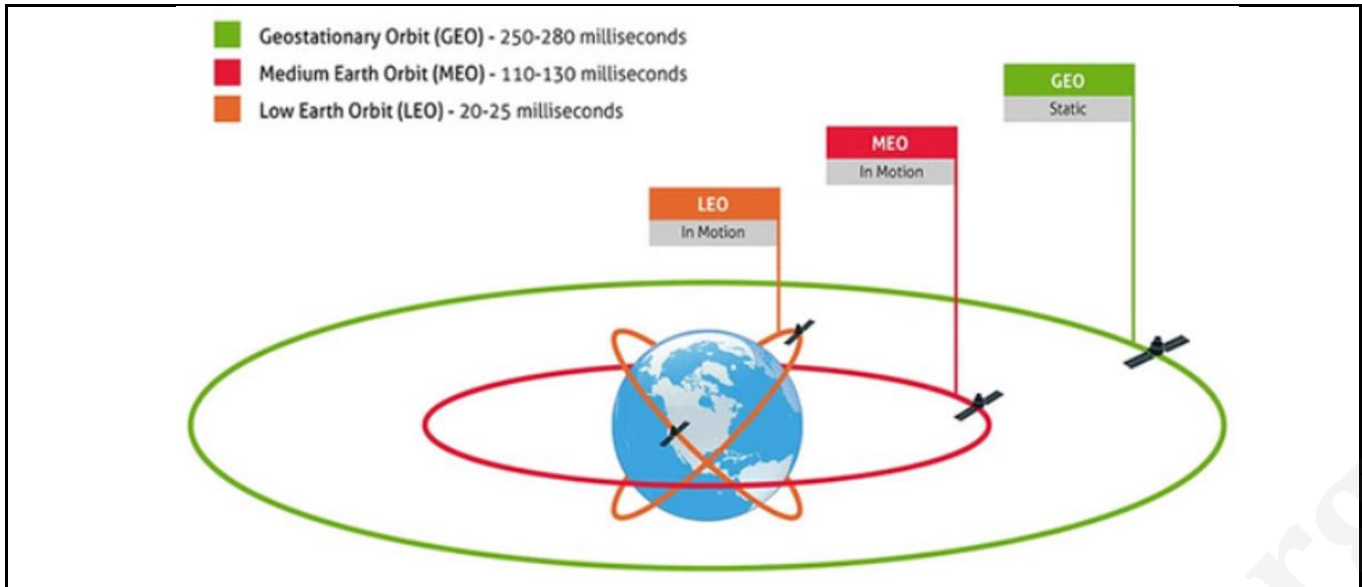
Motion of satellite in Geostationary Orbit

ADDITIONAL INFORMATION:

TYPES OF ORBITS

An orbit is the curved path that an object in space (like a star, planet, moon, asteroid or spacecraft) follows around another object due to gravity. Many factors influence the choice of an optimal orbit for a space mission, all depending on the mission's objectives. The following are different types of orbits:

- **Low Earth Orbit (LEO):** Ranges from 160–2,000 km above Earth. Satellites in LEO orbit quickly (90–120 minutes) and are used for Earth observation, imaging, reconnaissance, and the International Space Station.
- **Polar Orbit (PO):** Passes over the Earth's poles, enabling coverage of the entire surface over time as Earth rotates. Common for mapping, Earth observation, and military reconnaissance.
- **Sun-Synchronous Orbit (SSO):** A near-polar orbit that ensures a satellite passes over the same point at the same local solar time, providing consistent lighting conditions for imaging, weather, and environmental monitoring.
- **Medium Earth Orbit (MEO):** The range is between 2,000–35,786 km, used for navigation satellites like GPS, Galileo, and GLONASS. It balances coverage area and signal latency.
- **Highly Eccentric Orbit (HEO):** Elongated orbit where satellites spend most time far from Earth, giving long-duration coverage over high latitudes. Used for communications in polar regions or scientific observations.
- **Transfer Orbits & Geostationary Transfer Orbit (GTO):** Transfer orbits move satellites from launch orbit to target orbit. GTO is an elliptical orbit used to efficiently reach GEO using onboard propulsion.
- **Lagrange Points (L-points):** Five positions in a two-body system where gravitational and centrifugal forces balance. Spacecraft can “park” here with minimal fuel, e.g., Sun-Earth L1 for solar observation and L2 for deep-space telescopes.
- **Heliocentric Orbit:** An orbit around the Sun. Used for planetary exploration, solar observation, and interplanetary missions like spacecraft to Mars or Venus.



89. With reference to Vyommitra, consider the following statements:

1. It is a humanoid robot developed by the Defence Research and Development Organisation.
2. It assists astronauts in microgravity experiments during space missions.
3. Its primary objective is to carry out autonomous lunar exploration in ISRO's upcoming space missions

Which of the statements given above is/are **not** correct?

- (a) 2 only
(b) 1 and 3 only
 (c) 3 only
 (d) 1, 2 and 3

EXPLANATION:

Vyommitra is India's first humanoid robot developed by the Indian Space Research Organization ISRO (Not the DRDO) to assist in human space missions. With human-like expressions, speech, and intelligence, Vyommitra stands at the heart of Gaganyaan, India's maiden human spaceflight programme. **So, Statement 1 is not correct.**

The ISRO unveiled Vyommitra in early 2020. The name is derived from Sanskrit-"Vyoma" meaning space, and "Mitra" meaning friend that literally means, "friend in space".

This humanoid robot is designed to act as an intelligent, anthropomorphic companion for astronauts, handling both mechanical tasks and communication duties aboard India's crewed spacecraft.

Therefore, Vyommitra's primary objective is not to carry out autonomous lunar exploration, but rather to assist astronauts in the Gaganyaan mission as an intelligent, anthropomorphic companion. **So, Statement 3 is not correct.**

Gaganyaan will send Indian astronauts ("vyomanauts" as Indian Space Research Organisation (ISRO) calls them), into low-Earth orbit for the first time. Before that happens, ISRO plans multiple uncrewed test flights, with Vyommitra on board.

During these test missions, Vyommitra will:

- Operate control panels and communicate with the ground station.
- Monitor environmental parameters such as cabin temperature, humidity, and oxygen levels.
- Perform switch operations and system checks.
- Deliver real-time status updates.
- Imitate human physiological responses using embedded sensors.

Vyommitra's ability to interact naturally will help ground teams study how onboard systems respond to human-like passenger conditions, ensuring the safety and reliability of future human missions. In the future, Vyommitra's technology could be adapted for use in satellites, planetary rovers, or even lunar habitats. Once fully validated, her systems could assist astronauts with complex maintenance or research tasks in microgravity environments. **So, Statement 2 is correct.**

ADDITIONAL INFORMATION:

VYOMMITRA	
Recently in the News	ISRO To Launch Half-Humanoid Vyommitra On Gaganyaan Mission In December 2025.
How She works? 	Vyommitra's design strikes a balance between functionality and familiarity. Here are a few things that she can do: ➤ Recognise and respond to human speech and commands in English and Hindi. ➤ Emulate human gestures, including head and limb movements. ➤ Identify various control panels using vision-based technology. ➤ Execute ISRO-programmed tasks autonomously or in coordination with mission control. Her AI module allows limited decision-making, mimicking cognitive responses to routine events or anomalies detected during flight. This autonomy is crucial for deep-space expeditions, where communication delays may impact real-time control.

90. Consider the following statements about the 'Fibre optic drone' that was recently in the news:

1. It is a type of Unmanned Aerial Vehicle that operates while connected to the ground through a fibre optic tether.
2. The use of fibre optic cable makes it extremely difficult to detect and target such drones with some counter-unmanned aircraft systems (c-UAS).
3. Although connected by an optical cable, the fibre optic drone can operate independently without ground control.

Which of the statements given above are correct?

(a) 1 and 2 only

(b) 2 and 3 only

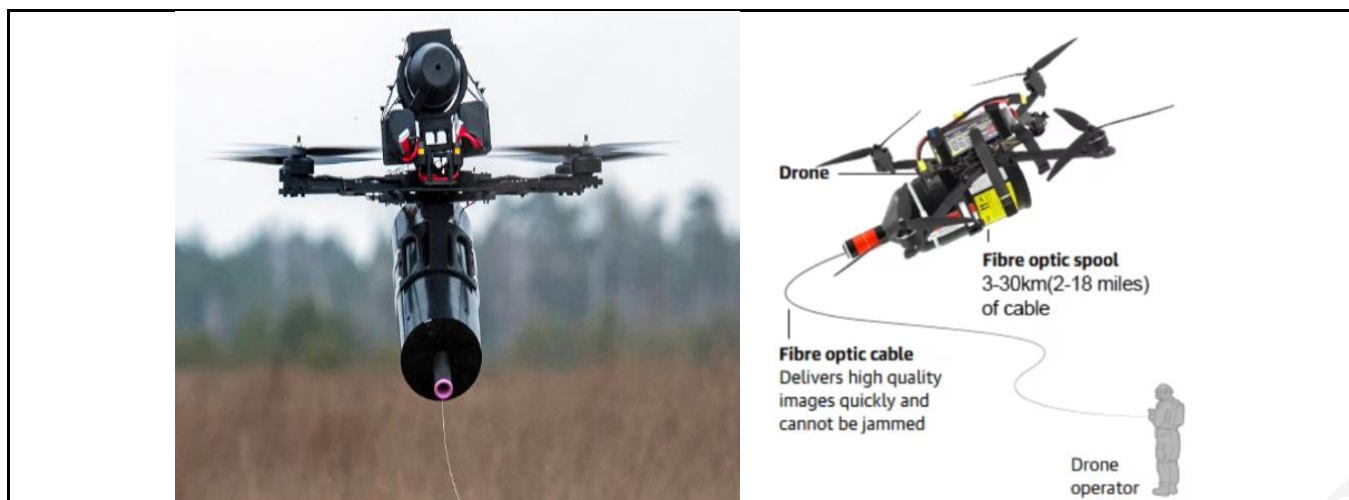
(c) 1 and 3 only

(d) 1, 2, and 3

EXPLANATION:

A fibre-optic drone is a type of Unmanned Aerial Vehicle that is connected to the operator by an ultra-thin fibre-optic cable instead of a radio link.

The tether, which can stretch over 20 km, carries high-speed data for control and video transmission. Because the connection is physical, these drones are immune to jamming and signal spoofing, allowing secure, precise, and reliable operation even in contested environments. **So, Statement 1 is correct.**



Fibre-optic drones use a thin, lightweight fibre-optic cable that unwinds from a spool as the drone flies, maintaining a high-speed link with the operator. Using a fibre-optic tether makes these drones difficult for some counter-UAS systems (unmanned aircraft systems) to detect or target. **So, Statement 2 is correct.**

Unlike regular drones that rely on radio frequencies for communication and onboard batteries for power, fibre optic drones receive both data connectivity and, often, electrical power through a tether. The fibre cable serves two critical functions:

- It enables extremely high-bandwidth data transfer with minimal latency.
- When paired with a powered tether system, it supplies the drone with continuous energy from a ground station.

The core purpose of a fibre optic drone is to maintain a secure, high-speed connection with the ground station through this tether. They cannot operate independently without ground support or external power. **So, Statement 3 is not correct.**

ADDITIONAL INFORMATION:

FIBER-OPTIC DRONES	
Recently in news	Recently, the fibre-optic drones have emerged as one of the deadliest threats on the battlefield in Ukraine.
First-Person View (FPV) drone	➤ A fibre optic drone can be referred to as an FPV (First-Person View) drone because its fibre optic cable provides the pilot with a real-time, high-quality video feed, allowing them to control the drone as if they were inside the aircraft. ➤ The term “FPV” specifically describes the immersive viewing experience from the drone’s perspective, rather than the type of communication link.
Advantages & disadvantages of fibre optic drones	Advantages: ➤ Stable, High-Quality Signal: Fibre optic links provide uninterrupted, high-bandwidth video and control, even in complex terrain. ➤ Stealth: No radio emissions make them harder to detect or track. ➤ Anti-Jamming: Immune to electronic warfare and signal interference. ➤ Long Endurance: Powered tether allows extended flight time without battery limitations. Disadvantages: ➤ Limited Range & Mobility: Tether length restricts distance and manoeuvrability. ➤ Snag Risk: Cables can get caught on trees, fences, or buildings. ➤ Payload Constraints: Cable weight limits speed and carrying capacity. ➤ Debris Issue: Broken fibre strands can clutter battlefields and pose hazards.

91. Consider the following statements:

1. Satellite Internet Services delivers wireless internet connectivity through communication satellites deployed in both Low and Medium Earth Orbit.
 2. India has traditionally relied on Geostationary Satellites (GSAT) of ISRO for satellite communication.
 3. In India, the Department of Space regulates the provision of satellite-based communication.
- How many of the statements given above is/are correct?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Satellite Internet Services, use satellites placed in Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) to provide wireless internet connectivity with lower latency and broader coverage compared to traditional geostationary satellites.

- LEO satellites orbit close to Earth, typically between 400 to 2,000 km altitude. Their proximity allows for low-latency communication, making them ideal for internet services.
- MEO satellites operate at altitudes ranging from 8,000 to 20,000 km. They cover larger regions than LEO satellites and have a slightly higher latency than LEO satellites. **So, Statement 1 is correct.**

India has traditionally relied on Geostationary Satellites (GSAT) of ISRO for satellite communication. Currently, India's satellite communication (Satcom) ecosystem is undergoing a transformative shift. The country is moving towards LEO and MEO-based satellite internet services to provide faster and more reliable broadband services nationwide.

Over 10 satellite operators, including the licensed Starlink, have entered India, with the private sector allowed up to 100% FDI. **So, Statement 2 is correct.**

In India, the Department of Telecommunications (DoT), under the Ministry of Communications, regulates satellite-based communication by granting authorisations under the Unified Licence Regime. This enables a variety of satellite services, such as Commercial VSAT CUG services and GMPCS (Global Mobile Personal Communication by Satellite).

These services complement terrestrial networks by extending connectivity to remote and unserved areas across the country. The Telecommunications Act, 2023, empowers the government to assign spectrum, enforce security requirements, and regulate satellite-based services as part of the broader telecom ecosystem.

So, Statement 3 is not correct.

ADDITIONAL INFORMATION:

SATELLITE COMMUNICATION	
Recently in news	India is moving towards LEO and MEO-based satellite internet services to deliver faster and more reliable broadband services nationwide.
Satellite Internet	➤ Satellite internet refers to the internet service provided through satellites placed in Geostationary Orbits (GSO) or Non-Geostationary Orbits (NGSO). ➤ For realising the Digital India vision of a digitally inclusive nation, satellite internet is an emerging technology with the potential to provide connectivity from space to any location. ➤ This makes it particularly valuable for remote villages, hilly terrains, border areas, and islands where terrestrial internet services are either difficult to reach or economically unviable.

Applications	Communications ➤ Provides reliable network access in remote regions. ➤ Supports the Internet of Everything (IoE), connecting devices globally. Transportation ➤ Enhances navigation systems. ➤ Supports autonomous/self-driving vehicles. ➤ Improves logistics and fleet management. Public Administration & Disaster Management ➤ Powers innovative city initiatives. ➤ Provides early warning systems for natural disasters. ➤ Coordinates rescue and relief operations efficiently. Healthcare ➤ Enables telemedicine services in remote locations. ➤ Supports remote patient monitoring and healthcare data management. Agriculture ➤ Facilitates precision farming techniques. ➤ Allows crop health monitoring and real-time farm management. Environmental Monitoring ➤ Tracks climate patterns and environmental changes. ➤ Monitors natural resources and pollution levels. Energy & Exploration ➤ Assists in oil, gas, and mineral exploration in remote areas. ➤ Supports operations in offshore and inaccessible regions. Tourism ➤ Provides internet connectivity in remote tourist destinations. ➤ Enables enhanced safety, navigation, and traveller services. Defence & Strategic Applications ➤ Supports secure communications and reconnaissance. ➤ Enhances situational awareness in remote or hostile areas. National & Global Importance ➤ Countries must integrate satellite internet into national resilience and digital development plans. ➤ Helps bridge the digital divide and foster economic development. ➤ Participation in international governance is crucial as mega-constellations shape global connectivity and strategic power.
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92. Consider the following statements with reference to the Gaganyaan mission:

1. It aims to send a three-member crew to an orbit of about 400 km for three days.
2. The first uncrewed mission will not have the environmental control and life support systems, and will ensure an earth-like environment inside the module.
3. The Crew Escape System is designed to protect the crew in case of an emergency during launch, but it cannot be used during re-entry.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

EXPLANATION:

Gaganyaan project envisages demonstration of human spaceflight capability by launching a crew of 3 members to an orbit of 400 km for a 3-day mission and bringing them back safely to Earth, by landing in the Indian sea waters.

The project is accomplished through an optimal strategy by considering in-house expertise, experience of Indian industry, intellectual capabilities of Indian academia & research institutions, along with cutting-edge technologies available with international agencies. **So, Statement 1 is correct.**

The first uncrewed mission, Gaganyaan-1 (G-1), which is scheduled for the fourth quarter of 2025, will demonstrate technology preparedness before the manned mission.

The unmanned mission will carry an unpressurised crew module to space and back. The G-1 mission's crew module will not have the Environment Control and Life Support System, which ensures an Earth-like environment inside the module. **So, Statement 2 is correct.**

The Crew Escape System is a fundamental safety mechanism incorporated into spacecraft to safeguard astronauts in the event of an emergency during launch or ascent.

- It is powered by a set of quick-acting, high burn rate solid motors, which ensure that the Crew Module, along with the crew, is taken to a safe distance in case of any emergency either at the launch pad or during the ascent phase.
- Its primary function is to swiftly and securely evacuate the crew from the spacecraft in the case of an abort, which could be triggered by various potential life-threatening situations or malfunctions.

Therefore, the crew escape system is designed for use during launch emergencies and not during re-entry. **So, Statement 3 is correct.**

93. The voices of men, women and children differ because:

- (a) The shape of their lungs differs
- (b) Their vocal cords differ in length and thickness**
- (c) Their eardrums vibrate differently under the same conditions
- (d) Their throats are of different sizes

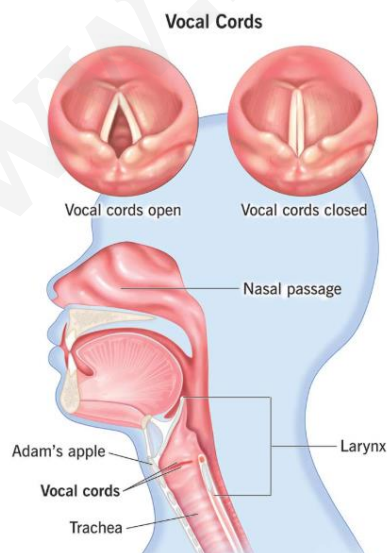
EXPLANATION:

Vocal cords, or vocal folds, are two muscular bands inside the voice box (larynx) that produce the sound of our voice. The length and thickness of the vocal cords determine the pitch of the voice. Thicker vocal cords produce a lower pitch, resulting in a deeper voice.

- In men, the vocal cords are about 20 mm long
- In women, they are about 15 mm long
- In newborns, they are about 6–8 mm long

This explains why men, women, and children have different voices. With age, the vocal cords and other muscles in the larynx may shrink and weaken, making it harder for some people to talk.

So, Option (b) is correct.



94. Consider the following:

1. Solution
2. Colloids
3. Suspension

How many of the above mixtures can be seen in naked eye?

- (a) Only one
(b) Only two
(c) All three
(d) None

EXPLANATION:

A solution is a homogeneous mixture of two or more substances. Example: Lemonade, soda water, etc.

- Usually, we think of a solution as a liquid that contains either a solid, a liquid or a gas dissolved in it. But we can also have solid solutions (alloys) and gaseous solutions (air).
- In a solution, there is homogeneity at the particle level.
 - **For example:** lemonade tastes the same throughout. This shows that particles of sugar or salt are evenly distributed in the solution.
- A solution has a solvent and a solute as its components.
 - The component of the solution that dissolves the other component in it (usually the component present in larger amounts) is called the solvent.
 - The component of the solution that is dissolved in the solvent (usually present in lesser quantity) is called the solute.

Properties of a Solution:

- The particles of a solution are smaller than 1 nm (10^{-9} metre) in diameter, so they cannot be seen with the naked eye. **So, Statement 1 is not correct.**
- Because of their very small size, solute particles do not scatter a beam of light passing through the solution, so the path of light is not visible.
- The solute particles cannot be separated from the mixture by filtration.
- Additionally, solute particles do not settle down when left undisturbed, meaning a solution is stable.

A colloid is a heterogeneous mixture. The particles of a colloid are too small to be seen with the naked eye. **Example:** Milk, fog, smoke etc. **So, Statement 2 is not correct.**

Properties of colloids:

- Colloidal particles are large enough to scatter a beam of light passing through them, making the path of light visible.
- Colloids do not settle down when left undisturbed, which means they are quite stable.
- The particles of a colloid cannot be separated by ordinary filtration, but they can be separated using a special technique called centrifugation.
- A colloidal system consists of two components: the dispersed phase and the dispersion medium.
- The dispersed phase refers to the solute-like particles suspended in the mixture, while the dispersion medium is the substance in which these particles are distributed.
- Colloids are classified based on the state (solid, liquid, or gas) of both the dispersed phase and the dispersion medium.

A suspension is a heterogeneous mixture in which the solute particles do not dissolve but remain suspended throughout the bulk of the medium. Particles of a suspension are visible to the naked eye.

Example: Muddy water, Dust in air, Chalk powder in water, etc.

Properties of a Suspension:

- Suspension is a heterogeneous mixture.
- The particles of a suspension can be seen with the naked eye. **So, Statement 3 is correct.**
- The particles of a suspension scatter a beam of light passing through it and make its path visible.

- The solute particles settle down when a suspension is left undisturbed; that is, a suspension is unstable.
- They can be separated from the mixture by the process of filtration.
- When the particles settle down, the suspension breaks and it does not scatter light anymore.

95. Match List-I with List-II and select the correct answer using the code given below the Lists:

	List-I (Naturally occurring acid)		List-II (Main source)
(A)	Methanoic acid	1.	Orange
(B)	Citric acid	2.	Tomato
(C)	Lactic acid	3.	Nettle sting
(D)	Oxalic acid	4.	Sour milk

Codes :

- (a) **A-3 B-1 C-4 D-2**
 (b) A-2 B-4 C-1 D-3
 (c) A-3 B-4 C-1 D-2
 (d) A-2 B-1 C-4 D-3

EXPLANATION:

Formic acid is also known as methanoic acid. Formic acid (HCO_2H), the simplest of the carboxylic acids, used in processing textiles and leather.

- The acid was named “formic acid” after the Latin word *formica*, meaning “ant”, because of its natural occurrence in the stings of ants and other insects.
- It is also found in the stinging hairs of nettles (A herbaceous plant which grows in the wild), as well as in some bee and wasp venoms. Hence, formic acid occurs naturally in various organisms that use it for defense. **A-3**
- Pure formic acid is a colourless, fuming liquid with a pungent odour; it irritates the mucous membranes and blisters the skin.

Citric acid ($\text{C}_6\text{H}_8\text{O}_7$), a colourless crystalline organic compound belonging to the family of carboxylic acids, present in practically all plants and in many animal tissues and fluids.

- It is one of a series of compounds involved in the physiological oxidation of fats, proteins, and carbohydrates to carbon dioxide and water.
- The natural source of Citric acid are Lemon, Orange, Amla and other citrus fruits. **B-1.**
- Citric acid was first isolated from lemon juice by Swedish chemist Carl Wilhelm Scheele in 1784 and is manufactured by fermentation of cane sugar or molasses in the presence of a fungus, *Aspergillus niger*.
- It is used in confections and soft drinks (as a flavouring agent), in metal-cleaning compositions, and in improving the stability of foods and other organic substances (by suppressing the deleterious action of dissolved metal salts).

Lactic acid ($\text{C}_3\text{H}_6\text{O}_3$), an organic compound belonging to the family of carboxylic acids, present in certain plant juices, in the blood and muscles of animals, and in the soil.

- It is the commonest acidic constituent of fermented milk products such as sour milk, cheese, and buttermilk. **C-4.**
- First isolated in 1780 by a Swedish chemist, Carl Wilhelm Scheele, lactic acid is manufactured by the fermentation of molasses, starch, or whey in the presence of alkaline substances such as lime or calcium carbonate.
- Lactic acid is used in tanning leather and dyeing wool; as a flavouring agent and preservative in processed cheese, salad dressings, pickles, and carbonated beverages; and as a raw material or a catalyst in numerous chemical processes.

- Pure lactic acid, rarely prepared, is a colourless, crystalline substance that melts at 18° C (64° F); it rapidly absorbs moisture from the atmosphere.

Oxalic acid ($C_2H_2O_4$), a colourless, crystalline, toxic organic compound belonging to the family of carboxylic acids.

- The natural source of the Oxalic acid is tomato. **D-2.**
- Oxalic acid is widely used as an acid rinse in laundries, where it is effective in removing rust and ink stains because it converts most insoluble iron compounds into a soluble complex ion.
- For the same reason, it is the chief constituent of many commercial preparations used for removing scale from automobile radiators.

Therefore, the correct match of List I with List II is A-(Methanoic Acid-needles)

List-I

(Naturally occurring acid) - List-II (Main source)

Methanoic acid - Nettle sting

Citric acid - Orange

Lactic acid -

Oxalic acid

96. Which one among the following statements about the Aqua regia is correct?

- (a) It's a mixture of concentrated Hydrochloric acid and concentrated nitric acid in the ratio of 3:1.
- (b) It is a reagent to dissolve gold and platinum.
- (c) It is a highly corrosive and fuming liquid
- (d) All the above statements are correct.**

EXPLANATION:

Aqua regia, mixture of concentrated hydrochloric and nitric acid, usually three parts of the former to one part of the latter by volume (3:1 ratio). This mixture was given its name (literally, "royal water") by the alchemists because of its ability to dissolve gold. It is a red or yellowish liquid.

- Aqua regia is a highly corrosive, fuming liquid and can cause skin burns.
- Aqua regia is frequently used to dissolve gold and platinum. It and other similar mixtures are used in analytical procedures for the solution of certain iron ores, phosphate rocks, slags, nickel-chromium alloys, antimony, selenium, and some of the less-soluble sulfides, such as those of mercury, arsenic, cobalt, and lead. **So, Option (d) is correct.**

97. With reference to Chandrayaan-3 and Chandrayaan-2, consider the following statements:

- Both were placed in the lunar orbit using the Polar Satellite Launch Vehicle.
- Other than India, the USA and China are the only countries to have landed a spacecraft on the moon.
- Chandrayaan-3 made India the first country to land a spacecraft on the south pole region of the Moon.

How many of the above statements is/are correct?

- (a) **Only one**
- (b) Only two
- (c) All three
- (d) None

EXPLANATION:

Chandrayaan-2: Launched on July 22 2019, by GSLV Mk III from Sriharikota, it aimed to explore the Moon's surface and atmosphere.

The mission included an Orbiter, Lander (Vikram), and Rover (Pragyan). While the Orbiter successfully continues to study the Moon from orbit, the Lander unfortunately lost communication during the descent.

The mission provided valuable experience in lunar orbit operations and deep-space navigation.

Chandrayaan-3: This is a follow-up mission designed to demonstrate safe landing and rover operations on the Moon.

- It includes a Lander, Rover, and Propulsion Module and was successfully launched by GSLV Mk III.
- Chandrayaan-3 made India the first country to land near the Moon's south pole, with the Rover performing experiments and in-situ chemical analysis of the lunar surface.
- Both Chandrayaan-2 and Chandrayaan-3 were placed in lunar orbit using GSLV Mk III (Also known as Launch Vehicle Mark-3), not PSLV. **So, Statement 1 is not correct, and Statement 3 is correct.**

India is the fourth country to achieve a soft landing on the Moon. Before India, Russia, the United States, and China had successfully soft-landed spacecraft.

Russia (USSR): On September 12 1959, the USSR became the first country to land on the Moon (hard landing). It achieved its first soft landing in 1966.

United States: In 1966, the US achieved its first soft landing. The US has the most soft landings (11) and is the only country to have sent 12 astronauts to the Moon through six missions.

China: In 2013, China became the third country to land on the Moon. On January 3 2019, it became the first country to land a rover on the Moon's far side. **So, Statement 2 is not correct**

98. With reference to Mangalyaan (Mars Orbiter Mission), consider the following statements:

1. It was India's first deep-space mission.
2. It carried only three payloads, namely the Mars Color Camera, the Thermal Infrared Imaging Spectrometer, and the Mars Exospheric Neutral Composition Analyzer.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) **Neither 1 nor 2**

EXPLANATION:

The Mars Orbiter Mission (MOM), also known as Mangalyaan, was India's first interplanetary mission and was launched on November 5, 2013, on board PSLV-C25.

- With this mission, India became the fourth space agency in the world to successfully send a spacecraft to orbit Mars.
- Although the mission was designed to last for six months, MOM exceeded expectations, completing more than seven years in orbit as of September 24, 2021.
- Though Mangalyaan was India's first interplanetary mission, it is not technically India's first deep-space mission. That distinction goes to Chandrayaan-1, which confirmed the presence of water molecules on the Moon, making it India's first deep-space mission. **So, Statement 1 is not correct.**

The Indian Mars Orbiter Mission carried the following five scientific payloads:

- **Mars Colour Camera (MCC):** The main objectives of the Mars Colour Camera are:
 - To map various morphological features on Mars at different resolutions and scales in its elliptical orbit.

- To provide contextual information for the other scientific payloads.
- **Thermal Infrared Imaging Spectrometer (TIS):** The Thermal Infrared Imaging Spectrometer is a grating-based spectrometer that measures thermal emission from the Martian surface. The data acquired by TIS is processed and analysed to:
 - Map the temperature of the Martian surface.
 - Study the composition and mineralogy of Mars.
- **Methane Sensor for Mars (MSM):** The primary scientific objective of MSM is to detect and measure methane concentration in the Martian atmosphere (if present) under clear sky conditions.
- **Mars Exospheric Neutral Composition Analyser (MENCA):** The main scientific objective of MENCA is to study the neutral composition and density distribution of the Martian exosphere. It also aims to investigate radial, diurnal, and possibly seasonal variations, which help in understanding the escape of the Martian atmosphere.
- **Lyman Alpha Photometer (LAP):** LAP is designed to measure hydrogen and deuterium levels in the Martian upper atmosphere, providing insights into the history of water loss on Mars. **So, Statement 2 is not correct.**

99. Consider the following statements:

Statement-I: The density of liquids is nearly constant at all pressures.

Statement II: Liquids are incompressible.

Which of the following is correct in respect of the above statements?

- (a) **Both Statement-I and Statement-II are correct, and Statement-II is the correct**

Explanation for Statement-I.

- (b) Both Statement-I and Statement-II are correct and Statement-II is not the correct Explanation for Statement-I
- (c) Statement-I is correct but Statement-II is incorrect
- (d) Statement-I is incorrect but Statement-II is correct

EXPLANATION:

A liquid, like a solid, has its own characteristic density. The density of a liquid is the amount of mass it contains in a given volume.

$$\text{Density } (\rho) = \text{Volume } (V) / \text{Mass } (m)$$

The density of a liquid depends on how closely its molecules are packed together. Liquids are largely incompressible, and their volume does not change significantly with pressure.

This is because their molecules are already packed closely together, leaving very little empty space for them to be pushed closer. Therefore, their density remains nearly constant at all pressures. **Both Statement-I and Statement-II are correct, and Statement-II is the correct Explanation for Statement-I.**

ADDITIONAL INFORMATION:

DENSITY OF LIQUID	
About	Density is a fundamental physical property that measures the "compactness" of matter within a substance and is defined as mass per unit volume. For liquids, density is typically expressed in grams per milliliter (g/mL). The density of a liquid is a characteristic property, meaning it remains constant regardless of the sample size, making it useful for identifying unknown substances. ➤ If we measure equal volumes of two different liquids, the one that weighs more is denser. This is because the density of a liquid is a measure of how heavy the liquid is for a given amount or volume.

	➤ If a liquid less dense than water is gently added to the surface of water, it will float. Conversely, if a liquid denser than water is added to the surface, it will sink. Example: ➤ Water vs. Oil: Water has a higher density than oil. That's why oil floats on water. ➤ Water vs. Honey: Honey is denser than water, so honey sinks below water.
Pascal's Law	➤ Pascal's Law states that when pressure is applied to a confined fluid, it is transmitted equally and undiminished in all directions. ➤ This works because liquids are nearly incompressible and their molecules are already packed closely together, leaving very little space to be squeezed. ➤ As a result, when a force is applied at one point in the liquid, it cannot compress the liquid much, so the pressure is passed on fully and evenly to every part of the fluid and the walls of the container. ➤ This principle allows small forces applied on one area of a liquid to generate larger forces elsewhere, which is the basis for hydraulic systems like lifts, presses, and brakes.

100. Consider the following pairs regarding Newton's Laws of Motion :

S.no	Law	Principle	Application
1.	First law	Law of inertia	Catching a fast-moving cricket ball
2.	Second law	Rate of change of momentum is proportional to the applied force	A passenger jerks backward when a bus starts suddenly
3.	Third law	Action and Reaction are equal and opposite	Recoil of a gun

How many of the rows given above is/ are **not** correctly matched?

- (a) Only one
(b) **Only two**
(c) All three
(d) None

EXPLANATION:

Newton's First Law states that every object will remain at rest or move in a straight line with uniform velocity unless acted upon by an external force. This tendency to resist changes in motion is called inertia.

If all external forces on an object cancel out, there is no net force, and the object will maintain a constant velocity.

Example of Newton's first law:

- When a motorcar brakes suddenly, we tend to lurch forward because our body continues in its state of motion due to inertia, while the car slows down.
- When a bus starts suddenly, we tend to fall backward because our feet move with the bus floor, but the rest of our body resists motion.
- During a sharp turn at high speed, we are thrown to one side. The motorcar changes direction due to an unbalanced force from the engine, but our body continues in straight-line motion due to inertia, causing us to slip to one side.

Catching a fast-moving cricket ball is an example of Newton's Second Law in action (not first law). **So, Row 1 is not correct.**

Newton's Second Law states that the force acting on an object is equal to the rate of change of its momentum with respect to time.

The momentum (p) of an object is defined as the product of its mass (m) and velocity (v).

$$P = mv$$

Momentum has both direction and magnitude. Its direction is the same as that of velocity. The SI unit of momentum is kilogram-metre per second (kg m s^{-1}).

Examples of Newton's second law:

- When you press the gas pedal in a car, you are applying a force to the car, causing it to accelerate forward. The more force you apply (by pressing the pedal harder), the greater the acceleration will be.
- When you throw a ball, you are applying a force to it, causing it to accelerate in the direction you throw it. The harder you throw the ball (applying more force), the faster it will accelerate.
- A rocket engine exerts a force on the rocket, propelling it forward. The more powerful the rocket engine (applying more force), the greater the acceleration of the rocket will be.

A passenger jerks backward when a bus starts suddenly is an application of Newton's first law of motion (not second law). **So, Row 2 is not correct.**

Newton's third law of motion states that when one object exerts a force on another object, the second object instantaneously exerts a force back on the first. These two forces are always equal in magnitude but opposite in direction. These forces act on different objects and never on the same object.

Examples of Newton's third law:

- When a gun is fired, it exerts a forward force on the bullet. The bullet exerts an equal and opposite force on the gun. This results in the recoil of the gun. Since the gun has a much greater mass than the bullet, the acceleration of the gun is much less than the acceleration of the bullet. **So, Row 3 is correct.**
- When a sailor jumps out of a rowing boat. As the sailor jumps forward, the force on the boat moves it backwards.
