

Q.5)

Exp) Option a is the correct answer.

Humoral Immunity and cell-mediated immunity are two branches of the adaptive or acquired immune system, which is responsible for recognizing and defending against specific pathogens and antigens. They work together to provide a comprehensive defense against a wide range of threats.

Statement 1 is incorrect: In Humoral immunity, when foreign material - antigens - is recognized in the body, the body responds with an antibody-mediated reaction. B cell lymphocytes, a type of immune cell that makes antibodies after detecting a specific antigen, are principally responsible for this method.

Cell-mediated immunity, unlike humoral immunity, does not rely on antibodies to perform adaptive immunological activities. Mature T cells, macrophages, and the production of cytokines in response to an antigen are the main drivers of cell-mediated immunity.

Statement 2 is incorrect: Both **Humoral immunity and Cell-mediated immunity are acquired immunity.** Innate immunity is a non-specific type of defense, that is present at the time of birth. Acquired immunity, on the other hand, is pathogen specific. It is characterised by memory.

Statement 3 is correct: Humoral and cell-mediated immunity work together to provide a comprehensive defense against pathogens. **Antibodies produced by humoral immunity can aid cell-mediated immunity by opsonizing pathogens (process of coating pathogens with specific molecules called opsonins, which makes them more recognizable and easier for immune cells to engulf and destroy).** T cells, on the other hand, can help humoral immunity by activating B cells to produce antibodies and by providing signals that promote antibody class switching.

Q.10)

Exp) Option c is the correct answer.

Missile is a weapon that is self-propelled or directed by remote control, carrying conventional or nuclear explosive. There are two major types of Missiles- Ballistic and Cruise.

Statement a is incorrect. Cruise missile flies within earth's atmosphere and uses jet engine technology. Cruise missiles are known specifically for low-level flight which is staying relatively close to the surface of the earth to avoid detection from anti-missile systems. Ballistic missile travels well outside earth's atmosphere. They are launched directly into the upper layers of the earth's atmosphere. They travel outside the atmosphere, where the warhead detaches from the missile and falls towards a predetermined target.

Statement b is incorrect. Payload capacity is limited in Cruise missiles. Cruise missile usually carries a single payload while Ballistic missiles can carry more than one payload (Multiple Independently targetable Re-entry Vehicle).

Statement c is correct. Both ballistic missiles and cruise missiles can be launched from aircraft, ships, and submarines in addition to land-based silos and mobile platforms.

Statement d is incorrect. Prithvi, Agni, Dhanush range missiles are Ballistic while BrahMos and Nirbhay missiles are cruise missiles.

Q.13)

Exp) Option b is the correct answer.

Option a is incorrect: Pressurised Heavy Water Reactor commonly uses heavy water (Deuterium oxide D₂O) as its coolant and moderator. While some SMRs are essentially pressurised water reactors which use heavy water as coolant, other SMRs use sodium, lead, gas or salt as a coolant instead of water.

Option b is correct: Small Modular Reactors (SMR) are much cheaper and quicker to get running than standard plants. The International Atomic Energy Agency (IAEA) defines Small Modular Reactors as nuclear power stations producing nuclear energy under 300 megawatts electrical (MWe). SMRs are considered as a more efficient alternative to older model mega-plants in terms of achieving energy

security. Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants.

Option c is incorrect: Like every other nuclear reactor, SMRs too can succumb to the seismic activity such as earthquakes and Tsunami.

Option d is incorrect: Plutonium-239 and uranium-235 are the most common isotopes used in nuclear weapons. SMRs too can be used to enrich the Uranium to produce nuclear weapons. Activists raised the concern that the proliferation of SMRs across the world will increase the risk of various countries producing nuclear weapons or its reactor being captured by terrorists for malicious purpose.

Q.14)

Exp) Option a is the correct answer.

The formation of glittering colors in thin foam of soap is the result of total reflection and interference of light.

Total reflection: Total Internal reflection is involved in the formation of glittering colors in thin soap film because it allows the light waves to travel through the film multiple times before being reflected back. This **increases the distance that the light waves travel and allows for more interference to occur.**

Interference: When light shines on a thin film of soap, the light is reflected from both the front and back surfaces of the film. **The two reflected waves interfere with each other, and the color of the light that is seen depends on the thickness of the film.** If the film is thick enough, the two reflected waves will destructively interfere, and all of the light will be cancelled out. However, **if the film is thin enough, the two reflected waves will constructively interfere, and certain colors of light will be seen.** The different colors that are seen in soap foam are due to the different thicknesses of the film. **The thicker parts of the film will reflect longer wavelengths of light, such as red and orange. The thinner parts of the film will reflect shorter wavelengths of light, such as blue and green.**

Q.17)

Exp) Option a is the correct answer.

Thorium is a weakly radioactive metallic chemical element. Thorium has high thermal conductivity and higher melting point.

Statement 1 is correct. Nearly 25 per cent of the world's thorium ore is available in India. India's reserves of thorium are at least three times larger than its uranium reserves. India's thorium deposits, estimated at 360,000 tonnes, far outweigh its natural uranium deposits at 70,000 tonnes.

Statement 2 is incorrect. Thorium itself will not split and release energy. Thorium is fertile rather than fissile, which means reactions can be stopped when necessary. It can only be used as a fuel in conjunction with a fissile material such as recycled plutonium. It needs to undergo transmutation to U-233 in a reactor fuelled by other fissile material. It produces waste products that are less radioactive, and generates more energy per tonne.

Q.19)

Exp) Option a is the correct answer.

Nuclear reactors generate energy through fission, the process by which an atomic nucleus splits into two or more smaller nuclei. During fission, a small amount of mass is converted into energy, which can be used to power a generator to create electricity.

Statement 1 is incorrect. The Pressurised Heavy Water Reactors (PHWRs) uses natural Uranium as fuel. PHWRs not only produce energy from natural uranium but also produce fissile plutonium (Pu)-239. The Fast Breeder Reactors (FBRs) use plutonium-239 (and not thorium) for generating electricity. Once a sufficient amount of plutonium-239 is built up, thorium will be used in the reactor, to produce Uranium-233.

Statement 2 is correct. PHWR uses heavy water (deuterium oxide D₂O) as its coolant and neutron moderator. The heavy water coolant is kept under pressure, allowing it to be heated to higher temperatures without boiling. The heavy water creates greatly enhanced neutron economy, allowing the reactor to operate without fuel-enrichment facilities (offsetting the additional expense of the heavy water) and enhancing the ability of the reactor to make use of alternate fuel cycles. FBRs do not have a neutron moderator, and use less-moderating coolants such as liquid sodium, so its neutrons remain high-energy. Breeder reactors use a small core, which is important to sustain chain reactions. Statement 3 is incorrect. The increased rate of fuel movement through the PHWR results in higher volumes of spent fuel. However, fast reactors have the potential to produce less radioactive waste because fuel is highly enriched in fissile material. There is no need of large quantity of fuel materials for the annual external feed in FBR and thus eliminates the need for large capacity waste storage spaces with complex construction features.

Q.20)

Exp) Option b is the correct answer.

Option a is incorrect: Pressurised Heavy Water Reactor commonly uses heavy water (Deuterium oxide D₂O) as its coolant and moderator. While some SMRs are essentially pressurised water reactors which uses heavy water as coolant, other SMRs uses sodium, lead, gas or salt as a coolant instead of water.

Option b is correct: Small Modular Reactors (SMR) are much cheaper and quicker to get running than standard plants. The International Atomic Energy Agency (IAEA) defines Small Modular Reactors as nuclear power stations producing nuclear energy under 300 megawatts electrical (MWe). SMRs are considered as a more efficient alternative to older model mega-plants in terms of achieving energy security. Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants.

Option c is incorrect: Like every other nuclear reactor, SMRs too can succumb to the seismic activity such as earthquakes and Tsunami.

Option d is incorrect: Plutonium-239 and uranium-235 are the most common isotopes used in nuclear weapons. SMRs too can be used to enrich the Uranium to produce nuclear weapons. Activists raised the concern that the proliferation of SMRs across the world will increase the risk of various countries producing nuclear weapons or its reactor being captured by terrorists for malicious purpose

Q.26)

Exp) Option b is the correct answer.

Nuclear reactors work by using the heat energy released from splitting atoms of certain elements to generate electricity. The energy released from continuous fission of the atoms of the fuel is harnessed as heat in either a gas or water, and is used to produce steam. The steam is used to drive the turbines which produce electricity.

Pair 1 is correct: A Boiling Water Reactor uses **normal water as both coolant and moderator**, like in Pressurised Water Reactor (PWR). Unlike the PWR, it is characterised by one section with low pressure, where a section of the coolant turns into steam and goes to the turbine directly to create energy. It uses Enriched Uranium as fuel. It is used mainly in the USA, Japan, and Sweden.

Pair 2 is incorrect: A Pressurised Heavy Water Reactor (PHWR) uses Heavy Water (D₂O) as coolant and moderator. It **uses natural Uranium (not Plutonium) as fuel**. Hence this pairing is incorrect. It is mainly used in Canada and India.

Pair 3 is correct: Fast Neutron Reactor (FNR) **uses liquid sodium as coolant, and unlike all other nuclear reactors, doesn't use a Moderator at all**. It uses a mixture of Plutonium & enriched Uranium as fuel. It uses the fast neutrons released in the reaction to generate power from plutonium while converting Plutonium into Uranium, thus creating more fuel while creating energy. This is why they are also known as Fast Breeder Reactors. India doesn't have the technology as of now, but is working

on getting it as a future phase of its civilian nuclear program. They are very costly to build. They are used by Russia.

Pair 4 is incorrect: High Temperature Gas Cooled reactors **use Helium (not CO₂) as coolant and Graphite as moderator.** Hence this pairing is incorrect. It is the Advanced Gas Cooled Reactor that uses carbon dioxide as coolant and Graphite as moderator.

Q.30)

Exp) Option a is the correct answer.

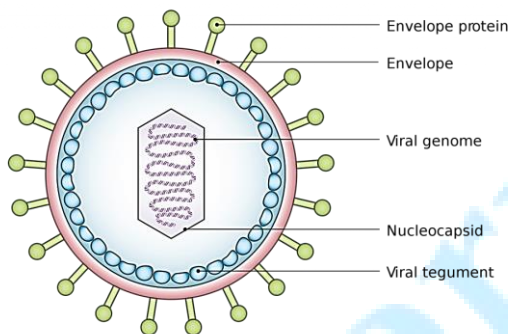
Proof of stake is a consensus mechanism used to verify new cryptocurrency transactions. Since blockchains lack any centralized governing authorities, proof of stake is a method to guarantee that data saved on the network is valid. A consensus mechanism is a method for validating entries into a distributed database and keeping the database secure that is a blockchain. Proof-of-stake reduces the amount of computational work needed to verify blocks and transactions.

Q.32)

Exp) Option a is the correct answer.

Viruses are microscopic infectious agents that are incapable of independent life. They can only replicate and carry out their life cycle within the host cells of living organisms. Viruses are diverse and can infect various forms of life, including animals, plants, bacteria, archaea, fungi, and other microorganisms.

Structure of Virus

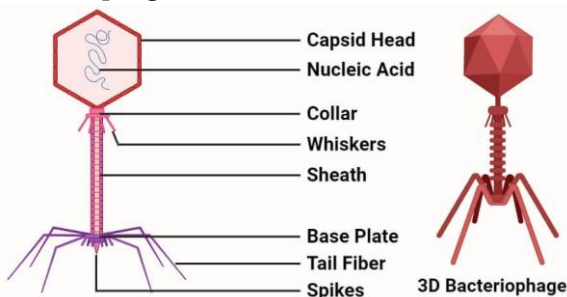


Statement 1 is incorrect. In general viruses **contain either RNA or DNA in a single virion.** Viruses are generally classified based on the **type of genetic material they use**, either DNA or RNA with one exception i.e Leuko virus. It is a retrovirus also called RNA-DNA virus. This virus possesses reverse transcriptase. This enzyme builds DNA over RNA genome.

Statement 2 is incorrect. Viruses can **infect both animal cells and plant cells.** Viruses are pathogens that are known to infect a wide range of organisms, including animals, plants, bacteria, fungi, and even archaea.

Statement 3 is correct. **Bacteriophages** are the viruses that kill bacteria. Bacteriophages are the most abundant and diverse biological entities on Earth, playing a crucial role in shaping bacterial populations and influencing ecosystems.

Bacteriophages



Knowledge Base:

Applications of Bacteriophages in Biotechnology:

Bacteriophages have applications in various fields, including biotechnology. They are used in phage therapy as natural antibacterial agents against specific bacterial infections. Additionally, phages are employed in molecular biology techniques, such as phage display, to study protein-protein interactions and identify specific proteins

Q.33)

Exp) Option b is the correct answer.

Haemophilia is a genetic disorder that impairs the body's ability to make blood clots, a process needed to stop bleeding. It is usually inherited from one's parents through an X chromosome carrying a nonfunctional gene. The genes for clotting factors VIII and IX are located on the X chromosome, so males have only one copy of these genes while females have two copies. This means that if a male inherits a haemophilia allele (a variant of the gene) on his only X chromosome, he will have the disorder. A female with a haemophilia allele on one X chromosome usually has a normal allele on her other X chromosome that can produce normal clotting factor, so she has some protection against having haemophilia. A female with one haemophilia allele and one normal allele is called a carrier.

Therefore, the correct answer to the question is (b) i.e., the Women are the carrier of the disease and it appears in men. This is because women can carry the haemophilia allele and pass it on to their sons, who will have haemophilia.

Q.34)

Exp) Option b is the correct answer.

Statement 1 is incorrect. U-235 cannot be used directly to produce electricity they have to undergo enrichment process before being used to generate electricity.

Statement 2 is incorrect. Nuclear fusion-based power plant is presently not in operation for meeting the energy needs. However, some nuclear fusion-based power plants are under construction around the world. More common ones are the nuclear fission plants.

Statement 3 is correct. Water, solid graphite and heavy water are used as a moderator in nuclear reactors.

Statement 4 is correct. Nuclear technology can be used in medical diagnosis and treatment. It can also be used in different industries for different purposes such as in the irradiation of food, sterilization of disposable products etc

Q.35)

Exp) Option b is the correct answer.

Directed Energy Weapons (DEWs) are a ranged weapon that damages its target with highly focused energy without a solid projectile, including lasers, microwaves, particle beams and sound beams. Hypersonic weapons are weapons capable of travelling at hypersonic speed, defined as between five and 25 times the speed of sound.

Statement 1 is correct: DEWs use directed energy in the form of laser, microwave, or particle beams to destroy targets. These weapons are designed to damage or destroy targets by emitting highly focused energy in the form of lasers, microwaves, or particle beams.

Statement 2 is incorrect: DEWs can be expensive to produce and maintain compared with traditional kinetic weapons as they require complex and advanced technology.

Statement 3 is correct: Hypersonic weapons are weapons that can travel at speeds of Mach 5 to Mach 10, which is five to ten times the speed of sound. These weapons can be used to strike targets with high precision and at long ranges.

Statement 4 is incorrect: Hypersonic cruise weapons are highly manoeuvrable and able to change course during flight. They are different from ballistic missiles, which can also travel at hypersonic speeds (of at least Mach 5) but have set trajectories and limited manoeuvrability

Q.38)

Exp) Option c is the correct answer.

Statement 1 is correct. Microwave weapons aim highly focused energy in the form of sonic, laser, or microwaves directly at a target.

Statement 2 is correct. Microwave weapons use a focused beam of high-frequency electromagnetic radiation to heat the water in a human target's skin, causing pain and discomfort. The process is similar to microwave oven where electromagnetic waves are used to agitate the water molecules in the food and the vibration produces heat which cooks the food.

Q.44)

Exp) Option b is the correct answer.

Statement 1 is correct- When a fissile nucleus, such as **uranium-235**, absorbs a neutron, it splits into **two smaller nuclei** and **releases two or three neutrons**. This process is called **nuclear fission**. The neutrons released in nuclear fission can then go on to split other fissile nuclei, creating a chain reaction.

Statement 2 is incorrect- The neutrons released in nuclear fission are **fast neutrons**. Fast neutrons are **less likely to cause fission than slow neutrons**. This is because fast neutrons are more likely to escape from the reactor before they can split a fissile nucleus.

Statement 3 is correct- **Graphite** is a material that is used to **slow down fast neutrons**. This makes it more likely that the neutrons will **split into a fissile nucleus**, which helps to sustain the chain reaction.

Statement 4 is incorrect- Not every neutron released in a fission reaction initiates further fission. Some neutrons may **escape from the reactor**, and others may be **absorbed by non-fissile materials** in the reactor.

Q.46)

Exp) Option d is the correct answer.

Recently, Russia has delivered a letter to the United Nations claiming that Ukraine is preparing to detonate a dirty bomb on its territory. The allegations, however, have been denied by Ukraine.

Option d is the correct: A **dirty bomb** also known as a radiological dispersal device is a weapon that **combines conventional explosives like dynamite and radioactive material** such as uranium.

1) The primary objective of a dirty bomb is to **create panic, confusion and anxiety** by hurling radioactive dust and smoke into the atmosphere. Hence, it has been long feared as a potential weapon of terrorists.

2) A dirty bomb doesn't need to contain highly refined radioactive material, as is used in a nuclear bomb. Instead, it could use radioactive materials from hospitals, nuclear power stations or research laboratories. This makes them much cheaper and quicker to make than nuclear weapons.

Option a is incorrect: A thermobaric bomb is a type of explosive that utilizes oxygen from the surrounding air to generate an intense, high-temperature explosion, and in practice the blast wave typically produced by such a weapon is of a significantly longer duration than that produced by a conventional condensed explosive. The fuel-air bomb is one of the best-known types of thermobaric weapons.

Option b is incorrect: Space weapons are weapons used in space warfare. They **include weapons that can attack space systems in orbit** (i.e., anti-satellite weapons), attack targets on the earth from space or disable missiles travelling through space.

Option c is incorrect: A thermonuclear weapon, **fusion weapon or hydrogen bomb** (H bomb) is a second-generation nuclear weapon design. Its greater sophistication affords it vastly greater destructive power than first-generation nuclear bombs, a more compact size, a lower mass, or a combination of these benefits.

Q.54)

Exp) Option c is the correct answer.

A **Fractional Orbital Bombardment System (FOBS)** is a **warhead delivery system** that uses a **low Earth orbit** towards its target destination. Just before reaching the target, it deorbits through a **retrograde engine burn**. FOBS was first developed by the **Soviet Union** in the **1960s** as a **nuclear-weapons delivery system**. It was one of the first Soviet efforts to use space to deliver nuclear weapons. In August 2021, the **People's Republic of China** tested a weapon that combined a FOBS with a **hypersonic glide vehicle**.

Important Tips Advantage and Disadvantage of FOBS:

Advantage	Disadvantage
No range limit	Very complex to develop and deploy
Flight path would not reveal the target location	Vulnerable to attack by anti-satellite weapons
Warheads could be directed to North America over the South Pole, evading detection by NORAD's north-facing early warning systems	Violates the Outer Space Treaty, which prohibits the placement of weapons of mass destruction in orbit

What is retrograde engine burn?

A retrograde engine burn is a maneuver in which a spacecraft fires its engines to **slow down** and move in the **opposite direction of its travel**. This can be done for a variety of reasons, such as to enter orbit around a planetary body, to rendezvous with another spacecraft, or to deorbit a spacecraft. The Apollo spacecraft used retrograde engine burns to enter orbit around the Moon and to return to Earth.

Q.56)

Exp) Option b is the correct answer.

- Haemophilia is a genetic disease** that affects the blood clotting process. This causes unexplained bleeding, pain, swelling or tightness in joints, blood in urine or stool, and nose bleeds. Haemophilia is caused by a defect in the gene that determines how the body makes factors VIII, IX or XI, which are proteins that help the blood to clot.
- Diabetes is a hormonal disorder** that occurs when the body cannot produce or use insulin properly. Insulin is a hormone that helps the cells to take up glucose from the blood and use it for energy. When insulin is deficient or ineffective, glucose accumulates in the blood, causing high blood sugar levels. This can damage various organs and tissues in the body and lead to serious health problems.
- Rickets is a deficiency disease** that results from a lack of vitamin D, calcium, or phosphate. These nutrients are essential for the growth and development of bones and teeth. Vitamin D helps the body to absorb calcium and phosphate from food and sunlight. When these nutrients are insufficient, the bones become soft and weak, leading to abnormal bone growth and deformities.
- Ringworm is a fungal infection** that causes a red, scaly, itchy rash on the skin or scalp. Ringworm is not caused by a worm but by a type of fungus called dermatophytes that live on the dead tissues of the skin, hair and nails. Ringworm can affect different parts of the body and has different names depending on its location.

Q.60)

Exp) Option a is the correct answer.

Statement 1 is correct: Jet engines, whether turbojet or turbofan, rely on the intake of air from the surrounding atmosphere for their combustion process. They compress this air, mix it with fuel, ignite it, and expel it at high velocity to generate thrust. In the vacuum of space, there is no air to intake, making jet engines unsuitable for propulsion in space.

Statement 2 is incorrect: Rockets do carry their own supply of fuel, which includes both a fuel source and an oxidizer. However, the oxidizer used in rockets is typically in the form of a chemical compound, such as liquid oxygen (LOX), rather than gaseous oxygen. Rockets combine their fuel and oxidizer internally and do not rely on the surrounding atmosphere for combustion, which allows them to operate in the vacuum of space.

Important Tips Jet Engine vs Rocket:

Characteristic	Jet Engine	Rocket Engine
Type of engine	Air-breathing	Non-air-breathing
Propulsion system	Thrust generated by pushing air backwards	Thrust generated by expelling propellant backwards
Fuel	Jet fuel	Rocket fuel
Efficiency	High	Low
Complexity	High	Simple
Applications	Airplanes, helicopters	Spacecraft, missiles