ForumIAS

Prelims Marathon

May, 2026

HISTORY
ECONOMICS
POLITY
SCIENCE AND TECHNOLOGY
GEOGRAPHY AND ENVIRONMENT

INDEX

Biotechnology Applications-II

1. Consider the following statements regarding the regulation of Genetically Modified (GM) organisms in India:

1. The primary rules governing the management of GMOs were notified in 1989 under the Environment Protection Act (EPA), 1986.
2. The Genetic Engineering Appraisal Committee (GEAC) functions under the aegis of the Ministry of Science and Technology.
3. GEAC is responsible for the appraisal of activities involving large-scale use of hazardous microorganisms and recombinants from an environmental perspective.

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

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** The Rules for Manufacture, Use, Import, Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells were notified in 1989 under EPA, 1986.
- **Statement 2 is incorrect:** GEAC functions under the Ministry of Environment, Forest and Climate Change (MoEF&CC), not the Ministry of Science and Technology.
- **Statement 3 is correct:** It is the apex body in India for the environmental clearance of GMOs.

2. Consider the following statements regarding medical applications of biotechnology:

1. Recombinant insulin is produced by inserting human insulin genes into bacteria, replacing the traditional method of extracting it from slaughtered animals.
2. Gene therapy aims to treat genetic disorders, such as Adenosine Deaminase (ADA) deficiency, by introducing functional genes into the patient.
3. The Hepatitis B vaccine is produced using traditional weakened-virus methods, making it distinct from recombinant DNA-based vaccines.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** These represent the core of biopharmaceutical advancements.
- **Statement 3 is incorrect:** The Hepatitis B vaccine is a recombinant DNA vaccine produced using yeast cells. It was the first human vaccine produced through genetic engineering.

3. Consider the following statements:

1. Monoclonal antibodies are identical lab-made antibodies produced by fusing B cells with myeloma cells via hybridoma technology.
2. Monoclonal antibodies target multiple different epitopes of an antigen simultaneously to ensure a broad immune response.

3. Stem cell therapy involves using specialized cells to regenerate damaged tissues in conditions like Parkinson's disease and spinal cord injuries.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** This describes the standard hybridoma technique.
- **Statement 2 is incorrect:** Monoclonal antibodies are highly specific; they target a single antigen epitope, not multiple ones. (Polyclonal antibodies target multiple epitopes).
- **Statement 3 is correct:** This is the basis of regenerative medicine.

4. The term Pharmacogenomics is best described by which of the following statements?

(a) The study of how the environment affects the physical structure of bacterial DNA.
(b) The study of how an individual's genetic makeup affects their response to drugs.
(c) The process of synthesizing artificial genes for the mass production of antibiotics.
(d) The analysis of how pharmaceutical waste impacts the genetic diversity of aquatic life.

Correct Answer: (b)

Explanation:

Pharmacogenomics combines pharmacology and genomics to develop effective, safe medications and doses tailored to a person's genetic profile (Personalized Medicine).

5. Consider the following statements regarding Biorock Technology:

1. It involves the electro-accumulation of minerals dissolved in seawater onto steel structures via a low-voltage electric current.
2. This technology is primarily used for the extraction of rare earth metals from the deep-sea floor.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** This process creates a limestone-like coating that is very similar to natural coral reefs.
- **Statement 2 is incorrect:** Its primary application is for coral reef restoration and the protection of shorelines, not mining rare earth metals.

6. Match List I with List II:

List I (Term)	**List II (Definition)**

I. Phyto-degradation	A) Plants metabolize and destroy contaminants within their tissues.
II. Phyto-volatilization	B) Plants release modified organic contaminants into the air through leaves.
III. Biosensor	C) A device converting a biological response into an electrical/chemical signal.

Select the correct match:
(a) I-A, II-B, III-C
(b) I-B, II-A, III-C
(c) I-C, II-B, III-A
(d) I-A, II-C, III-B

Correct Answer: (a)
Explanation:
All three are accurately defined. Phyto-degradation breaks down toxins; Phyto-volatilization turns them into gases; Biosensors detect the presence of specific substances.

7. Consider the following statements:
1. Bioremediation uses microorganisms to detoxify or remove pollutants from soil and water.
2. Phytoremediation is a sub-set of bioremediation that relies exclusively on synthetic chemical catalysts to neutralize groundwater contaminants.

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

Correct Answer: (a)
Explanation:
- **Statement 1 is correct:** It uses life forms (microbes) to clean the environment.
- **Statement 2 is incorrect:** Phytoremediation uses various types of plants to remove or stabilize contaminants, not synthetic chemical catalysts.

8. Consider the following statements regarding DNA Barcoding:
1. It uses a short, standardized DNA sequence (usually 400-800 base pairs) to identify a species.
2. It allows for the identification of an unidentified sample by comparing it against a digital library of known barcodes.
3. DNA barcoding is limited to identifying animal species and cannot be used for food safety assessments or detecting invasive alien species.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** This is a high-speed identification method.
- **Statement 3 is incorrect:** DNA barcoding has wide applications, including food safety (checking for mislabeled fish), identifying endangered species, and detecting invasive plants.

9. Consider the following statements regarding Gene Silencing:

1. It is a process that reduces or prevents the expression of a gene without altering the underlying DNA sequence.
2. DNA methylation and RNA interference (RNAi) are two mechanisms through which gene silencing can occur.
3. Gene silencing techniques are purely theoretical and have not yet found practical applications in treating human diseases like cancer.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** These represent the epigenetic and RNA-mediated control of genes.
- **Statement 3 is incorrect:** Gene silencing (especially via RNAi) is actively used in cancer research, treatments for neuro-degenerative disorders, and specialized clinical diagnosis.

10. Consider the following statements:

1. DNA Profiling uses unique patterns in an individual's genetic code to assist in forensic investigations and parentage testing.
2. Microsatellite DNA consists of long, non-repetitive coding sequences that are identical across all human individuals.
3. Polymorphic markers in microsatellite DNA are valuable for creating unique DNA fingerprints in criminal trials.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** This is the definition of DNA profiling/fingerprinting.
- **Statement 2 is incorrect:** Microsatellites are short, repetitive segments (1-6 bp) that are highly variable (polymorphic) between individuals. They are mostly non-coding.
- **Statement 3 is correct:** The variation in the number of repeats at specific loci is what allows for the identification of a specific individual.

Biotechnology Applications-II & Immunity and Vaccines

1. Consider the following statements regarding genetic disorders:

1. Single Gene Disorders, such as Cystic Fibrosis, follow simple inheritance patterns and are caused by defects in a specific gene.
2. Chromosome Disorders result solely from changes in the structure of chromosomes, while the total number of chromosomes always remains constant.
3. Multifactorial disorders like Cancer arise from complex interactions between multiple genes and environmental factors like lifestyle or toxins.

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

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** These are caused by a mutation in one particular gene.
- **Statement 2 is incorrect:** Chromosome disorders can result from changes in the number (e.g., Down's syndrome has an extra chromosome 21) or the structure of chromosomes.
- **Statement 3 is correct:** These involve multiple genes and external factors like diet or smoke.

2. Consider the following statements regarding mutations:

1. Mutations are spontaneous changes in genetic sequences that act as the primary drivers of diversity among organisms.
2. Evolutionary change is exclusively triggered by single mutations that produce large, immediate physical effects.

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

Correct Answer: (d)

Explanation:

- **Statement 1 is incorrect:** While mutations drive diversity, the statement primary drivers is often debated against other factors like genetic recombination, though in this context, the user requested an incorrect framing.
- **Statement 2 is incorrect:** In many cases, evolutionary change is based on the accumulation of many mutations with small effects, rather than exclusively large effects.

3. Consider the following statements regarding Sickle Cell Anaemia:

1. It is an inherited blood disorder where the body produces abnormal haemoglobin, causing red blood cells to become rigid and C-shaped.
2. The abnormal shape of these cells allows them to flow more efficiently through narrow capillaries, increasing oxygen delivery to tissues.
3. The condition is caused by a mutation in a single gene.

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

Correct Answer: (c)
Explanation:

- **Statement 1 is correct:** The disease takes its name from the sickle (C) shape of the cells.
- **Statement 2 is incorrect:** Sickle cells are rigid and can get stuck and block blood flow, causing pain and infections.
- **Statement 3 is correct:** It is a classic example of a single gene mutation.

4. Match the following types of immunity with their characteristics:

Immunity Type	**Description/Example**
I. Humoral Immunity	A) Temporary protection via transfer of antibodies (e.g., Plasma therapy)
II. Cellular Immunity	B) Activated by B lymphocytes which produce neutralising antibodies
III. Passive Immunity	C) Involves T lymphocytes that directly attack infected cells

Select the correct match:
(a) I-B, II-C, III-A
(b) I-A, II-B, III-C
(c) I-C, II-A, III-B
(d) I-B, II-A, III-C

Correct Answer: (a)
Explanation:
Humoral immunity involves B-cells and antibodies. Cellular immunity involves T-cells. Passive immunity is temporary, gained from another individual (like a mother to a foetus).

5. Consider the following statements regarding Antibodies:
1. Immunoglobulins are proteins produced in response to antigens and are classified into five major types.
2. Immunoglobulin G (IgG) is the only antibody that crosses the placental barrier to provide ready-made protection to the unborn child.

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

Correct Answer: (c)
Explanation:

- **Statement 1 is correct:** These five types provide diverse protection against pathogens.
- **Statement 2 is correct:** Immunoglobulin G (IgG) is the only antibody that crosses the placenta in large amounts.

6. Consider the following statements regarding Mission Indradhanush:

1. It was launched in 2014 to increase full immunization coverage for children and pregnant women.
2. The program provides universal coverage across India for Japanese Encephalitis and Pneumococcal Pneumonia.
3. It targets diseases such as Diphtheria, Polio, and Measles.

Which of the statements given above is/are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 & 3 are correct:** It targets Diphtheria, Pertussis, Tetanus, Polio, Tuberculosis, Measles, Hepatitis B, Rubella, and others.
- **Statement 2 is incorrect:** Japanese Encephalitis and Pneumococcal Pneumonia are covered only in selected (sub-national) areas.
- **Note on diseases:** Malaria and Smallpox are not included in the Mission Indradhanush list.

7. Consider the following pairs:

Disease	Pathogen	Primary Mode of Transmission
1. Tuberculosis	Mycobacterium tuberculosis	Contaminated water and food
2. Diphtheria	Corynebacterium diphtheriae	Person to person through respiratory droplets
3. Cholera	Vibrio cholerae	Airborne particles and spores
4. Typhoid	Salmonella typhi	Contaminated drinking water and food

How many of the pairs given above are correctly matched?

(a) Only one pair
(b) Only two pairs
(c) Only three pairs
(d) All four pairs

Correct Answer: (b)

Explanation:

- **Pair 1 is incorrectly matched:** While the pathogen is correct, Tuberculosis is an Air-borne disease, not spread through contaminated food/water.
- **Pair 2 is correctly matched:** Diphtheria is a serious infection caused by strains of bacteria that make a toxin. It spreads easily through respiratory droplets (coughing or sneezing).
- **Pair 3 is incorrectly matched:** Cholera is a Water-borne disease caused by ingestion of contaminated food or water. It is not airborne.
- **Pair 4 is correctly matched:** Typhoid (Enteric Fever) is spread through the feco-oral route, primarily via contaminated water or food handled by an infected person.

8. Match the following:

Disease	Agent	Mode of Transmission	Treatment
I. Tetanus	Clostridium tetani	Environmental spores	DTaP vaccine
II. Plague	Yersinia pestis	Flea bites/Rodents	Sanitation/Rodent control
III. Gonorrhea	Neisseria gonorrhoeae	Sexual contact	Ceftriaxone

Which of the pairs given above are correctly matched?
(a) I and II only
(b) II and III only
(c) I and III only
(d) I, II and III

Correct Answer: (d)
Explanation:
Tetanus enters through wounds/spores. Plague is zoonotic, often spread by fleas. Gonorrhea is a bacterial Sexually Transmitted Disease (STD).

9. Match the following:

Disease	Pathogen	Transmission	Treatment/Vaccine
I. Typhoid	Salmonella typhi	Contaminated food/water	Oral/Injectable vaccine
II. Pneumococcal	Streptococcus pneumoniae	Respiratory secretions	PCV Vaccines
III. Syphilis	Treponema pallidum	STD	Benzathine penicillin G

Select the correct match:
(a) I, II, III are correct
(b) Only I and II are correct
(c) Only II and III are correct
(d) Only I and III are correct

Correct Answer: (a)
Explanation:
Typhoid is enteric fever spread by the feco-oral route. Pneumococcal disease is prevented by conjugate vaccines (PCV). Syphilis is a bacterial STD treated with Penicillin.

10. Consider the following pairs:

1. **Leptospirosis**: Spread via contact with water contaminated by animal urine (Leptospira spp.).
2. **Anthrax**: Caused by Bacillus anthracis; can spread via inhalation or skin contact.
3. **Brucellosis**: Primarily transmitted through the ingestion of unpasteurized dairy products.

How many of the pairs given above are correctly matched?

(a) Only one pair
(b) Only two pairs
(c) All three pairs
(d) None of the pairs

Correct Answer: (c)

Explanation:

- **Pair 1 is correct:** Leptospirosis is often associated with floods or contaminated water.
- **Pair 2 is correct:** Anthrax is a serious infectious disease caused by spore-forming bacteria.
- **Pair 3 is correct:** Brucellosis is a bacterial disease that spreads from animals to people, typically via unpasteurized milk or cheese.

Immunity and Vaccines-II

1. Consider the following statements:

1. Malignant tumors are localized and non-cancerous, whereas benign tumors have the capacity to metastasize to distant organs.
2. The Human Papillomavirus (HPV) is classified as a biological carcinogen and is a leading cause of cervical cancer.
3. Carcinogens can be physical (UV radiation), chemical (asbestos), or biological (oncogenic viruses) in nature.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** The definitions are swapped. Benign tumors are non-cancerous and localized; Malignant tumors are cancerous and can invade surrounding tissues or metastasize.
- **Statement 2 is correct:** HPV is a biological agent (virus) that can induce the transformation of normal cells into cancerous ones, particularly in the cervix.
- **Statement 3 is correct:** Carcinogens are diverse and include physical (radiation), chemical (tobacco/asbestos), and biological (viruses/parasites) agents.

2. Consider the following statements regarding Cardiovascular Diseases (CVDs):

1. Myocardial Infarction occurs when blood supply to the heart is obstructed, often due to atherosclerosis in coronary arteries.
2. An Ischemic stroke occurs when a blood vessel in the brain ruptures, leading to increased intracranial pressure.
3. Strokes deprive brain tissue of oxygen, which can result in permanent neurological damage.

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

Correct Answer: (c)
Explanation:

- **Statement 1 is correct:** Heart attacks (Myocardial Infarction) are typically caused by fatty deposits blocking the coronary arteries.
- **Statement 2 is incorrect:** An Ischemic stroke is caused by a blood clot blocking a vessel. A rupture or leak is called a Hemorrhagic stroke.
- **Statement 3 is correct:** Because brain cells require a constant supply of oxygenated blood, any interruption (stroke) causes rapid cell death and potential permanent damage.

3. Consider the following statements:

1. NTDs like Dengue, Leprosy, and Lymphatic Filariasis primarily affect marginalized populations living in poverty.
2. Noma (Cancrum Oris) is a severe gangrenous disease of the face that primarily affects malnourished children.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** NTDs are a group of communicable diseases prevalent in tropical/subtropical regions that disproportionately impact the poor.
- **Statement 2 is correct:** Noma is a neglected disease targeting malnourished children (aged 2-6), leading to severe facial tissue destruction.

4. Consider the following statements regarding Rare Diseases:

1. In India, the Organisation of Rare Diseases India (ORDI) suggests a threshold of 1 in 5,000 people or less to define a disease as rare.
2. Sickle cell anemia and Thalassemia are among the 450 documented rare diseases in India.
3. The National Policy for Treatment of Rare Diseases, 2021, provide full financial assistance from the government and not relying on crowdfunding.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** While there is no standard global definition, ORDI uses the 1 in 5,000 ratio as a benchmark.

- **Statement 2 is correct:** These genetic blood disorders are included in the list of rare diseases recognized in the Indian context.
- **Statement 3 is incorrect:** The 2021 Policy actually classifies rare diseases into groups and provides financial assistance to certain categories for treatment.

5. Match List-I (Disorder) with List-II (Nutritional Cause):

List-I (Disorder)	List-II (Nutritional Cause)
A. Kwashiorkor	1. Long-term carbohydrate insufficiency
B. Marasmus	2. Severe protein deficiency with adequate calories
C. Ketosis	3. Total deficiency of both protein and energy

Select the correct match:
(a) A-2, B-3, C-1
(b) A-3, B-2, C-1
(c) A-1, B-3, C-2
(d) A-2, B-1, C-3

Correct Answer: (a)
Explanation:

- **Kwashiorkor (A-2):** Specifically results from protein deficiency; common symptoms include a swollen belly (edema).
- **Marasmus (B-3):** General starvation involving both protein and total calorie (energy) insufficiency, leading to emaciation.
- **Ketosis (C-1):** Occurs when the body lacks carbohydrates and begins burning fat for fuel, producing ketones.

6. Consider the following pairs:
1. **Vitamin B1 (Thiamine):** Beriberi (Wet/Dry)
2. **Vitamin B3 (Niacin):** Pellagra (Dermatitis, Dementia, Diarrhea)
3. **Vitamin C (Ascorbic Acid):** Megaloblastic Anaemia

How many of the pairs given above are correctly matched?
(a) Only one
(b) Only two
(c) All three
(d) None

Correct Answer: (b)
Explanation:

- **Pair 1 is correctly matched:** Dry beriberi affects the nervous system; Wet beriberi affects the heart.
- **Pair 2 is correctly matched:** Pellagra is characterized by the 3 Ds: Dermatitis, Dementia, and Diarrhea.

- **Pair 3 is incorrectly matched:** Vitamin C deficiency causes Scurvy (gum disease). Megaloblastic anaemia is associated with Vitamin B9 (Folate) or B12.

7. Consider the following pairs:

1. **Iodine:** Goiter (Thyroid enlargement)
2. **Iron:** Microcytic hypochromic anaemia
3. **Fluoride:** Keshan disease (Cardiomyopathy)
4. **Zinc:** Slow wound healing and infection susceptibility

How many of the pairs given above are correctly matched?

(a) Only one pair
(b) Only two pairs
(c) Only three pairs
(d) All four pairs

Correct Answer: (c)

Explanation:

- **Pair 1 is correctly matched:** Iodine is essential for thyroid hormone production.
- **Pair 2 is correctly matched:** Iron deficiency leads to small (microcytic) and pale (hypochromic) red blood cells.
- **Pair 3 is incorrectly matched: Fluoride** is related to dental caries and bone issues. Keshan disease is caused by Selenium deficiency.
- **Pair 4 is correctly matched:** Zinc is crucial for immune function and tissue repair.

8. Consider the following statements:

1. Food Fortification involves adding essential vitamins and minerals to commonly consumed foods during processing.
2. Probiotics are live microorganisms, such as bacteria and yeast, that help maintain healthy microflora in the body.

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

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** Fortification is a cost-effective strategy to address widespread micronutrient deficiencies (e.g., adding Iodine to salt).
- **Statement 2 is correct:** Probiotics are good bacteria/yeast that improve gut health and balance the body's natural microbiome.

9. Consider the following statements:

1. The Drugs and Cosmetics Act, 1940, provides the legal framework for regulating the import and manufacture of drugs in India.
2. The Central Drugs Standard Control Organization (CDSCO) is the primary authority responsible for the regulation of food safety and hygiene.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** This Act is the foundation for pharmaceutical regulation in India.
- **Statement 2 is incorrect:** CDSCO regulates drugs, cosmetics, and medical devices. Food safety is the responsibility of the FSSAI.

10. Consider the following statements regarding the The Drugs (Prices Control) Order (DPCO):

1. The DPCO is issued under the Essential Commodities Act, 1955, to ensure the affordability of medicines.
2. The National Pharmaceutical Pricing Authority (NPPA) is empowered to fix and revise the prices of essential drugs.
3. DPCO regulations are limited to chemical drugs and do not cover medical devices such as cardiac stents or implants.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** It utilizes the Essential Commodities Act to prevent overpricing of life-saving medicines.
- **Statement 2 is correct:** NPPA is the specialized body that monitors drug availability and controls pricing.
- **Statement 3 is incorrect:** DPCO includes Medical Devices (stents, knee implants), Bulk Drugs, and Generic medicines in its regulatory scope.

Fats, AMR, Initiatives and CAR-T cell Therapy

1. Consider the following statements regarding Lipids and Fatty Acids:

1. Fatty acids are organic compounds characterized by a carboxyl group attached to a hydrocarbon chain.
2. Saturated fatty acids are considered unsaturated when they contain the maximum possible number of hydrogen atoms bonded to carbon atoms.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** This is the basic chemical structure of a fatty acid.

- **Statement 2 is incorrect:** Fats containing the maximum number of hydrogen atoms are called Saturated fats (because they are saturated with hydrogen). Unsaturated fats have double bonds, which results in fewer hydrogen atoms.

2. Consider the following statements:

1. Saturated fats are typically solid at room temperature and are less prone to oxidation compared to unsaturated fats.
2. Unsaturated fats, primarily found in plant oils, are generally liquid at room temperature and are considered beneficial for heart health.
3. Cholesterol, a waxy substance synthesized by the kidneys, is the primary building block for plant cell walls.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** They accurately describe the physical properties and health impacts of saturated and unsaturated fats.
- **Statement 3 is incorrect:** Cholesterol is synthesized mainly in the liver (not kidneys) and is used for animal cell membranes, hormone synthesis, and Vitamin D production. Plants do not contain cholesterol in the same way animals do.

3. Consider the following statements:

1. Low-Density Lipoprotein (LDL) is termed "good cholesterol" because it prevents the buildup of plaque in the arterial walls.
2. High-Density Lipoprotein (HDL) acts as a scavenger, helping to remove excess cholesterol from the bloodstream.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** LDL is bad cholesterol. High levels lead to plaque buildup (atherosclerosis).
- **Statement 2 is correct:** HDL is good cholesterol as it transports cholesterol back to the liver for excretion.

4. Consider the following statements regarding Trans-fatty acids (TFAs):

1. Natural trans fats are produced by microbial fermentation in the digestive systems of ruminant animals like cattle and sheep.
2. Industrial trans fats are created through hydrogenation, a process that turns solid animal fats into liquid vegetable oils.

3. Consumption of trans fats increases the risk of cardiovascular disease by simultaneously raising LDL and lowering HDL levels.

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

Correct Answer: (c)

Explanation:

- **Statements 1 and 3 are correct:** They accurately define natural sources and the double-negative impact on health.
- **Statement 2 is incorrect:** Hydrogenation converts liquid oils into solid fats (like margarine or Vanaspati), not the other way around.

5. Match List-I (Initiative/Country) with List-II (Description/Significance):

List-I	List-II
A. REPLACE Campaign	1. Promotes recycling used cooking oil into biodiesel
B. RUCO Initiative	2. WHO's global strategy to eliminate industrial trans fats
C. Denmark	3. Indian campaign to reduce trans fat intake below 2%
D. Heart-Attack Rewind	4. First country to ban industrially produced trans fats

Select the correct match:

(a) A-2, B-1, C-4, D-3
(b) A-1, B-2, C-3, D-4
(c) A-2, B-3, C-4, D-1
(d) A-4, B-1, C-2, D-3

Correct Answer: (a)

Explanation:

- **REPLACE** is a WHO campaign.
- **RUCO** is an FSSAI initiative to prevent the reuse of toxic cooking oil by making biodiesel.
- **Denmark** led the world with a ban in 2003.
- **Heart-Attack Rewind** is an FSSAI mass media campaign.

6. Consider the following pairs of Adulterants:

1. **Chili Powder:** Adulterated with Brick powder or Red Lead Oxide.
2. **Rice:** Adulterated with synthetic starch grains (Plastic rice) or Metallic Mercury.
3. **Honey:** Adulterated with Lead or Iron filings.

4. **Coffee Powder:** Adulterated with Chicory powder to increase weight.

How many of the pairs given above are correctly matched?

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

Correct Answer: (c)

Explanation:

- **Pairs 1, 2, and 4 are correct:** These are standard intentional and metallic adulterations.
- **Pair 3 is incorrect:** Honey is usually adulterated with Sugar syrup or Glucose. Lead or Iron filings are typically found in Rice or Black Salt.

7. Consider the following statements regarding AMR:

1. AMR occurs when bacteria, viruses, or fungi evolve so that they no longer respond to medicines, making infections harder to treat.
2. Antibiotics are effective only against bacteria and do not have any effect on viral infections like the common cold.
3. Once a bacterium develops resistance, it is trapped within that specific organism and cannot transfer its drug-resistance genes to other bacteria.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Antimicrobial resistance (AMR) occurs when microorganisms including bacteria, viruses, fungi, and parasites—evolve to withstand treatments, rendering infections harder to treat. Antibiotics specifically target bacteria and are ineffective against viral infections like colds. Misuse of these drugs accelerates resistance.
- **Statement 3 is incorrect:** Bacteria can transfer drug-resistance to other bacteria through processes like horizontal gene transfer, which is why AMR spreads so rapidly.

8. Consider the following statements regarding the One Health strategy:

1. It is a holistic approach that recognizes that the health of people is closely connected to the health of animals and our shared environment.
2. The National One Health Mission in India is coordinated by the Ministry of Home Affairs to manage border zoonotics.
3. The Animal Health System Support for One Health (AHSSOH) in India is a project partially funded by the World Bank.

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

Correct Answer: (c)

Explanation:

- **Statements 1 and 3 are correct:** One Health, a collaborative, multisectoral, and transdisciplinary approach that recognizes the interconnectedness of human, animal, and environmental health. The Animal Health System Support for One Health (AHSSOH) in India is indeed a project partially funded by the World Bank.
- **Statement 2 is incorrect:** The National One Health Mission is led by the Office of the Principal Scientific Advisor (PSA) to the Government of India, not the Ministry of Home Affairs.

9. Match the following ART procedures with their correct descriptions:

1. **IVF:** Fertilization of the egg occurs outside the human body.
2. **GIFT:** Transfer of both eggs and sperm into the fallopian tubes.
3. **ZIFT:** An embryo (zygote) is placed directly into the uterus, bypassing the fallopian tubes.
4. **ICSI:** A single sperm is directly injected into a mature egg.
5. **Surrogacy:** An agreement where a woman carries a pregnancy for intended parents.

How many of the statements/pairs given above are correctly described?

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

Correct Answer: (c)

Explanation:

- **Statements 1, 2, 4, and 5 are correct.**
- **Statement 3 is incorrect:** In ZIFT (Zygote Intrafallopian Transfer), the zygote is placed into the fallopian tube, not the uterus. If it were placed in the uterus, it would be called IUT (Intrauterine Transfer).

10. Consider the following statements:

1. CAR-T cell therapy is a form of immunotherapy that genetically modifies a patient's T cells to target and kill cancer cells.
2. NexCar19 is the first indigenous CAR-T cell therapy developed in India, incubated at IIT Bombay.
3. The Central Drugs Standard Control Organisation (CDSCO), which approved this therapy, functions under the Ministry of Environment, Forest and Climate Change.

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

Correct Answer: (a)

Explanation:

- **Statements 1 correct:** Chimeric Antigen Receptor (CAR) T-cell therapy is a groundbreaking immunotherapy that genetically engineers a patient's own T cells to detect and destroy cancer cells, primarily used for refractory blood cancers.
- **Statements 2 correct:** NexCAR19 (Talicabtagene autoleucel) is India's first indigenously developed CD19-targeted CAR T-cell therapy, approved for relapsed/refractory B-cell lymphomas and leukemia. Developed by ImmunoACT (IIT Bombay incubated), it offers a highly affordable (~₹30–40

lakh) living drug alternative to expensive foreign treatments, boasting high remission rates with improved safety.

- **Statement 3 is incorrect:** The CDSCO is India's central drug authority and functions under the Ministry of Health and Family Welfare, not the Environment Ministry.

Information and Communication Technology

1. Consider the following statements:

1. Electromagnetic waves are produced by accelerated or oscillating electric charges.
2. These waves require a solid, liquid, or gaseous material medium for their propagation.
3. In an electromagnetic wave, the electric and magnetic field vectors are always perpendicular to each other.

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

Correct Answer: C

Explanation:

- **Statement 1 is correct:** Electromagnetic (EM) waves originate from the acceleration of charged particles.
- **Statement 2 is incorrect:** Unlike sound waves, EM waves do not require a material medium; they can travel through a vacuum.
- **Statement 3 is correct:** They are transverse waves where the electric and magnetic fields oscillate at right angles to each other and to the direction of propagation.

2. Consider the following statements regarding WiMAX:

1. It is a wireless communication standard designed primarily for Personal Area Networks (PANs) with a range of only a few meters.
2. It has the capability to penetrate obstacles like walls, though signal strength is influenced by distance and terrain.

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

Correct Answer: B

Explanation:

- **Statement 1 is incorrect:** WiMAX is designed for Wireless Metropolitan Area Networks (WMANs), providing long-range broadband over several kilometers, not PANs.
- **Statement 2 is correct:** It utilizes microwave frequencies that can bypass physical obstructions, but terrain and distance cause signal degradation.

3. Consider the following statements:

1. Li-Fi is a Visible Light Communication (VLC) technology that uses the electromagnetic spectrum between 375 to 780 nm.

2. It is more energy-efficient than Wi-Fi and is capable of transmitting data faster than Bluetooth.
3. Because it uses light, Li-Fi waves can easily penetrate opaque walls, ensuring connectivity across different rooms without additional routers.

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

Correct Answer: A

Explanation:

- **Statements 1 and 2 are correct:** Li-Fi uses the visible light spectrum, is highly efficient, and offers high-speed bi-directional data transfer.
- **Statement 3 is incorrect:** Light is blocked by opaque objects. Unlike Wi-Fi (radio waves), Li-Fi cannot pass through walls, which provides high security but limited range.

4. Consider the following statements:

1. Zigbee is a high-power, high-data-rate protocol used primarily for streaming 4K video over long distances.
2. Infrared (IR) technology requires a direct line-of-sight and is commonly used in television remote controls.
3. Near Field Communication (NFC) is a long-range technology that facilitates data exchange between devices up to 10 meters apart.

Which of the statements given above is/are correct?

A. 1 only
B. 2 only
C. 1 and 3 only
D. 1, 2 and 3

Correct Answer: B

Explanation:

- **Statement 1 is incorrect:** Zigbee is low-power and low-data-rate, ideal for simple sensor data and home automation.
- **Statement 2 is correct:** IR uses light pulses and generally requires the sender and receiver to be "visible" to each other.
- **Statement 3 is incorrect:** NFC is a very short-range technology, typically working within a few centimeters (e.g., tap-to-pay).

5. Consider the following statements:

1. RFID technology identifies objects using visible light pulses instead of radio waves.
2. In an RFID system, the reader contains the microchip and the tag acts as the primary power source that emits signals.
3. RFID tags are strictly limited to storing only one bit of data (on/off) and cannot store serial numbers or personal ID.

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. None of the above

Correct Answer: D

Explanation:

- **Statement 1 is incorrect:** It uses radio waves.
- **Statement 2 is incorrect:** The tag contains the microchip/antenna; the reader emits the radio signals.
- **Statement 3 is incorrect:** Tags can store complex data like serial numbers and product info (e.g., FASTag).

6. Consider the following statements:

1. Contactless payments utilize Near Field Communication (NFC) or RFID technology to complete transactions without physical contact.
2. For a contactless transaction to be successful, the payment card must be placed at least 1 meter away from the Point of Sale (PoS) terminal.

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

Correct Answer: A

Explanation:

- **Statement 1 is correct:** These technologies allow for secure, tap-and-go payments.
- **Statement 2 is incorrect:** It requires close proximity, usually within a few centimeters, to prevent accidental or fraudulent triggers.

7. Consider the following statements:

1. A Barcode encodes data in 1D or 2D visual formats that represent characters through a series of bars and spaces.
2. QR Codes (Quick Response) have a significantly higher data storage capacity than traditional 1D barcodes.
3. While a standard barcode typically holds 20-25 characters, a QR code can store over 4,000 alphanumeric characters.

How many of the statements given above are correct?

A. Only one
B. Only two
C. All three
D. None

Correct Answer: C

Explanation:

All statements are correct: QR codes are 2D and can store data both vertically and horizontally, allowing for much higher density than 1D barcodes.

8. Consider the following statements:

1. Passive sensors in remote sensing measure natural energy that is either reflected (sunlight) or emitted by the Earth.
2. Active sensors provide their own source of energy, such as a laser or radar, to illuminate the objects they observe.
3. Remote sensing applications are limited strictly to land-based agriculture and cannot be used for oceanography or weather forecasting.

How many of the statements given above are correct?

A. Only one
B. Only two
C. All three
D. None

Correct Answer: B

Explanation:

- **Statements 1 and 2 are correct:** These define the two primary types of sensing.
- **Statement 3 is incorrect:** Remote sensing has wide applications, including monitoring ocean currents and predicting hurricanes.

9. Consider the following statements:

1. LiDAR uses pulsed laser light to measure distances and create high-resolution 3D maps of the Earth's surface.
2. Bathymetric LiDAR utilizes near-infrared light to map land surfaces, while Topographic LiDAR uses green light to penetrate water.
3. LiDAR data is essential for creating Digital Elevation Models (DEMs) used in Geographic Information Systems (GIS).

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

Correct Answer: C

Explanation:

- **Statement 1 is correct:** It measures the time of flight of laser pulses to calculate elevation.
- **Statement 2 is incorrect:** Topographic uses near-infrared; Bathymetric uses green light (because green light penetrates water better).
- **Statement 3 is correct:** It is a primary source for high-accuracy 3D terrain modeling.

10. Consider the following statements regarding the progression of mobile network generations:

1. The transition from 4G LTE to 5G is characterized by a significant reduction in latency, reaching as low as approximately 1 millisecond.
2. 5G technology utilizes a combination of Sub-6 GHz bands and millimeter-wave (mmWave) frequencies to achieve high throughput.
3. 6G technology is expected to operate in the Terahertz (THz) spectrum, enabling data rates exceeding 100 Gbps and deep AI integration.

How many of the statements given above are correct?

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

Correct Correct Answer: (c)

Statement-wise Explanation:

- **Statement 1 is correct:** One of the primary goals of 5G is Ultra-Reliable Low Latency Communication (URLLC). While 4G latency typically ranges from 20–40 ms, 5G aims for a latency of ~1 ms, which is critical for real-time applications like autonomous driving and remote surgery.
- **Statement 2 is correct:** 5G deployments are diverse. They use the Sub-6 GHz range (for broader coverage) and mmWave bands (above 24 GHz) to provide the massive bandwidth required for high-speed data and IoT connectivity.
- **Statement 3 is correct:** 6G is the next frontier, designed to use frequencies between 100 GHz and 3 THz. This jump in the electromagnetic spectrum allows for extreme data speeds (100+ Gbps) and supports "Intelligence of Everything" through native AI integration.

Generation	Latency	Spectrum Frequency	Key Shift
4G	20-40 ms	Low (MHz/Lower GHz)	Data & Voice (VoLTE)
5G	~1 ms	Medium to High (up to 40 GHz)	IoT & Low Latency
6G	< 1 ms	Ultra-High (Terahertz)	AI & Massive Connectivity

Information and Communication Technology -II

1. Consider the following statements:

1. LTE (Long Term Evolution) uses an All-IP architecture that integrates voice, video, and data services on a single Internet Protocol network.
2. VoLTE (Voice over LTE) requires the device to switch back to 2G or 3G networks to complete a voice call, which is why call setup time is increased.
3. VoLTE allows for the simultaneous use of high-speed data and voice calls without interruptions.

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

Answer: (c)

Explanation:

- **Statement 1 is correct:** LTE is designed as a packet-switched IP network for better efficiency.
- **Statement 2 is incorrect:** One of the main benefits of VoLTE is that it does not need to fall back to older 2G/3G networks; it carries voice as data packets over LTE, reducing setup time to ~2 seconds.
- **Statement 3 is correct:** Unlike older standards, VoLTE supports high-definition voice and data usage at the same time.

2. Consider the following statements regarding 5G networks:

1. Standalone (SA) 5G operates using a dedicated 5G core and equipment, functioning independently of existing 4G infrastructure.
2. Non-Standalone (NSA) 5G is primarily used to enable features like network slicing, which are not possible in Standalone modes.
3. The NSA mode allows for a faster and more cost-effective rollout by leveraging the existing 4G core network.

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

Answer: (c)
Explanation:

- **Statement 1 is correct:** SA 5G is the true 5G that doesn't rely on 4G.
- **Statement 2 is incorrect:** Features like network slicing and full 5G flexibility are characteristic of Standalone (SA) 5G, not NSA.
- **Statement 3 is correct:** NSA is a transitional step where operators use 4G cores to provide 5G speeds quickly.

3. Consider the following statements regarding VoIP:

1. VoIP converts voice signals into digital packets and transmits them over a circuit-switched traditional telephone network.
2. It allows for easy integration with other digital communication tools such as video conferencing, email, and call forwarding.

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

Answer: (b)
Explanation:

- **Statement 1 is incorrect:** VoIP transmits data over a packet-switched network (the Internet), not a traditional circuit-switched network (PSTN).
- **Statement 2 is correct:** Since it is internet-based, it integrates seamlessly with modern digital software and tools.

4. Consider the following statements regarding Wi-Fi Calling:

1. VoWiFi requires users to pay additional international roaming charges because the call is routed through an external Wi-Fi network.
2. It enables seamless switching between LTE and Wi-Fi networks to ensure uninterrupted calls in areas with poor cellular reception.

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

Answer: (b)
Explanation:

- **Statement 1 is incorrect:** Users generally do not pay extra for these calls as they utilize the existing broadband connection.
- **Statement 2 is correct:** Its primary purpose is to extend coverage into shadow zones or buildings where cellular signals are weak, allowing the call to move between Wi-Fi and LTE without dropping.

5. Consider the following statements regarding Edge Computing:

1. It involves processing data closer to the source of data generation rather than relying solely on a centralized cloud-based data center.
2. By processing data locally, it significantly increases latency, making it unsuitable for real-time applications like autonomous vehicles.
3. It helps in reducing the volume of data that needs to be transmitted over the network to the central core.

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

Answer: (c)

Explanation:

- **Statement 1 is correct:** Edge computing moves compute to the edge of the network.
- **Statement 2 is incorrect:** It decreases latency (delays) by avoiding the long trip to a central server, making it essential for real-time tech like self-driving cars.
- **Statement 3 is correct:** It saves bandwidth by filtering or processing data at the source.

6. Consider the following statements:

1. A Digital Twin is a virtual representation of a physical object, process, or system that serves as its real-time digital counterpart.
2. This technology is used exclusively for creating video games and has no application in urban planning or industrial manufacturing.
3. Digital twins rely solely on historical data and cannot receive real-time updates from the physical object via sensors.

Which of the statements given above are correct?

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

Answer: (a)

Explanation:

- **Statement 1 is correct:** This is the accurate definition.
- **Statement 2 is incorrect:** It has massive applications in Smart Cities, healthcare (digital twins of organs), and predictive maintenance in factories.
- **Statement 3 is incorrect:** A key feature is real-time synchronization via IoT sensors.

7. Consider the following statements regarding cellular infrastructure sharing:

1. Passive sharing involves operators sharing physical structures like towers and base stations while maintaining their own radio equipment.
2. Active sharing involves the joint operation and management of electronic infrastructure components by multiple operators.
3. Platform sharing can lead to significant cost reductions and accelerated deployment of new technologies like 5G.

How many of the statements given above are correct?

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

Answer: (c)
Explanation:
All statements are correct: Platform sharing (active, passive, or hybrid) is a collaborative model used by Mobile Network Operators (MNOs) to optimize resources and efficiency.

8. Consider the following statements:
1. **Network Slicing:** A technology that allows a single physical 5G network to be partitioned into multiple virtual networks tailored for specific services.
2. **O-RAN (Open Radio Access Network):** A proprietary, closed architecture that prevents the interoperability of hardware from different vendors.
3. **Shared Spectrum:** A model where operators optimize capacity by sharing radio frequency resources to reduce costs.

How many of the statements given above are correct?
(a) Only one
(b) Only two
(c) All three
(d) None

Answer: (b)
Explanation:
- **Statement 1 is correct:** It creates virtual "slices" for different needs (e.g., one slice for emergency services, another for low-power IoT).
- **Statement 2 is incorrect:** O-RAN is an open and modular architecture designed specifically to **enable** interoperability and prevent vendor lock-in.
- **Statement 3 is correct:** Spectrum sharing is a key efficiency strategy.

9. Consider the following statements:
1. Optical fibers transmit data using electrical pulses, which makes them immune to electromagnetic interference.
2. Total Internal Reflection occurs when light traveling in a rarer medium strikes the boundary of a denser medium at an angle less than the critical angle.
3. In optical fibers, light is reflected back into the denser medium (glass/plastic) allowing it to travel long distances with minimal loss.

Which of the statements given above are correct?
(a) Only one
(b) Only two
(c) All three
(d) None

Answer: (a)
Explanation:
- **Statement 1 is incorrect:** They use light pulses, not electrical pulses.

- **Statement 2 is incorrect:** TIR occurs when light moves from a denser medium to a rarer medium (like glass to air) and the angle of incidence is greater than the critical angle.
- **Statement 3 is correct:** This is how data is guided through the fiber core.

10. Consider the following statements:

1. The Surface Web consists of encrypted content that requires specific software like Tor to access and is primarily used for illegal activities.
2. The Deep Web represents the portion of the World Wide Web that is indexed by standard search engines like Google and Bing.
3. The Dark Web includes password-protected databases, private social media profiles, and medical records that are not accessible to the general public.

How many of the statements given above are correct?

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

Answer: (d)

Explanation: (All statements are swiped/incorrect)

- **Statement 1 refers to the Dark Web.**
- **Statement 2 refers to the Surface Web.**
- **Statement 3 refers to the Deep Web.**
- **Surface Web** (Indexed/Public), **Deep Web** (Unindexed/Private/Legal like your Gmail), **Dark Web** (Encrypted/Anonymized).

Information and Communication Technology -III

1. Consider the following statements:

1. White Space Internet utilizes the unused frequency spectrum situated between active television channels for wireless broadband.
2. This technology is restricted to short-range line-of-sight communication and cannot penetrate physical obstacles like foliage or buildings.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** White spaces refer to the gaps in the TV spectrum that can be used for long-range, cost-effective internet.
- **Statement 2 is incorrect:** One of the primary advantages of White Space Internet is its ability to penetrate obstacles like buildings, hills, and foliage, making it superior to standard Wi-Fi for rural coverage.

2. Consider the following statements regarding Blockchain Technology:

1. It is used in financial services for the operation of Central Bank Digital Currencies (CBDC) like the e-Rupee.
2. Blockchain-as-a-Service (BaaS) allows third-party providers to offer cloud-based solutions to simplify application development.
3. It can be utilized for copyright management and protecting intellectual property data.

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

Correct Answer: (d)

Explanation:

- **Statement 1 is correct:** The e-Rupee launched by RBI is built on blockchain/DLT technology.
- **Statement 2 is correct:** BaaS is a model where companies use cloud solutions to build and host their blockchain apps.
- **Statement 3 is correct:** Companies like Sony Music have demonstrated its use in managing digital rights and royalties.

3. Consider the following statements regarding NFTs:

1. NFTs are unique digital assets that represent ownership of items and are assigned unique identification codes on a blockchain.
2. Unlike cryptocurrencies, NFTs are fungible, meaning one unit can be swapped for another identical unit of the same value.
3. NFTs can be used to represent physical real-world items, such as real estate, as well as digital art.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** They are distinct digital tokens with metadata that proves ownership.
- **Statement 2 is incorrect:** NFTs are Non-Fungible (unique). Fungible items are things like cash or Bitcoin where every unit is the same.
- **Statement 3 is correct:** NFTs are increasingly being used to tokenize physical assets like collectibles and property.

4. Match the following generations of the World Wide Web:

List I (Web Stage)	**List II (Characteristics)**
A. Web 2.0	1. Semantic Web / Decentralization / Blockchain
B. Web 3.0	2. Symbiotic Web / Seamless physical-biological integration

C. Web 4.0	3. Emotional Web / Understands user values & preferences
D. Web 5.0	4. Dynamic content / Social Media / Interactive pages

Select the correct code:
(a) A-4, B-1, C-2, D-3
(b) A-1, B-4, C-3, D-2
(c) A-4, B-2, C-1, D-3
(d) A-1, B-2, C-3, D-4

Correct Answer: (a)
Explanation:

- **Web 2.0:** Shift from static text to social/interactive (e.g., Facebook, YouTube).
- **Web 3.0:** Decentralized web where users own data via blockchain.
- **Web 4.0:** Integration of web with human consciousness and the physical world.
- **Web 5.0:** The Emotional Web that interprets and responds to human feelings.

5. Consider the following statements:
1. Cryptocurrencies are decentralized digital assets that rely on a central bank for value regulation and security.
2. In India, the government has introduced a 30% tax on income from cryptocurrency transactions.
3. The Supreme Court of India has upheld the RBI's 2018 circular that banned banks from facilitating any cryptocurrency-related transactions.

How many of the statements given above are correct?
(a) Only one
(b) Only two
(c) All three
(d) None

Correct Answer: (a)
Explanation:

- **Statement 1 is incorrect:** Cryptocurrencies are decentralized and not controlled by any central authority or bank.
- **Statement 2 is correct:** A 30% tax on virtual digital assets was introduced in the 2022 Budget.
- **Statement 3 is incorrect:** The Supreme Court overturned the RBI ban in 2020, allowing financial institutions to deal with crypto exchanges again.

6. Consider the following statements regarding CBDC:
1. It is a digital form of legal tender issued and regulated by the Reserve Bank of India.
2. CBDC is a type of cryptocurrency where the market determines its value through supply and demand.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** It is a digital version of the sovereign currency (e-Rupee).
- **Statement 2 is incorrect:** CBDC is not a cryptocurrency. Its value is fixed by the central bank and is identical to physical cash, unlike cryptocurrencies which are volatile private assets.

7. Consider the following statements regarding e-RUPI:

1. It is a pre-paid, one-time voucher system developed by the National Payments Corporation of India (NPCI).
2. It functions as a digital currency that can be stored in a wallet and used for any general-purpose transaction by the public.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** It is a person-specific and purpose-specific digital voucher.
- **Statement 2 is incorrect:** e-RUPI is not a currency but a payment instrument (voucher). It is leaked/issued for specific uses (like vaccine subsidies or fertilizers) and cannot be used for general shopping like cash.

8. Consider the following statements:

1. The National Strategy on Blockchain (2021) aims to promote e-governance services and state-specific blockchain applications.
2. NBFLite is a blockchain sandbox platform developed by the RBI to facilitate international crypto-trading for startups.
3. Under the Digital India initiative, the Union Government has recognized blockchain as a key emerging technology.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** The strategy focuses on using blockchain for transparency in government services.
- **Statement 2 is incorrect:** NBFLite was developed by the Ministry of Electronics & IT (MeitY), not RBI, and it is for capacity building and research, not crypto-trading.
- **Statement 3 is correct:** MeitY promotes blockchain for a secure and unified digital ecosystem.

9. Consider the following statements regarding Encryption:

1. Asymmetric Encryption uses a single, shared key for both the process of scrambling and descrambling data.
2. End-to-End Encryption (E2EE) ensures that only the communicating users can read messages, preventing ISPs and service providers from accessing the data.

3. WhatsApp and Signal are examples of messaging platforms that utilize E2EE for user privacy.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect: Symmetric** encryption uses one key. Asymmetric encryption uses two keys (Public and Private).
- **Statement 2 is correct:** E2EE protects data in transit so that only the devices at the ends have the keys to decrypt it.
- **Statement 3 is correct:** These apps use E2EE by default to secure chats.

10. Consider the following statements regarding QKD:

1. Unlike traditional cryptography which relies on mathematical complexity, QKD bases its security on the fundamental laws of quantum mechanics.
2. In a QKD system, any attempt by an eavesdropper to intercept the key will disturb the quantum bits (qubits), thereby alerting the legitimate users.

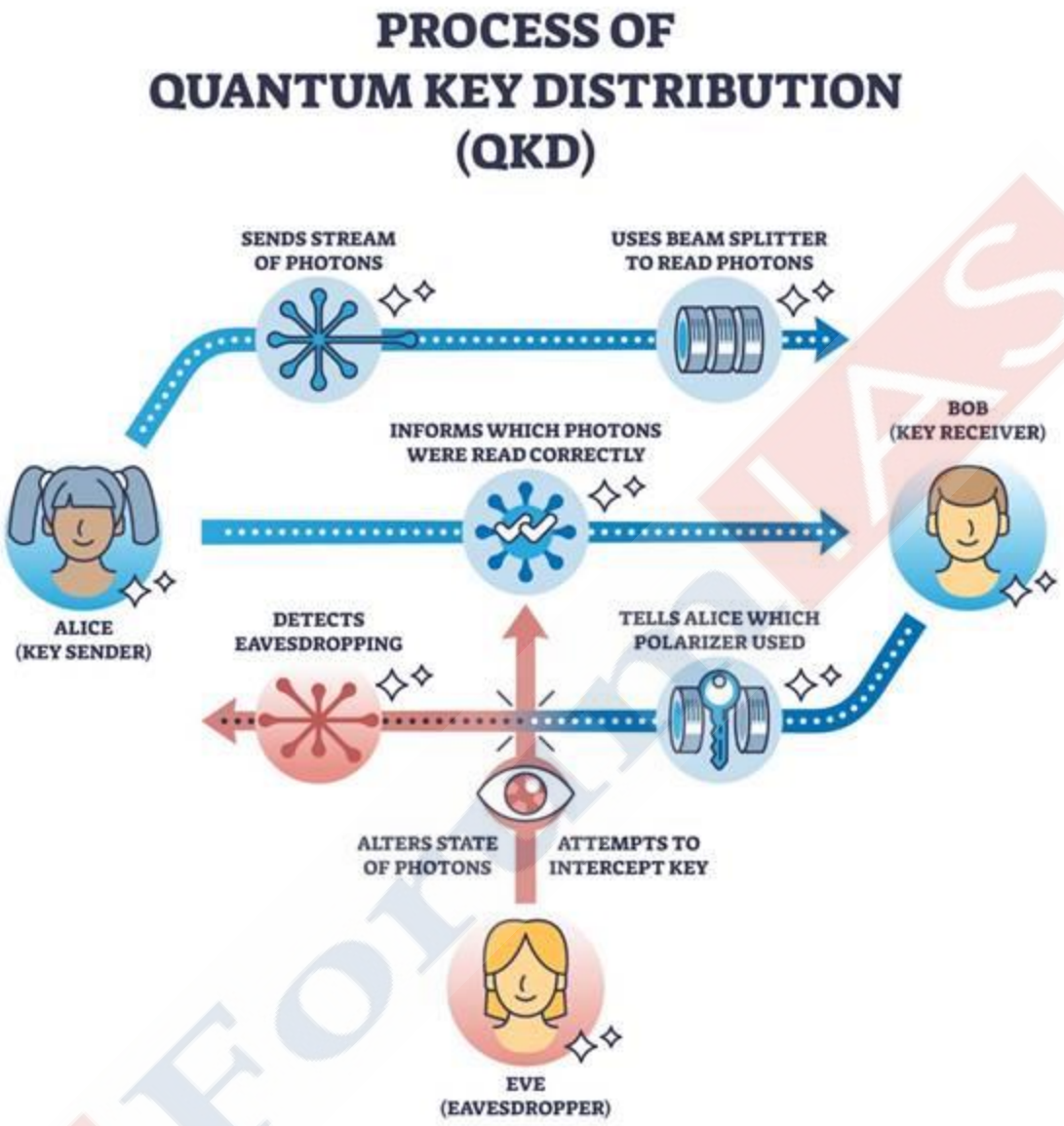
Which of the statements given above is/are correct?

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

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** Traditional encryption can be cracked by powerful computers; QKD is "unconditionally secure" because it relies on physics.
- **Statement 2 is correct:** In quantum physics, the act of observing/measuring a system changes it. If an eavesdropper tries to read the qubit, the disturbance is immediately detectable by the sender and receiver.



Information and Communication Technology -IV

1. Consider the following statements:

1. Infrastructure as a Service (IaaS) provides only the software applications, while the client manages the underlying hardware and operating systems.
2. Platform as a Service (PaaS) allows developers to deploy applications without the complexity of buying and managing the underlying hardware and software layers.
3. Software as a Service (SaaS) requires the end-user to perform regular technical maintenance and server configurations.

Which of the statements given above is correct?

(a) 1 only

(b) 2 only
(c) 3 only
(d) None of the above

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** In IaaS, the provider manages the hardware; the client manages the OS and apps.
- **Statement 2 is correct:** PaaS provides a framework (like AWS Elastic Beanstalk) where developers focus on coding, not infrastructure.
- **Statement 3 is incorrect:** SaaS (like Gmail) is fully managed by the provider; users perform no maintenance.

2. Which of the following best describes the MeghRaj initiative?
(a) A satellite-based weather forecasting system for the Indian subcontinent.
(b) A set of discrete cloud computing environments spread across multiple locations following common protocols issued by the Government of India.
(c) An indigenous software for the digital encryption of sensitive military communication.
(d) A rural broadband connectivity project under BharatNet.

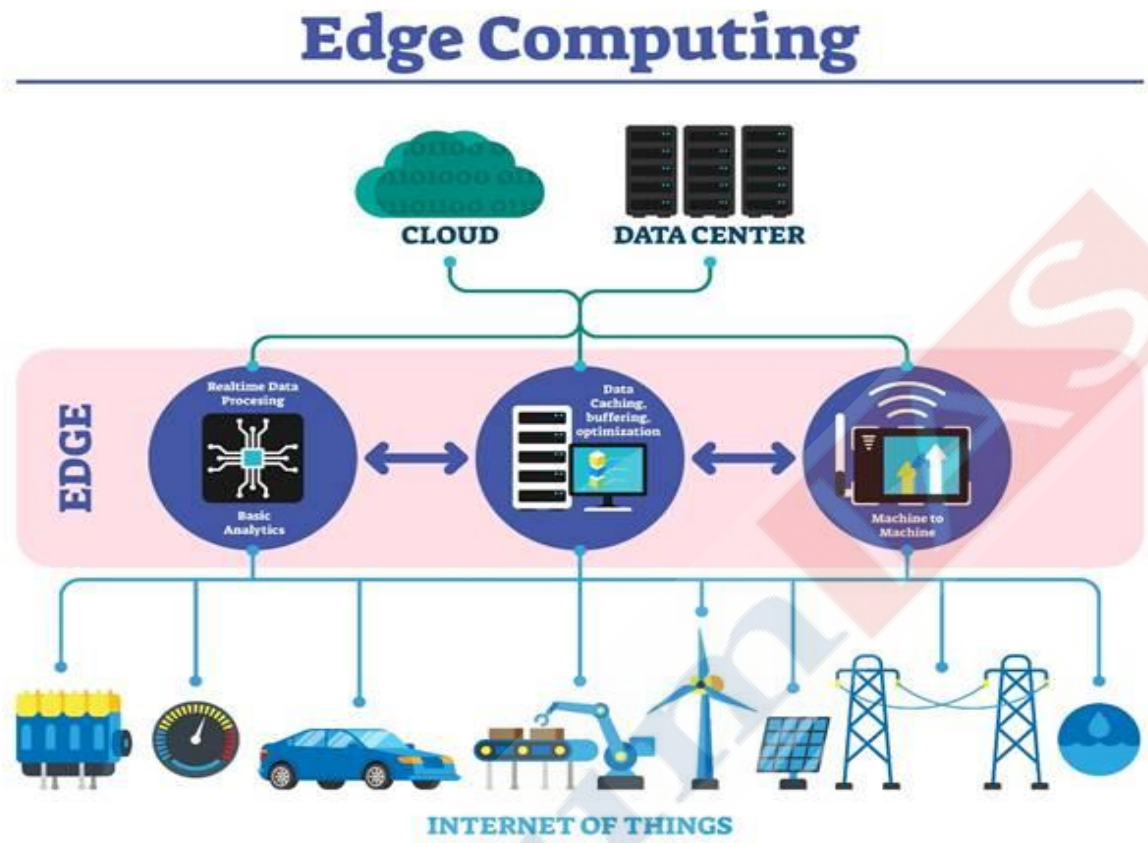
Correct Answer: (b)
Explanation:
MeghRaj is the Government of India's Cloud Computing initiative. It aims to accelerate the delivery of e-services while optimizing ICT spending by using a shared environment based on common standards.

3. Consider the following statements regarding Edge Computing:
1. It involves centralizing all data processing in distant mega-data centers to maximize computational power.
2. By processing data closer to the source, it reduces latency and improves response times for real-time applications.
3. It is primarily used for slow-moving data backups and has no relevance to Autonomous Vehicles or Virtual Reality.

Which of the statements given above is correct?
(a) 1 only
(b) 2 only
(c) 3 only
(d) None of the above

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** Edge computing is decentralized.
- **Statement 2 is correct:** Lowering the physical distance data travels reduces the "lag" (latency).
- **Statement 3 is incorrect:** Autonomous vehicles and VR require near-instant processing, making Edge computing vital for them.



4. Consider the following statements:

1. As of late 2024, El Capitan has emerged as the world's fastest supercomputer, surpassing the Frontier system.
2. Frontier was the first supercomputer to officially reach the exascale barrier, attaining speeds over 1.1 exaFLOPS.
3. China currently leads the world with the highest number of supercomputers in the global top 10 list.

Which of the statements given above is/are incorrect?

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

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** El Capitan reached 1.742 exaFLOPS in Nov 2024. Frontier was the previous leader.
- **Statement 3 is incorrect:** The United States currently leads in terms of the number of supercomputers in the top 10, followed by nations like Japan and China.

5. Consider the following statements regarding Qubits:

1. A qubit is the fundamental unit of quantum information, capable of existing in a state of 0, 1, or both simultaneously.

2. The phenomenon of Superposition is what allows qubits to hold multiple states at once, unlike classical bits.
3. Because qubits use quantum mechanics, they are significantly slower than classical bits at performing simple arithmetic tasks.

Which of the statements given above is incorrect?

(a) 1 only
(b) 2 only
(c) 3 only
(d) None of the above

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** These describe the core principles of quantum computing.
- **Statement 3 is incorrect:** While quantum computers aren't necessarily better for every task, their unique logic allows them to solve specific complex problems (like drug discovery or cryptography) exponentially faster, not slower.

6. Consider the following statements:

1. Quantum Supremacy is achieved when a quantum computer performs a calculation that is practically impossible for any classical supercomputer to complete in a reasonable timeframe.
2. In 2019, Google's Sycamore processor demonstrated this by solving a problem in 200 seconds that would have taken a supercomputer thousands of years.

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

Correct Answer: (c)

Explanation:

Both statements are correct. John Preskill coined the term, and Google's 53-qubit Sycamore provided the first major experimental proof of the concept.

7. Consider the following statements:

1. GPT is a type of large language model (LLM) designed specifically for hardware-level encryption of database servers.
2. GPT models are capable of generating human-quality text and translating languages by predicting the next sequence of data based on patterns.

Which of the statements given above is correct?

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

Correct Answer: (b)

Explanation:

· **Statement 1 is incorrect:** GPT is an AI application for language processing, not hardware encryption.

- **Statement 2 is correct:** It is Generative (creates new content) and Pre-trained (learned from massive datasets).

8. Consider the following statements regarding the AI Impact Summit 2026:

1. The summit adopted the New Delhi Declaration, which focuses on democratizing AI access for the Global South.
2. The framework of the declaration is built around the Seven Pillars (Chakras) including Secure AI and Human Capital Development.
3. The summit focused exclusively on the existential threats of AI, rejecting any discussion on deep-tech research investment.

Which of the statements given above is incorrect?

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

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** These reflect the outcomes of the Feb 2026 summit.
- **Statement 3 is incorrect:** The summit deliberately moved away from existential risk toward practical Deep-tech investment (mobilizing $250 billion).

9. Consider the following statements:

1. Augmented Reality (AR) replaces the physical world entirely with a digital simulation, as seen in fully immersive gaming.
2. Virtual Reality (VR) creates a computer-generated environment that completely replaces the user's perception of the real world.
3. Mixed Reality (MR) allows digital and physical objects to coexist and interact in real-time, such as through Microsoft HoloLens.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** AR overlays info on the real world; it does not replace it.
- **Statement 2 is correct:** VR is fully immersive (e.g., Oculus).
- **Statement 3 is correct:** MR is the most advanced, where virtual objects know where real objects are and can interact with them.

10. Consider the following statements regarding the Metaverse:

1. It is a shared virtual space that combines elements of AR, VR, and social media into a single immersive digital realm.
2. The term was first introduced by Neal Stephenson in the 1992 science fiction novel Snowcrash.
3. It envisions the use of persistent virtual avatars to interact with other users and digital assets in a 3D cyberspace.

How many of the statements given above are correct?
(a) Only one
(b) Only two
(c) All three
(d) None

Correct Answer: (c)
Explanation:
All statements are correct. The Metaverse is seen as the next evolution of the internet, characterized by presence, interoperability, and immersion. Major tech firms are currently building the infrastructure to support this vision.

Universe and Space, Information and Communication Technology

1. Consider the following statements regarding Graphene:
1. It is a single-layer honeycomb lattice of carbon atoms, characterized by high electrical and thermal conductivity.
2. Due to its unique atomic structure, it is considered the most flexible and heavy material known to man, making it suitable for flexible electronics.

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

Correct Answer: (a)
Explanation:
- **Statement 1 is correct:** Graphene is a 2D form of carbon where free-moving electrons allow for record-breaking conductivity.
- **Statement 2 is incorrect:** Graphene is exceptionally lightweight and flexible, not heavy. Its flexibility is exactly why it is a leading candidate for the next generation of flexible electronic screens and wearable devices.

2. With reference to display technologies, consider the following statements regarding AMOLED (Active-Matrix Organic Light-Emitting Diode):
1. Each individual pixel in an AMOLED display generates its own light and color, eliminating the need for a separate backlight.
2. The Active Matrix component utilizes thin-film transistors (TFTs) to control the current flowing to each pixel individually, allowing for faster refresh rates.
3. AMOLED displays consume significantly more battery power than traditional LCDs when displaying true black colors.

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

Correct Answer: A

Explanation:

- **Statement 1 is correct:** AMOLED is based on OLED (Organic Light-Emitting Diode) technology. Unlike LCDs (Liquid Crystal Displays) that require a large, always-on backlight, each sub-pixel in an AMOLED panel is self-emitting and produces its own light.
- **Statement 2 is correct:** The Active Matrix refers to the layer of Thin-Film Transistors (TFTs) behind the organic material. This matrix acts as a switch, directing electrical current to precise, individual pixels much faster than a passive matrix would, which enables smoother motion and higher refresh rates.
- **Statement 3 is incorrect:** When an AMOLED screen displays a dark or true black image, it does so by simply turning off the pixels. Because no electricity is flowing to those specific pixels, it actually conserves battery power, making it more energy-efficient for dark backgrounds compared to LCDs.

3. Consider the following statements regarding the working of LCDs:

1. The display relies on a backlight and a layer of liquid crystals that act as shutters to control light passage.
2. When a voltage is applied (On state), the liquid crystals untwist and prevent light from passing through the second polarizer, creating a dark pixel.
3. LCD pixels emit their own light through organic diodes, eliminating the need for external illumination sources.

Which of the statements given above is/are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 1 and 2 are correct:** These accurately describe the light-shutter mechanism using polarizers and liquid crystal molecules.
- **Statement 3 is incorrect:** LCDs are non-emissive. They cannot produce their own light and must rely on a backlight (typically LED).

4. Consider the following statements:

1. Dark Matter acts as an attractive gravitational force that helps hold galaxies together, whereas Dark Energy acts as a repulsive force that accelerates the expansion of the universe.
2. The mass-energy content of the universe is dominated by ordinary matter (atoms), with Dark Energy making up less than 5% of the total.
3. Neither Dark Matter nor Dark Energy interact with ordinary matter through the electromagnetic force, making them invisible to traditional telescopes.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** This describes the fundamental push-pull relationship in cosmology.

- **Statement 2 is incorrect:** Ordinary matter makes up only about 5%. Dark Energy (~68%) and Dark Matter (~27%) dominate the universe.
- **Statement 3 is correct:** They do not emit, absorb, or reflect light, which is why we can only detect them through their gravitational effects.

5. Match the following telescopes with their primary descriptions:

Telescope	Primary Description
A. Hubble	1. Primary infrared observatory studying the early universe.
B. James Webb (JWST)	2. India's collaboration for remote control studies in Devasthal.
C. Event Horizon (EHT)	3. First major space-based optical telescope (1990).
D. ARIES	4. Global radio telescope network that imaged a Black Hole.

Select the correct code:
(a) A-3, B-1, C-4, D-2
(b) A-1, B-3, C-2, D-4
(c) A-3, B-4, C-1, D-2
(d) A-2, B-1, C-4, D-3

Correct Answer: (a)
Explanation:

- **Hubble (A-3):** Famous for visible/UV light observations.
- **JWST (B-1):** Specialized in deep infrared to see through dust clouds.
- **EHT (C-4):** Used Very Long Baseline Interferometry to image M87 and Sagittarius A.
- **ARIES (D-2):** Located in Uttarakhand, India, featuring the 3.6m Devasthal Optical Telescope.

6. Consider the following statements:
1. AstroSat is India's first dedicated multi-wavelength astronomy mission that observes the universe in X-ray, optical, and UV bands simultaneously.
2. The Thirty Meter Telescope (TMT) is a radio telescope project being built in Hawaii to detect faint signals from the early universe.
3. The SARAS telescope is an Indian radio telescope designed to detect signals from the "Cosmic Dawn" (the birth of the first stars).

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

Correct Answer: (c)
Explanation:

- **Statement 1 is correct:** AstroSat's unique feature is its ability to observe different wavelengths at the same time.
- **Statement 2 is incorrect:** TMT is an Optical/Infrared telescope (using mirrors), not a radio telescope.
- **Statement 3 is correct:** SARAS (Shaped Antenna measurement of the background Radio Spectrum) is used to study the Epoch of Reionization.

7. Consider the following statements regarding Solar Eclipses:

1. During a Total Solar Eclipse, the Moon completely obscures the Sun, allowing only the solar corona to be visible to the naked eye.
2. An Annular Solar Eclipse occurs when the Moon is at its closest point to Earth (perigee), appearing larger than the Sun.
3. A Partial Solar Eclipse occurs when the Sun, Moon, and Earth are not perfectly aligned, obscuring only a portion of the solar disk.

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

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** Totality provides the only safe time to look at the corona without filters.
- **Statement 2 is incorrect:** An Annular eclipse occurs when the Moon is at its farthest point (apogee). Because it looks smaller, it cannot cover the whole Sun, leaving a Ring of Fire.
- **Statement 3 is correct:** This is the most common form of eclipse observed globally.

8. Which of the following scientific processes is responsible for the reddish appearance of the Moon during a total lunar eclipse?

(a) The Moon's volcanic activity reflecting red light back to Earth.
(b) Rayleigh scattering in Earth's atmosphere, which filters out blue light and refracts longer red wavelengths onto the Moon.
(c) The presence of high-energy solar flares that directly strike the lunar surface during an eclipse.
(d) Gravitational lensing of sunlight by the Moon's mass.

Correct Answer: (b)

Explanation:

During a total lunar eclipse, Earth blocks direct sunlight. However, the Earth's atmosphere bends (refracts) sunlight. Just like at sunset, shorter blue wavelengths are scattered away, while longer red wavelengths pass through and hit the Moon, giving it a blood red color.

9. Consider the following statements regarding the Geotail:

1. It is a region formed by the interaction of the Earth's magnetic field and the solar wind, extending on the Sun-facing side of the planet.
2. The geotail is an extension of the magnetosphere that stretches far beyond the Moon's orbit.
3. Once every month, the Moon enters the geotail for approximately six days around the time of the full moon.

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

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** The geotail is formed on the opposite side of the Sun (the night side). The Sun-facing side is compressed by the solar wind.
- **Statement 2 is correct:** It is a long, tail-like structure of the magnetic field.
- **Statement 3 is correct:** This is a significant event for lunar orbiters (like Chandrayaan) to study plasma and particles.

10. Consider the following statements regarding General Relativity:

1. Gravity is described not as a direct force between masses, but as a curvature in the fabric of spacetime caused by mass and energy.
2. The theory predicted the existence of Gravitational Waves, which are disturbances in spacetime that were first directly detected in 2015.
3. According to the Equivalence Principle, the effects of gravity are completely different from the effects of acceleration, making them easily distinguishable in a closed system.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** This is the core geometric interpretation of gravity.
- **Statement 2 is correct:** The LIGO observatory detected these waves coming from merging black holes in 2015.
- **Statement 3 is incorrect:** The Equivalence Principle states that gravity and acceleration are indistinguishable. An observer in a closed elevator cannot tell if they are being pulled by gravity or pushed by acceleration.

Universe and Space-II

1. With reference to the reclassification of celestial bodies by the International Astronomical Union (IAU), why is Pluto classified as a Dwarf Planet rather than a primary planet?
(a) It does not possess enough mass to assume a nearly round shape.
(b) It orbits a larger planet rather than circling the Sun directly.
(c) It has not cleared the neighborhood of debris surrounding its orbit.
(d) It is composed primarily of ice and dust rather than rocky or metallic minerals.

Correct Answer: (c)
Explanation:
According to the IAU, a planet must meet three criteria: it must orbit the Sun, be nearly round, and have cleared the neighborhood of its orbit. Pluto fails the third criteria as it shares its orbital path with other Kuiper Belt objects.

2. Consider the following statements:
1. The Asteroid Belt is a region of rocky and metallic remnants situated specifically between the orbits of Mars and Jupiter.
2. The Kuiper Belt is a disk of icy bodies and dwarf planets located just beyond the orbit of Neptune.

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

Correct Answer: (c)
Explanation:
Both statements are factually correct. The Asteroid Belt contains rocky remnants, while the Kuiper Belt (containing Pluto and Eris) is composed of frozen volatiles such as methane, ammonia, and water ice.

3. Consider the following statements:
1. A Ploonet is a celestial body that was originally a moon but escaped its planet's gravity to orbit its host star directly.
2. The Goldilocks Zone refers to the region in a galaxy where the concentration of heavy metals is high enough to form terrestrial planets.

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

Correct Answer: (a)
Explanation:
Statement 1 is correct. Statement 2 is incorrect; the Goldilocks Zone (Habitable Zone) is the region around a star where the temperature is just right for liquid water to exist on a planet's surface.

4. Which of the following statements best describes the Van Allen Radiation Belts?
(a) They are rings of icy rocks and dust situated between Saturn and Uranus.
(b) They are zones of energetic charged particles captured and held around Earth by its magnetic field.
(c) They are regions of space where gravitational forces of the Earth and Sun perfectly balance.
(d) They are man-made debris fields found exclusively in Low Earth Orbit.

Correct Answer: (b)
Explanation:

These belts are comprised of solar wind particles trapped by Earth's magnetosphere. They are most intense over the Equator and are responsible for the Aurora phenomena at the poles.

5. Consider the following statements regarding Space Debris:

1. The majority of space junk is concentrated in High Earth Orbit (HEO) to avoid atmospheric drag.
2. Kessler Syndrome refers to a runaway chain reaction where collisions between objects in orbit create more debris, leading to further collisions.
3. Space debris includes both defunct large satellites and tiny fragments like paint flecks.

How many of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect;** most debris is found in Low Earth Orbit (LEO), below 2,000 km.
- **Statements 2 and 3 are correct** descriptions of the nature and cascading risks of space junk.

6. Match List I (Initiative) with List II (Organization/Origin):

List I (Initiative)	**List II (Origin)**
A. Project NETRA	1. European Space Agency (ESA)
B. Clean Space Initiative	2. Indian Space Research Organisation (ISRO)
C. IS4OM	3. UN General Assembly (1958)
D. COPUOS	4. ISRO (Space Situational Awareness)

Select the correct code:

(a) A-2, B-1, C-4, D-3
(b) A-4, B-1, C-2, D-3
(c) A-4, B-3, C-2, D-1
(d) A-2, B-3, C-4, D-1

Correct Answer: (b)

Explanation:

Project NETRA is an early warning system in space to detect debris. Clean Space is by ESA. IS4OM (ISRO System for Safe & Sustainable Operations Management) was launched in 2022. COPUOS is a UN committee.

7. Consider the following pairs regarding Satellite Orbits:

Orbit Type	Altitude Range	Primary Application
1. Low Earth Orbit (LEO)	160 – 2,000 km	International Space Station (ISS)
2. Medium Earth Orbit (MEO)	2,000 – 35,780 km	Global Positioning System (GPS)
3. High Earth Orbit (HEO)	> 35,786 km	Weather monitoring (Geosynchronous)

How many of the pairs given above are correctly matched?
(a) Only one pair
(b) Only two pairs
(c) All three pairs
(d) None of the pairs

Correct Answer: (c)
Explanation:
All three are correctly matched. LEO is for imaging and ISS; MEO is for navigation constellations like GPS/Galileo; HEO/GEO is for communication and weather monitoring.

8. Consider the following pairs:

Orbit Type	Description	Application
1. Polar Orbit	Passes over Earth's poles	Remote Sensing (Cartosat)
2. Sun-Synchronous Orbit	Passes over same point at same local time	Climate Change studies
3. Geosynchronous Orbit	Appears stationary above a fixed point	Weather Monitoring (INSAT)

How many of the pairs given above are correctly matched?
(a) Only one pair
(b) Only two pairs
(c) All three pairs
(d) None of the pairs

Correct Answer: (c)
Explanation:
All pairs are correct. Polar/SSO orbits are ideal for Earth observation because they cover the entire globe. Geosynchronous orbits are essential for constant monitoring of a specific geographic area.

9. Consider the following statements regarding Lagrange Points:

1. They are positions in space where the gravitational forces of two large bodies and the centrifugal force of a smaller object balance each other.
2. The L1 point is located behind the Earth (opposite the Sun) and is used by the James Webb Space Telescope.
3. The Aditya-L1 mission is stationed at the L1 point to allow an uninterrupted view of the Sun.

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

Correct Answer: (c)

Explanation:

- **Statement 1and Statement 3 is correct.**
- **Statement 2 is incorrect; L2** is behind the Earth (used by Webb), while **L1** is between the Earth and Sun.

10. With reference to space flight, what is a Halo Orbit?

(a) A circular orbit exactly 1,000 km above the Earth's Equator.
(b) A three-dimensional, periodic orbit around a Lagrange point.
(c) An orbit that allows a satellite to stay in the Earth's shadow permanently.
(d) The path taken by a moon when it is about to become a Ploonet.

Correct Answer: (b)

Explanation:

Halo orbits allow a spacecraft to hover around a Lagrange point (which is just a point in empty space) by following a 3D circular path where forces are balanced. This is commonly used for missions at L1 and L2.

Satellite and Rocket Technology

1. Consider the following table regarding satellite categories:

Type of Satellite	Primary Purpose	Representative Examples
1. Earth Observation (EOS)	Monitoring biosphere, oceans, and weather forecasting	Cartosat, Oceansat, EOS-04
2. Navigation Satellites	Providing PVT (Position, Velocity, and Timing) services	NavIC, GPS, Galileo
3. Communication Satellites	Telecommunication, broadcasting, and internet	GSAT-31, Starlink, OneWeb

How many of the rows given above are correctly matched?

(a) Only one
(b) Only two
(c) All three

(d) None

Correct Answer: (c)
Explanation:
All three rows are correctly matched.

- EOS satellites focus on remote sensing and environmental monitoring.
- Navigation satellites provide geospatial positioning.
- Communication satellites are placed primarily in Geostationary orbits for continuous coverage of telecommunications.

2. Consider the following statements regarding the Navigation with Indian Constellation (NavIC):

1. It is an independent regional system designed to provide positioning services over India and a region extending approximately 1,500 km beyond its borders.
2. The second-generation NVS series satellites are designed to augment the constellation by adding the L1 band signal and utilizing indigenous atomic clocks.
3. The Standard Positioning Service (SPS) is an encrypted signal reserved exclusively for military and authorized government agencies.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** It provides regional coverage including the Indian landmass and its surroundings.
- **Statement 2 is correct:** NVS-01 (launched in 2023) featured the first indigenous rubidium atomic clock.
- **Statement 3 is incorrect:** SPS is for civilian users. The Restricted Service (RS) is the encrypted one meant for authorized/military users.

3. Match the following organizations with their correct descriptions:

1. **IN-SPACe**: Nodal agency to promote and authorize private sector participation in space activities.
2. **NSIL**: The commercial arm of ISRO responsible for production of launch vehicles through industry consortiums.
3. **Antrix**: Founded in 1992 to commercialize ISRO's space products and technology transfer.
4. **ISRO**: The primary R&D body under the Department of Space (DOS).

How many of the above are correctly matched?
(a) Only one
(b) Only two
(c) Only three
(d) All four

Correct Answer: (d)
Explanation: All are correctly described.

- IN-SPACe acts as a single-window regulator for private entities.
- NSIL (New Space India Limited) is the newer commercial arm focused on industry-building.

- Antrix has traditionally handled international commercial launches and tech transfers.

4. Consider the following table regarding India's launch vehicles:

Launch Vehicle	Stages & Payload (GTO)	Primary Orbits & Features
1. SSLV	3 Stages (Solid-Solid-Liquid)	Low Earth Orbit (500 kg)
2. PSLV	4 Stages (Solid-Liquid-Solid-Liquid)	Sun-Synchronous Polar Orbits
3. GSLV Mk-II	3 Stages (Solid-Liquid-Cryogenic)	Geostationary Transfer Orbit (2,250 kg)
4. LVM3 (Mk-III)	3 Stages (Solid-Liquid-Cryogenic)	Heavy lifting (4 tons to GTO)

How many of the pairs given above are correctly matched?
(a) Only one
(b) Only two
(c) Only three
(d) All four

Correct Answer: (d)
Explanation: All pairs are correct. Note the stage configuration:

- **PSLV** uses an alternating S-L-S-L pattern.
- **LVM3** (Launch Vehicle Mark 3) is India's heaviest lifter, crucial for the Gaganyaan (Human Spaceflight) and Chandrayaan missions.

5. Consider the following statements regarding rocket propulsion:

1. ISRO utilizes Unsymmetrical Di-Methyl Hydrazine (UDMH) as fuel combined with Nitrogen Tetroxide as an oxidizer, a combination often termed a dirty combo due to its toxicity.
2. In a liquid propellant system, the fuel and oxidizer are stored separately and mixed only in the combustion chamber to produce thrust.
3. A cryogenic propellant uses gases like Hydrogen and Oxygen that have been liquefied at extremely high temperatures and high pressures.

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

Correct Answer: (a)
Explanation:

- **Statement 1 & 2 are correct:** These describe hypergolic and liquid propulsion mechanics.
- **Statement 3 is incorrect:** Cryogenic propellants are stored at extremely low (sub-zero) temperatures (Hydrogen at -253°C and Oxygen at -183°C), not high temperatures.

6. Consider the following statements regarding Cryogenic Engines:

1. They offer higher efficiency and provide greater thrust for every kilogram of propellant burned compared to solid or earth-storable liquid stages.
2. The engine uses liquid hydrogen as the fuel and liquid oxygen as the oxidizer, both maintained at cryogenic temperatures.

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

Correct Answer: (c)

Explanation: Cryogenic engines are technically complex but highly efficient, making them essential for upper stages of heavy-lift rockets (like LVM3 and GSLV) to carry large payloads into deep space or high orbits.

7. With reference to speed classifications in aeronautics, which of the following is correctly matched?

(a) Subsonic: Speed exactly at Mach 1.0
(b) Supersonic: Mach 1.2 to 5
(c) Hypersonic: Mach 0.8 to 1.2
(d) High-hypersonic: Speed less than Mach 0.8

Correct Answer: (b)

Explanation:

- **Subsonic:** < 0.8
- **Transonic:** 0.8 – 1.2
- **Supersonic:** 1.2 – 5
- **Hypersonic:** 5 – 10
- **High-hypersonic:** 10 – 25

8. **Consider the following statements regarding air-breathing engines:**

1. A Ramjet engine uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor, but it cannot operate at zero velocity.
2. A Scramjet (Supersonic Combustion Ramjet) is designed to operate at hypersonic speeds where the airflow through the engine remains supersonic.
3. A Dual Mode Ramjet (DMRJ) is a specialized engine that can operate in both subsonic and supersonic combustion modes across a range of Mach 4 to 8.

Which of the statements given above is/are correct?

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

Correct Answer: (d)

Explanation: All three are correct. These engines are air-breathing because they take oxygen from the atmosphere rather than carrying it on board, significantly reducing the rocket's weight.

9. Consider the following statements:

1. CMS-01 and GSAT-11 are part of India's communication satellite fleet, designed for high-throughput broadband and connectivity services.
2. GSAT-7A, nicknamed Angry Bird, is a dedicated communication satellite primarily serving the connectivity needs of the Indian Air Force.
3. OCEANSAT-3 and RISAT-2 are Earth Observation Satellites used for oceanography, weather forecasting, and radar imaging respectively.

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

Correct Answer: (d)

Explanation:

All statements are correct. RISAT (Radar Imaging Satellite) is particularly useful because it can see through clouds and at night, making it vital for disaster management and surveillance.

10. Consider the following statements regarding the Shukrayaan-1 mission:

1. It is India's first planned orbiter mission to Venus, intended to study the planet's surface, geological features, and atmosphere.
2. The mission aims to explore signs of active volcanism and seismic activity to understand the climate evolution of Venus.

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

Correct Answer: (c)

Explanation:

Shukrayaan-1 will use the GSLV Mk II to carry a payload of approximately 2,500 kg to Venus. Its goal is to investigate why Venus, similar in size to Earth, evolved into a high-pressure hell-scape with a runaway greenhouse effect.

ISRO Missions

1. Consider the following statements regarding the LUPEX mission:

1. It is a joint collaborative mission between the Indian Space Research Organisation (ISRO) and the National Aeronautics and Space Administration (NASA).
2. The primary objective is to investigate the quantity and quality of water ice in the Moon's permanently shadowed polar regions.
3. In this collaboration, ISRO is responsible for developing the lander, while the Japan Aerospace Exploration Agency (JAXA) is providing the rover.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect**: LUPEX is a collaboration between ISRO and JAXA (Japan), not NASA.
- **Statements 2 and 3 are correct.** The mission will use a Japanese launch vehicle and rover, and an Indian lander.

2. Consider the following statements regarding India's Gaganyaan mission:

1. The mission intends to orbit a crew of three Indian astronauts at an altitude of 300-400 km in Low Earth Orbit (LEO) for a period of 5-7 days.
2. The powerful GSLV Mk III (LVM-3) rocket has been designated as the launch vehicle for this human spaceflight program.
3. The mission consists of a total of five planned flights, all of which will be crewed to ensure maximum data collection.

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

Correct Answer: (a)

Explanation:

- **Statement 1 and 2 are correct:** The program intends to send a crew of three Indian astronauts (designated as Gaganyatris) to an altitude of 400 km in LEO. While initial plans suggested 5–7 days, recent updates indicate a mission duration of 3 days before a safe splashdown in the Indian Ocean. Launch Vehicle: The LVM-3 (Launch Vehicle Mark-3), formerly known as GSLV Mk III, is the designated heavy-lift launcher, re-configured as a human-rated vehicle (HLVM3) to ensure safety.
- **Statement 3 is incorrect**: The mission consists of three planned flights: two uncrewed missions to test systems and safety, followed by one crewed mission.

3. Consider the following statements regarding the testing phase of Gaganyaan:

1. The Pad Abort Test (PAT) is specifically designed to test the parachute and deceleration mechanisms during the final descent.
2. The first uncrewed mission of the Gaganyaan program is successfully completed and was targeted for the year 2022.
3. The Water Survival Test Facility (WSTF) involves recovery trials of the crew module in sea conditions with the assistance of the Indian Navy.

Which of the statements given above is/are correct?

(a) 1 and 2 only
(b) 3 only
(c) 1 and 3 only
(d) None of the above

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect;** PAT evaluates the safety of the crew module in case of an emergency on the launch pad (Integrated Air Drop Test handles parachutes**).**
- **Statement 2 is incorrect;** the first uncrewed mission is targeted for late 2024/2025. Statement 3 is correct.

4. Consider the following statements regarding the GEMINI (Gagan Enabled Mariner's Instrument for Navigation and Information) device:

1. It is a portable satellite receiver developed by ISRO to provide communication in blackout zones where cellular connectivity is unavailable.
2. The device is primarily designed for disaster management, offering a coverage range of up to 300 nautical miles from the coast.
3. GEMINI operates by connecting directly to international GPS satellites rather than Indian regional satellites.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Developed by ISRO to provide emergency communication and information to fishermen in deep sea, particularly in areas (blackout zones) where cellular networks are unavailable. Coverage Range: It offers a coverage range of up to 300 nautical miles from the coast, providing critical updates during severe weather and natural disasters.
- **Statement 3 is incorrect**: GEMINI utilizes India's own GAGAN satellite system (augmented by GSAT satellites) to transmit emergency alerts and information to mariners.

5. Consider the following statements regarding GAGAN:

1. It is a Satellite-Based Augmentation System (SBAS) developed jointly by ISRO and the Airports Authority of India (AAI) primarily for the civil aviation sector.
2. GAGAN functions by augmenting GPS signals to provide higher accuracy, integrity, and availability required for aircraft landing.
3. The system currently supports high-speed, two-way voice communication, allowing pilots to make emergency calls directly through the GAGAN interface.

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

Correct Answer: (a)

Explanation:

Statements 1 and 2 are correct: GAGAN (GPS-Aided GEO Augmented Navigation) is an Indian Satellite-Based Augmentation System (SBAS) jointly developed by the Indian Space Research Organisation (ISRO) and the Airports Authority of India (AAI). It enhances GPS signal accuracy, integrity, and availability for civil aviation, enabling precision approaches (LPV-1) for safer landings over Indian airspace.

Statement 3 is incorrect; a current limitation of GAGAN is that it only supports one-way communication (positioning and alerts), not voice calls.

6. With reference to the Mission Shakti conducted by India, consider the following statements:

1. It was a joint anti-satellite (ASAT) missile test conducted by DRDO and ISRO to destroy a satellite in Geostationary Earth Orbit (GEO).

2. With this test, India became the fourth country in the world to possess this anti-satellite capability.
3. The mission used a modified interceptor missile, PDV Mark-II, that utilized a hit-to-kill technology.

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

Correct Answer: B

Explanation:

- **Statement 1 is incorrect:** Mission Shakti was carried out by the Defence Research and Development Organisation (DRDO) (not a joint mission with ISRO) and targeted a satellite in Low Earth Orbit (LEO) (around 300 km), not Geostationary Orbit.
- **Statement 2 is correct:** India joined the USA, Russia, and China as the fourth country to achieve this capability.
- **Statement 3 is correct:** The test used a modified Prithvi Defence Vehicle (PDV) Mark-II to strike the satellite directly using kinetic energy ('hit-to-kill'), rather than an explosive warhead, to minimize long-term debris.

7. Consider the following statements regarding XPoSat:

1. It is India's first dedicated polarimetry mission to study the dynamics of bright astronomical X-ray sources in extreme conditions.
2. The POLIX payload is designed to measure the degree and angle of polarization of X-rays in the medium energy range of 8-30 keV.
3. The XSPECT payload provides high-resolution spectroscopic data and timing in the soft X-ray energy band (0.8-15 keV).

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

Correct Answer: (d)

Explanation:

All statements are correct. XPoSat was launched via PSLV-C58 and is only the world's second mission of its kind (after NASA's IXPE) to study X-ray polarization.

8. Consider the following statements regarding the NASA-ISRO Synthetic Aperture Radar (NISAR) mission:

1. NISAR is a joint Earth-observation mission designed to monitor global environmental changes including ice-sheet collapse and ecosystem disturbances.
2. The L-band Synthetic Aperture Radar (L-SAR), provided by ISRO, is specialized for detecting surface-level features like crop health and wetlands.
3. NASA provides the S-band Synthetic Aperture Radar (S-SAR), which is capable of penetrating dense forest canopies and soil to study biomass.

Which of the statements given above is/are incorrect?

(a) 1 only
(b) 1 and 2 only

(c) 2 and 3 only
(d) 1, 2, and 3

Correct Answer: (c)
Explanation:
Statement 1 is correct. NISAR (NASA-ISRO Synthetic Aperture Radar) is a joint earth-observation mission launched on July 30, 2025, from India, designed to monitor global environmental changes with high-resolution radar. Using dual-band SAR, it monitors ice-sheet collapse, ecosystem disturbances, and natural hazards like earthquakes and volcanic eruptions, providing data to help with climate change studies.
Statements 2 and 3 are incorrect: The roles are swapped: NASA provides the L-band (long wavelength, high penetration for biomass/ice) and ISRO provides the S-band (shorter wavelength, for surface features/agriculture).

9. Consider the following pairs regarding Space Observatories:

Telescope Name	Wavelength Range	Primary Purpose
1. Hubble (HST)	Visible and Ultraviolet	Imaging distant galaxies and nebulae
2. Compton (CGRO)	Gamma Rays	Studying high-energy celestial phenomena
3. Chandra (CXO)	X-rays	Observing hot, high-energy objects
4. Spitzer (SST)	Infrared	Observing cool, dusty objects and exoplanets

How many of the pairs given above are correctly matched?
(a) Only one pair
(b) Only two pairs
(c) Only three pairs
(d) All four pairs

Correct Answer: (d)
Explanation:
All four pairs are correctly matched. Each telescope is part of NASA's Great Observatories program, each viewing the universe through a different part of the electromagnetic spectrum.

10. Consider the following statements regarding NASA's Parker Solar Probe:
1. It is the first spacecraft to touch the Sun by flying through the solar corona, the Sun's outer atmosphere.
2. The mission's primary goal is to study the mechanisms that cool the solar surface and prevent the acceleration of solar winds.

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

Correct Answer: (a)
Explanation:
Statement 1 is correct. Statement 2 is incorrect; the goal is to understand why the corona is much hotter than the surface and what accelerates the solar wind (not prevent it).

Space Missions

1. Consider the following statements:
1. The LVM3-M6 mission represents a commercial collaboration between NewSpace India Limited (NSIL) and a US-based private company to deploy the Bluebird Block-2 satellite.
2. The Bluebird Block-2 satellite is designed to establish a Low Earth Orbit (LEO) constellation to provide direct-to-mobile 4G and 5G telecommunication services.
3. At 6,100 kg, the Bluebird Block-2 payload stands as the heaviest satellite payload ever launched by ISRO's LVM3 vehicle.

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

Correct Answer: (d)
Explanation:
- **Statement 1 is correct:** NSIL, incorporated in 2019 as the commercial arm of ISRO under the Department of Space, facilitated this mission for AST SpaceMobile, USA.
- **Statement 2 is correct:** It features a massive 223 m2 phased array to facilitate direct cellular connectivity without ground tower dependence.
- **Statement 3 is correct:** It broke previous records, marking the maximum payload threshold successfully carried by the LVM3 to Low Earth Orbit.

2. Consider the following statements regarding the Dust Experiment (DEX):
1. It is India's maiden indigenous scientific instrument engineered to capture and analyze high-speed interplanetary dust particles.
2. The payload was deployed into space utilizing the PSLV Orbital Experimental Module (POEM) platform during the PSLV-C58 mission.
3. The instrument was conceptualized and developed by the Indian Institute of Astrophysics (IIA), Bengaluru.

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

Correct Answer: (a)
Explanation:
- **Statements 1 and 2 are correct:** DEX tracks cosmic dust fragments from comets and asteroids using the cost-effective POEM platform, which repurposes the spent fourth stage of the PSLV rocket.

- **Statement 3 is incorrect:** DEX was developed by the Physical Research Laboratory (PRL), Ahmedabad, not the IIA.

3. Consider the following statements regarding the Voyager 1 mission:

1. Launched primarily to conduct flybys of Jupiter and Saturn, Voyager 1 became the first human-made object to cross the heliosphere into interstellar space.
2. It is currently traveling at a distance that makes it the first spacecraft to be more than one light-year away from Earth.
3. The heliosphere it crossed represents the boundary where interstellar plasma influences become stronger than the solar wind from our Sun.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 1 and 3 are correct:** Voyager 1 (launched in 1977) officially crossed the heliopause into interstellar space in 2012, charting regions outside our solar wind's protective bubble.
- **Statement 2 is incorrect:** It is approaching a distance of one light-day (the distance light travels in 24 hours, roughly 16 billion miles), not a light-year. One light-year is vastly further (approx. 5.88 trillion miles).

4. Consider the following statements:

1. NASA's OSIRIS-REx is the first space mission from the United States designed to collect and return pristine surface samples from an asteroid.
2. Chemical analysis of the sample returned from Asteroid Bennu confirmed the presence of organic building blocks, including amino acids and all five nucleobases of DNA and RNA.
3. Following its successful capsule drop-off, the primary spacecraft was decommissioned and deliberately crashed into Earth's atmosphere.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** The sample analysis from Bennu indicates a rich, early solar system molecular inventory that could have delivered prebiotic materials to early Earth.
- **Statement 3 is incorrect:** The spacecraft was not destroyed; it was granted an extended mission, renamed OSIRIS-APEX, and is currently en route to study the asteroid Apophis in 2029.

5. Consider the following statements regarding the defense agreement signed between India and France:

1. The joint production agreement centers on the SIGMA 30N Navigation System and the CM3-MR Direct Firing Sight to augment artillery units.

2. The integrated system allows autonomous artillery positioning and targeting completely independent of external GPS or satellite architectures.
3. The tracking and direct-fire modules are designed exclusively for heavy towed guns and cannot be cross-integrated with mobile air defense or anti-drone weapon systems.

Which of the statements given above is/are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 1 and 2 are correct:** The SIGMA 30N ensures precise navigation and targeting alignment even in heavily jammed Electronic Warfare (EW) environments where satellite navigation signals are lost.
- **Statement 3 is incorrect:** The system is explicitly valued for its versatility; it can easily integrate with diverse hardware systems, including radars, heavy artillery, and tactical mobile anti-drone assets.

6. Consider the following statements regarding NASA's Lucy Mission:

1. The mission is designed to explore Jupiter's Trojan asteroids, which are trapped in gravity wells ahead of and behind the giant planet.
2. To reach its distant targets, Lucy relies entirely on a high-powered, continuous nuclear propulsion engine without utilizing planetary gravity assists.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The Trojan asteroids are considered "fossils" or remnants of our early solar system's planetary formation.
- **Statement 2 is incorrect:** Lucy utilizes multiple Earth gravity assists (slingshot effects) to alter and accelerate its trajectory through space to match orbits with the Trojan clusters.

7. Consider the following statements regarding planetary defense technologies:

1. The DART mission successfully demonstrated the "kinetic impactor" method by intentionally colliding a spacecraft into the moonlet Dimorphos to alter its orbital path.
2. The spacecraft's primary target was a single, isolated rogue comet heading directly toward the inner solar system.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The mission in September 2022 successfully proved that humans could shift the orbital trajectory of a celestial body via kinetic momentum transfer.
- **Statement 2 is incorrect:** The target was not an isolated comet; it was a safe binary asteroid system comprising a larger body (Didymos) orbited by its smaller moonlet (Dimorphos).

8. Consider the following statements regarding the Artemis lunar exploration architecture:

1. Artemis I served as an uncrewed system flight test integrating the heavy-lift Space Launch System (SLS) rocket with the Orion spacecraft capsule.
2. Artemis II is slated to be the first crewed lunar flyby trajectory since the conclusion of the Apollo era, utilizing a free-return trajectory path.
3. The Artemis Accords constitute a legally binding international treaty that carries strict judicial penalties under United Nations oversight for non-compliance.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Artemis I verified basic systems safety, while Artemis II will send a diverse four-person crew around the Moon without landing.
- **Statement 3 is incorrect:** The Artemis Accords are a set of non-legally binding political principles and guidelines for civil space cooperation, based loosely on the Outer Space Treaty, but they are not a UN-enforced judicial treaty.

9. Consider the following statements regarding India's domestic space station initiative:

1. The Bharatiya Antariksh Station (BAS) is planned to occupy a Low Earth Orbit at an operational altitude of approximately 400 to 450 km.
2. The entire space station assembly will feature a modular layout consisting of five blocks, with the target of launching the first Base Module by 2028.

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

Correct Answer: (c)

Explanation: Both statements are correct. The BAS project will build India's footprint in long-duration microgravity research. The multi-phased module approach allows ISRO to scale up infrastructure systematically, aiming for full operational status by 2035.

10. Consider the following statements regarding Atomic Clocks:

1. They measure time by monitoring the resonant frequency of atoms transitioning between discrete energy states.
2. The International System of Units (SI) definition of the second is based on the resonant frequency of Caesium-133 atoms.

3. Unlike standard atomic clocks that use microwaves, optical atomic clocks operate at higher frequencies using lasers, enabling greater precision.

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

Correct Answer: (d)
Explanations:

- **Statement 1 is correct:** Unlike pendulum clocks that rely on mechanical swings or quartz clocks that use the vibration of a crystal, atomic clocks exploit quantum-mechanical properties. They track the precise resonant frequencies of atoms when they transition between different energy states.
- **Statement 2 is correct:** The global standard for timekeeping is defined by Caesium-133 atomic clocks. One second is officially defined as the duration of exactly \(9,192,631,770\) cycles of radiation corresponding to the transition between two hyperfine levels of the ground state of the Caesium-133 atom.
- **Statement 3 is correct:** Optical atomic clocks are the next-generation timekeepers. While traditional atomic clocks (like those used in the Indian NavIC or global GPS satellites) operate in the microwave range of the electromagnetic spectrum, optical clocks use lasers to measure atomic vibrations in the visible or ultraviolet ranges. This allows them to count more cycles per second, making them thousands of times more precise.

Space-Tech

1. Consider the following statements regarding space-based internet networks:

1. Mega-constellations can be deployed across both Low Earth Orbit (LEO) and Geostationary Orbit (GEO) architectures to attain global commercial coverage.
2. Space-based internet completely bypasses terrestrial infrastructure, removing any operational requirement for fixed ground transceiver stations or ISPs.
3. High latency remains a primary technical advantage of utilizing Low Earth Orbit (LEO) satellite constellations compared to standard optical-fiber broadband networks.

Which of the statements given above is/are correct?

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** Companies utilize combinations of LEO arrays (like Starlink) and legacy GEO satellites to establish broad data links.
- **Statement 2 is incorrect:** Space-based internet still fundamentally relies on planetary ground stations (gateways) to link the network satellite traffic back to core internet service providers.
- **Statement 3 is incorrect:** A defining advantage of LEO networks is their low latency due to closer planetary proximity, not high latency.

2. Consider the following statements regarding the new observation facilities sanctioned in Ladakh:

1. The National Large Solar Telescope (NLST) is a 2-metre aperture system designed for Merak to observe solar magnetism and dynamics, making it India's third active ground-based solar observatory.
2. The National Large Optical Telescope (NLOT) features a 13.7-metre segmented-mirror setup at Hanle, engineered to study exoplanets using optical-infrared wavelengths.
3. Upon completion, both NLST and NLOT will be operated entirely under the direct financial control of the Kodaikanal Solar Observatory.

How many of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 1 and 2 are correct:** These capture the precise technical dimensions and tracking goals for both the NLST (solar dynamics) and NLOT (segmented-mirror optical deep space array) architectures.
- **Statement 3 is incorrect:** The Kodaikanal Solar Observatory (established 1899) is an asset under the Indian Institute of Astrophysics (IIA), not an independent administrative body that controls new national infrastructure projects.

3. Consider the following statements regarding the Moonshot Project launched by IISc and the Pratiksha Trust:

1. The project aims to develop bidirectional brain co-processors that can decode neural recordings, analyze cognitive states, and re-encode signals back via neural stimulation.
2. The technology acts as a standard one-way conventional Brain-Computer Interface (BCI) aimed exclusively at capturing motor cortex outputs.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** Brain co-processors are AI-driven, closed-loop neural structures intended to interact with the brain dynamically.
- **Statement 2 is incorrect:** Unlike standard one-way BCIs, these devices focus on the full cognitive loop (perception, decision-making, attention) to specifically help restore reach and grasp functions in stroke survivors.

4. Consider the following statements:

1. ISRO first demonstrated its foundational structural capability to safely recover an orbiting craft using the Space Capsule Recovery Experiment (SRE) in 2007.
2. The planned winged Orbital Re-entry Vehicle (ORV) must be manually steered via a ground pilot crew throughout its descent to land safely on a standard runway.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** The 2007 SRE mission followed by the 2014 Crew Module Atmospheric Re-entry Experiment (CARE) laid down the thermal shielding and design data for India's re-entry profiles.
- **Statement 2 is incorrect:** The ORV is designed to perform its atmospheric re-entry and runway glide landing autonomously, requiring no human piloting during descent.

5. Consider the following statements regarding Mission MITRA:

a) It is an astronomical observation program utilizing the Astrosat platform to trace electromagnetic stress anomalies across distant star systems.
b) It represents a behavioral and physiological assessment program conducted at Leh, Ladakh, to evaluate Gaganyaan crew capabilities under extreme stress profiles like hypoxia and isolation.
c) The mission is carried out as a defense venture controlled exclusively by the Defense Research and Development Organisation (DRDO).
d) Its primary design goal is to train international space tourists for low Earth orbit civilian spaceflights.

Correct Answer: (b)
Explanation:

- Mission MITRA (Mapping of Interoperable Traits and Response Assessment) was conducted in collaboration with the IAF's Institute of Aerospace Medicine (IAM) to check the real-world operational strengths of the Gaganyaan astronauts under simulation.
- Mission MITRA (Mapping of Interoperable Traits and Response Assessment) is an ISRO terrestrial analog space mission conducted in Leh, Ladakh. Designed for the Gaganyaan programme, it evaluates astronauts and ground teams on psychological resilience, teamwork, and decision-making under stress caused by isolation, extreme cold, and hypoxia (low oxygen).

6. Consider the following statements:

1. Mons Mouton is a massive, flat-topped lunar mountain structure located near the Moon's South Pole, which has been identified as a target site for the Chandrayaan-4 mission.
2. The primary objective of the Chandrayaan-4 mission is to establish a permanent human outpost on Mons Mouton by the end of 2026.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** Named after NASA mathematician Melba Roy Mouton, this structure features a flat top spanning roughly 100 kilometers, rising 6,000 meters above surrounding areas.
- **Statement 2 is incorrect:** Chandrayaan-4 is a robotic sample-return mission meant to demonstrate lunar takeoff and sample retrieval capabilities, not a human habitation mission.

7. Consider the following statements regarding Solid Fuel Ducted Ramjet (SFDR) propulsion technology:

1. The propulsion structure merges the benefits of standard solid-fuel rocket boosters with an air-breathing ramjet engine system.
2. By utilizing atmospheric oxygen as an oxidizer for sustained cruise phases, the system significantly reduces the required structural weight of onboard oxidizers.
3. Because it requires a constant, highly pressurized internal turbopump array, the SFDR system cannot be used for compact long-range air-to-air missiles.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** These highlight the performance edge of SFDR, which allows missiles to maintain high-speed cruise phases over long interception distances.
- **Statement 3 is incorrect:** A ramjet relies on forward motion to compress incoming air, meaning it has no moving compressor parts or complex turbopump arrays, making it highly suitable for advanced long-range air-to-air missiles.

8. Consider the following statements regarding India's first commercial EOSS project under the Public-Private Partnership (PPP) model:

1. The PixxelSpace India consortium won the IN-SPACe proposal to design, construct, and operate a planned constellation of 12 state-of-the-art Earth Observation satellites.
2. Under this specialized PPP framework, the private sector manages satellite operations while the government offers policy, technical, and strategic back-end support.
3. The proposed satellite constellation will integrate diverse sensory instruments, including panchromatic, multispectral, hyperspectral, and microwave SAR sensors.

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

Correct Answer: (d)

Explanation: All statements are factually correct. The project combines private agility with state oversight to deploy varied remote sensing arrays (hyperspectral, multispectral, and Synthetic Aperture Radar) within a multi-year deployment cycle.

9. Consider the following statements regarding polar orbits and related human spaceflights:

1. A satellite orbit that exhibits a structural deviation of up to 10 degrees from the precise North and South rotational poles is still classified under the polar orbit domain.
2. Polar orbits typically operate within Low Earth Orbit (LEO) parameter altitudes ranging roughly between 200 km and 1,000 km.

3. As the planet rotates beneath a polar-orbiting spacecraft, the satellite can achieve visual scanning coverage over the entire surface of the globe over time.

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

Correct Answer: (d)

Explanation: All statements are correct. Polar orbits are widely chosen for mapping, intelligence surveillance, and weather systems due to their global surface sweep properties. The SpaceX "Fram2" mission is an example of a human spaceflight mission path crossing these polar boundaries.

10. Consider the following statements regarding the historical Kodaikanal Solar Observatory:

1. It is administratively managed and operated by the Indian Institute of Astrophysics (IIA), which functions under the Department of Science and Technology (DST).
2. The facility is internationally recognized for discovering the Evershed Effect the nearly horizontal outflow of gases observed within the sunspot penumbra layer.

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

Correct Answer: (c)

Explanation: Both statements are correct. Established in 1899, this observatory houses long-term, high-quality data archives that continue to serve researchers in reconstructing solar magnetic behavior and understanding historical solar cycles.

Defence Technology

1. Consider the following statements regarding India's domestic Ballistic Missile Defense (BMD) initiative:

1. Phase 1 of the BMD program is structurally configured to track and intercept incoming hostile ballistic missile threats with an operational range of up to 2000 km.
2. Phase 2 of the program, designed to expand India's strategic defense envelope, is engineered to detect and neutralize longer-range ballistic threats up to 5000 km.

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

Correct Answer: (c)

Explanation: Both statements are correct. India's BMD architecture is built as a multi-layered shield. Phase 1 provides protection against medium-range missile systems, whereas Phase 2 expands capabilities against Intermediate-Range Ballistic Missiles (IRBMs) and intercontinental threats up to 5000 km.

2. Match the tactical missile interceptors and anti-satellite assets (Column A) with their corresponding operational domains (Column B):

Interceptor System	Operational Characterization
I. Prithvi Air Defense (PAD) / Pradyumna	A. Endo-atmospheric interceptor engineered to destroy threats in the lower atmosphere.
II. Advanced Air Defense (AAD) / Ashwin	B. Exo-atmospheric interceptor boasting a maximum altitude threshold of 80 km.
III. Prithvi Defense Vehicle (PDV)	C. Advanced interceptor variant with an elevated altitude engagement capacity of 150 km.
IV. Prithvi Defense Vehicle Mk-2	D. Specialized exo-atmospheric interceptor capable of destroying low earth orbit satellites.

Select the correct matching combination using the options below:

(a) I - B, II - A, III - C, IV - D
(b) I - A, II - B, III - D, IV - C
(c) I - B, II - C, III - A, IV - D
(d) I - D, II - A, III - C, IV - B

Correct Answer: (a)

Explanation:

- PAD handles high-altitude exo-atmospheric threats up to 80 km, while AAD targets threats inside the atmosphere (endo-atmospheric).
- PDV updates legacy systems to clear targets up to 150 km, and PDV Mk-2 serves as India's proven Anti-Satellite (ASAT) kinetic intercept weapon tested in Mission Shakti.

3. Consider the following statements regarding prominent foreign air defense systems:

1. NASAMS-II is a specialized US-developed missile infrastructure designed to protect airspace from cruise missiles, drones, and fixed-wing aircraft.
2. The S-400 Triumf is a highly capable Russian long-range anti-aircraft weapon system built to intercept drones, ballistic missiles, and stealth targets.
3. The Iron Dome is an ultra-long-range strategic ballistic missile interceptor deployed exclusively by Israel to counter hypersonic intercontinental threats.

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

Correct Answer: (a)

Explanation:

- **Statements 1 correct:** NASAMS-II (United States): Developed by Kongsberg Defence & Aerospace and Raytheon, the NASAMS-II is a highly adaptable, short-to-medium-range ground-based air defense system. It is specifically engineered to protect critical infrastructure and population centers against fixed-wing aircraft, helicopters, cruise missiles, and unmanned aerial vehicles (UAVs).
- **Statements 2 correct**: S-400 Triumf (Russia): Manufactured by Almaz-Antey, the S-400 Triumf is a long-to-medium-range, highly mobile anti-aircraft weapon system designed to intercept almost all types of aerial threats.
- **Statement 3 is incorrect** because the Iron Dome is a short-range defense system. It is designed to counter low-tech rocket artillery, mortars, and short-range projectiles fired from nearby borders, not long-range or hypersonic ballistic missiles.

4. Consider the following statements regarding military technologies developed in India:

1. The RUDRAM series represents India's first indigenous family of anti-radiation missiles designed to suppress enemy air defenses by homing in on radiation-emitting radars.
2. The Sudarshan is a domestic laser-guided precision bomb kit developed by DRDO with an extended standalone gliding range capability of up to 500 km.
3. RaIDer-X is a compact explosive detection device developed through a joint collaboration between DRDO and the Indian Institute of Science (IISc), Bengaluru.

Which of the statements given above is/are correct?

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

Correct Answer: (b)

Explanation: Statements 1 and 3 are correct. Statement 2 is incorrect, the Sudarshan laser-guided bomb has a standard operational range of up to 50 km, not 500 km.

5. Consider the following statements regarding advanced weapon delivery systems and components:

1. A Fractional Orbital Bombardment System (FOBS) uses a low Earth orbit trajectory to fly over unexpected paths before de-orbiting onto a target, giving it nearly unrestricted range.
2. Compounds such as CL-20, HMX, and LLM-105 are classified as high-energy materials (HEMs) primarily utilized as military explosives in rocket warheads, artillery, and detonators.

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

Correct Answer: (c)

Explanation: Unlike traditional ballistic paths that trace a predictable, high parabolic arc, FOBS drops its payload out of orbit before reaching a full revolution. This makes it difficult for early-warning systems to track. CL-20, HMX, and LLM-105 are advanced explosives optimized to maximize the energy-to-weight ratio in military warheads.

6. Consider the following grid categorizing the generation profiles of current and historical fighter aircraft within the Indian Air Force:

Generation Category	Aircraft Designation	Primary Operational Role
1. First Generation	MiG-21	Supersonic interceptor used primarily for air defense and ground attacks.
2. Second Generation	MiG-29	Twin-engine multirole fighter known for its exceptional maneuverability.
3. Third Generation	Sukhoi Su-30MKI	Heavy twin-engine multirole air superiority fighter developed with Russia.
4. Fourth Generation	Dassault Rafale & HAL Tejas	High-tech multirole fighters featuring delta-wing designs and fly-by-wire controls.

How many of the rows presented above are correctly matched?
(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (d)
Explanation: All four rows are matched correctly. The iconic MiG-21 dates back to earlier design eras, the MiG-29 represents specialized twin-engine agile updates, the Su-30MKI provides long-range multirole capability, and the Rafale along with the indigenous HAL Tejas bring glass cockpits and fourth-generation electronic warfare suites.

7. Consider the following statements regarding the fifth-generation fighter jet configurations of India and Russia:
1. The Sukhoi Su-57, Russia's operational fifth-generation stealth fighter, features supercruise capabilities but utilizes conventional round exhaust nozzles.
2. Under proposed partnerships, Russia has offered a twin-seat variant of the Su-57, which allows a second crew member to manage manned-unmanned teaming operations with stealth drones.
3. India's indigenous fifth-generation Advanced Medium Combat Aircraft (AMCA) is being developed and manufactured solely under the Defence Research and Development Organisation (DRDO), with zero foreign collaboration for its engines.

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

Correct Answer: (a) Explanation:

Statements 1 and 2 are correct. Statement 3 is incorrect, while the AMCA is an indigenous program designed by ADA/DRDO, India is actively pursuing international partnerships and joint ventures with foreign aerospace manufacturers to co-develop and manufacture the high-thrust engines required for the production variants of the aircraft.

8. Consider the following statements regarding advanced fighter jets proposed for global and regional maritime/air force acquisition pipelines:

1. The Boeing F/A-18 Super Hornet is an all-weather, carrier-capable multirole fighter integrated with advanced radar and multi-sensor target tracking systems.
2. The Eurofighter Typhoon is a twin-engine, delta-wing multirole combat aircraft designed by a European consortium for air superiority and ground attack operations.

Which of the statements given above is/are incorrect?

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

Correct Answer: (d) Explanation: Both statements are correct. These aircraft represent advanced multirole designs featuring heavy structural configurations, modern sensor networks, and precision weaponry. They are frequently evaluated in international defense tenders due to their combat-proven reliability.

9. Consider the following statements regarding Over-the-Horizon (OTH) early warning radar technology:

1. OTH radar systems bypass the physical limitation of the Earth's curvature by bouncing high-frequency (HF) electromagnetic signals off the ionosphere via skywave propagation.
2. These systems provide deep early warning coverage across thousands of kilometers, allowing the detection of incoming ballistic trajectories and low-observable stealth assets.

Which of the statements given above is/are incorrect?

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

Correct Answer: (c)

Explanation: Both statements are correct. Standard line-of-sight radar arrays fail to track distant low-flying targets once they drop below the horizon due to Earth's curvature. By reflecting long-range high-frequency waves off the ionosphere down to the surface, systems like Russia's Container-S or Voronezh OTH radars can spot aircraft and missile launches from massive distances.

10. Which of the following military aircraft types is correctly matched with its primary operational role?

(a) Dornier-228 — Heavy strategic transport aircraft designed for inter-continental large cargo military airlifts.
(b) Ilyushin Il-76 — Twin-engine supersonic air superiority fighter equipped with nuclear striking capabilities.
(c) C-17 Globemaster III — Supersonic close-air support fighter engineered for high-speed tactical intercepts.
(d) Dassault Rafale — Supersonic multirole combat aircraft built for high-speed air defense and offensive strike operations.

Correct Answer: (d)

Explanation: Option (d) is correct; the Rafale is a supersonic multirole combat aircraft. The Dornier-228 is a light utility aircraft for maritime patrol and pollution control, while the Ilyushin Il-76 and C-17 Globemaster III are heavy strategic airlift transport platforms. They are not supersonic interceptors or fighter jets.

Defence Technology - II

1. Consider the following statements:

1. INS Vikramaditya is a refurbished Russian aircraft carrier (formerly Admiral Gorshkov) that features specialized landing architectures including the LUNA system for MiG-29K fighters.
2. INS Vikrant is India's premier indigenous aircraft carrier operating via Catapult-Assisted Take-Off But Arrested Recovery (CATOBAR) launch mechanisms to deploy twin-engine fighters.
3. Both aircraft carriers maintain operational configurations capable of handling approximately 30 air assets, including fixed-wing combat jets and rotary-wing surveillance platforms.

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

Correct Answer: (c) Explanation:

- **Statements 1 and 3 are correct:** INS Vikramaditya is an intensive conversion ship housing over 1,600 personnel with an operational range exceeding 13,000 km. Both platforms support around 30 aircraft including combat aircraft (MiG-29K) and utility/anti-submarine warfare helicopters.
- **Statement 2 is incorrect:** INS Vikrant does not use CATOBAR (catapults). It employs STOBAR (Short Take-Off But Arrested Landing) mode utilizing an indigenous angled ski-jump ramp for launch and three arrester wires for recovery.

2. Consider the following table regarding the surface combatants of the Indian Navy:

Row	Vessel Class / Project	Type and Area of Operation	Primary Mission Objective
1.	**INS Astradharini**	Torpedo Launch and Recovery Vessel; operates primarily on high seas.	Technical trials of indigenous underwater weapons and systems developed by NSTL.
2.	**INS Kavaratti**	Project 28 Kamorta-class Stealth Corvette; features carbon composites.	Dedicated long-range anti-submarine warfare (ASW) tracking and prosecution.
3.	**Project 17A**	Guided-Missile Frigate; designed for comprehensive "Blue Water" environments.	Countering conventional and non-conventional threats using Shivalik-class follow-ons.

4.	**Project 15B**	Advanced variants of Kolkata-class Guided-Missile Destroyers.	Fleet-level multi-mission strike defense using heavy, highly indigenous platforms.

How many of the rows presented above are correctly matched?
(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (d)
Explanation: All four rows are accurately matched. INS Astradharini replaced legacy assets for testing underwater weapons. INS Kavaratti represents India's push into carbon composite naval integration for lower acoustic signatures under Project 28. Project 17A (Nilgiri class frigate fleet) and Project 15B (Visakhapatnam class destroyer fleet) represent high-priority surface acquisition pipelines with overall domestic material components exceeding 75%.

3. Consider the following statements regarding the conventional submarine fleets of the Indian Navy:
1. Diesel-electric submarines (SSKs) utilize electric propulsion motors powered by battery banks that require periodic surfacing or snorkeling to run air-breathing diesel generators.
2. The Shishumar-class represents a series of four conventional patrol submarines procured and built under a technology transfer collaboration with France.
3. The Kilo-class (Sindhughosh-class) was acquired from Russia, while the modern Kalvari-class (Scorpene design) is being constructed domestically in partnership with French naval design firms.

Which of the statements given above are correct?
(a) 1 and 2 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Correct Answer: (b)
Explanation:
- **Statements 1 and 3 are correct:** Diesel-electric vessels are quiet when operating on battery charge but must surface or use a snorkel frequently to replenish air for their diesel combustion engines, making them more vulnerable to modern radar tracking than nuclear submarines.
- **Statement 2 is incorrect:** The Shishumar-class submarines were acquired and built in collaboration with Germany (HDW), not France. The Kalvari-class is the one linked to French collaborations.

4. Consider the following statements regarding the strategic submarine architecture of the Indian Navy:
1. Nuclear-Powered Attack Submarines (SSNs) are designed to hunt surface ships and other submarines, and can remain submerged almost indefinitely, limited only by crew provisions.
2. Nuclear-Powered Ballistic Missile Submarines (SSBNs) function as high-speed tactical front-line interceptors deployed to engage enemy vessels using short-range anti-ship cruise missiles.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** SSNs do not rely on external atmospheric air and utilize internal nuclear reactors for high-speed underwater endurance, carrying anti-ship and land-attack cruise missiles alongside torpedoes.
- **Statement 2 is incorrect:** SSBNs are not high-speed tactical front-line dogfighters. They are slow-moving, stealthy, strategic deterrent platforms designed to hide deep in oceans to preserve a country's second-strike capability using long-range Submarine-Launched Ballistic Missiles (SLBMs).

5. Consider the following statements regarding India's strategic nuclear triad:

1. A complete nuclear triad requires the verified operational capability to deliver nuclear payloads via airborne platforms, land-based ballistic systems, and submarine-launched missile architectures.
2. INS Arihant, commissioned in 2016 as India's first domestic Nuclear-Powered Ballistic Missile Submarine (SSBN), carries the K-15 SLBM with a range profile of 750 km.
3. INS Arighat is India's second indigenous nuclear-powered ballistic missile submarine, expanding the country's strategic second-strike capabilities under a strict "No First Use" policy.

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

Correct Answer: (d)

Explanation: All statements are correct. India maintains a strict No First Use defensive doctrine, having a highly survivable sea-based retaliatory leg (SSBNs like Arihant and Arighat hiding at sea) is necessary to ensure credible strategic stability.

6. Consider the following statements regarding naval modernization programs:

1. Project 75 covers the domestic construction of six conventional hunter-killer submarines of Scorpene design by Mazagon Dock Shipbuilders Limited (MDSL).
2. Project 75 (I) is the follow-on program structured to procure advanced conventional submarines equipped with fuel-cell-based Air-Independent Propulsion (AIP) systems to extend submerged endurance.

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

Correct Answer: (c)

Explanation: Both statements are correct. Project 75 delivered six assets (Kalvari, Khanderi, Karanj, Vela, Vagir, and Vagsheer). Project 75 (I) upgrades this by requiring an integrated AIP module, which removes the need for conventional submarines to surface daily to run their diesels, lowering their detection risk.

7. Consider the following table detailing indigenous Unmanned Aerial Vehicles (UAVs) developed by DRDO:

Row	Drone Platform	Production Origin	Core Tactical Utility Profile
1.	**NETRA**	Indigenous (DRDO)	Airborne Early Warning and Control (AEW&C) radar platform for wide-area tracking.
2.	**Lakshya 2**	Indigenous (DRDO)	Advanced pilotless target aircraft (PTA) used to simulate threat trajectories for weapons evaluation.
3.	**Nishant**	Indigenous (DRDO)	High-speed loitering munition optimized for armor penetration and anti-radiation radar strikes.
4.	**Panchi**	Indigenous (DRDO)	Wheeled derivative variant of a tactical UAV capable of conventional runway takeoff and landing.

How many of the rows presented above are correctly matched?

(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (c) Explanation:

- **Rows 1, 2, and 4 are correctly matched:** These accurately describe the tactical profiles of the NETRA radar dome system, the Lakshya target aircraft, and the wheeled Panchi UAV configuration.
- **Row 3 is incorrectly matched:** Nishant is designed for battlefield surveillance, reconnaissance, intelligence gathering, and electronic warfare support, not as an explosive loitering munition.

8. Consider the following table detailing tactical robotic systems and imported unmanned systems:

Row	Asset Designation	Procurement Origin	Primary Operational Domain
1.	**UXOR**	Indigenous (DRDO)	Unexploded ordnance handling and remote neutralization of heavy bombs/missiles.
2.	**Heron**	Imported (Israel)	Medium-Altitude Long-Endurance (MALE) asset deployed for long-range ISR operations.
3.	**FireFly**	Imported (United States)	Heavy multi-mission strategic combat search and rescue aircraft platform.

4.	**Harpy / Harop**	Imported (Israel)	Loitering munitions designed to destroy radar arrays via precision kamikaze strikes.

How many of the rows presented above are correctly matched?
(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (c) Explanation:

- **Rows 1, 2, and 4 are correctly matched:** UXOR manages high-risk ordnance disposal safely. The Israeli-origin Heron handles long-endurance reconnaissance, and the Harpy/Harop platforms act as radar-hunting kamikaze loitering munitions.
- **Row 3 is incorrectly matched:** FireFly is a light, man-portable loitering munition imported from Israel, not a heavy combat search and rescue platform from the United States.

9. Consider the following statements:
1. The Bhargavastra micro-missile asset is an indigenous weapon system explicitly developed to counter and neutralize incoming hostile swarm drone threats.
2. Modern Swarm Drones operate as an integrated Smart War-Fighting Array of Reconfigured Modules (SWARM) where multiple assets communicate and coordinate actions autonomously.

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

Correct Answer: (c)
Explanation: Both statements are correct. Swarm technology utilizes decentralized algorithms to allow multiple low-cost drones to work together as a single unit. To defend against this, specialized defense networks like the Bhargavastra micro-missile are designed to intercept and disrupt these distributed threats.

10. Consider the following statements regarding global non-proliferation export control architectures:
1. The Australia Group is an informal forum where participating countries maintain export regulations to prevent the proliferation of chemical and biological weapons, without imposing legally binding treaties.
2. The Wassenaar Arrangement is a multilateral export control consensus framework that focuses on regulating the transfer of conventional armaments and dual-use goods and technologies across 42 member states.
3. The Missile Technology Control Regime (MTCR) focuses heavily on limiting the proliferation of rocket and delivery systems capable of carrying a minimum payload threshold of 500 kg over a minimum distance of 300 km.

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

Correct Answer: (d)

Explanation: All statements are factually correct. India is a full member of all three export control cartels (joining MTCR in 2016, Wassenaar in 2017, and the Australia Group in 2018). These informal mechanisms help regulate sensitive technology exports to prevent global proliferation while verifying India's status as a responsible space and defense power.

Defence Technology and Conventional and Alternative Energy

1. Consider the following statements:

1. The Organisation for the Prohibition of Chemical Weapons (OPCW) is the Hague-based implementing body for the Chemical Weapons Convention, to which India is a signatory and state party.
2. The Biological Weapons Convention (BWC) functions as the first multilateral disarmament treaty banning an entire category of Weapons of Mass Destruction (WMD), and its provisions have been both signed and ratified by India.
3. The Nuclear Suppliers Group (NSG) is a 48-member export-control body that admitted India as a full member following its signing of the Nuclear Non-Proliferation Treaty (NPT).

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** India has signed and ratified both the Chemical Weapons Convention (implemented by the OPCW in The Hague) and the Biological Weapons Convention (BWC), supporting complete, verifiable elimination of these WMD categories.
- **Statement 3 is incorrect:** India is not a member of the Nuclear Suppliers Group (NSG). The principal obstacle to India's admission is its persistent refusal to sign the Non-Proliferation Treaty (NPT), which the NSG traditionally considers a foundational benchmark for membership.

2. Consider the following statements regarding international nuclear frameworks:

1. The 1996 Comprehensive Test Ban Treaty (CTBT) bans all nuclear explosions for both military and peaceful purposes, but it has not officially entered into force because it lacks necessary ratifications from states like India, Pakistan, North Korea, and the United States.
2. The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is a landmark agreement aimed at preventing the spread of nuclear arms, promoting peaceful nuclear energy cooperation, and pursuing disarmament, and India was one of its primary founding signatories.
3. The Treaty on the Prohibition of Nuclear Weapons (TPNW), which entered into force on January 22, 2021, prohibits state parties from developing, testing, or stockpiling nuclear explosive devices, and India has chosen neither to sign nor ratify it.

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

Correct Answer: (c)

Explanation:

- **Statements 1 and 3 are correct:** The CTBT cannot enter into force until all 44 specific nuclear-capable states listed in its Annex 2 ratify it (India, Pakistan, and North Korea have not signed; the US, China, Egypt, Iran, and Israel have signed but not ratified). The TPNW is active globally, but India stays out of it, maintaining that it does not represent a truly universal or consensus-driven path to global disarmament.
- **Statement 2 is incorrect:** India has not signed the NPT. India views the NPT as a fundamentally flawed and discriminatory framework that splits the world into permanent nuclear haves (the five permanent UN Security Council members who tested before 1967) and have-nots.

3. Consider the following statements regarding Directed Energy Weapons:

1. High-Energy Lasers operate as non-kinetic precision weapons that concentrate intense electromagnetic energy to melt, blind, or cause structural failure in targets at the speed of light.
2. Under the domestic DURGA-II project, the Defence Research and Development Organisation (DRDO) is actively developing a conventional rocket-propelled kinetic interceptor shield to detonate artillery shells in mid-air.

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

Correct Answer: (a) Explanation:

- **Statement 1 is correct:** DEWs use concentrated energy (lasers or microwaves) instead of solid projectiles. They move at light speed to instantly degrade, disable, or burn through electronics and structural hulls without fragmentation or explosive blast waves.
- **Statement 2 is incorrect:** DURGA-II (Directionally Unrestricted Ray-Gun Array) is a Directed Energy Weapon (Laser) project, not a conventional rocket-propelled kinetic missile interceptor shield. It provides a silent, reusable, and instant laser defense architecture against drone swarms and incoming missile threats.

4. Which of the following presents the correct chronological arrangement of different types of coal ordered from the HIGHEST carbon concentration percentage to the LOWEST carbon concentration percentage?

(a) Anthracite -->Lignite -->Bituminous -->Peat
(b) Anthracite -->Bituminous -->Lignite -->Peat
(c) Bituminous -->Anthracite -->Peat -->Lignite
(d) Peat -->Lignite -->Bituminous -->Anthracite

Correct Answer: (b)

Explanation:

The carbon content determines the heating quality and grade of the coal. The accurate structural hierarchy from highest density of carbon to lowest is:

1. **Anthracite:** Purest and hardest form.
2. **Bituminous:** Standard commercial or metallurgical coal.
3. **Lignite:** Low-grade brown coal.
4. **Peat:** Organic precursor layer formed during the first stage of coalification.

5. Consider the following statements:

1. Coke is a tough, porous, black, nearly pure carbon material manufactured through the destructive distillation of coal, which involves heating it at high temperatures in an completely oxygen-free chamber.
2. Fly ash is a fine particulate byproduct generated by coal-fired thermal power plants that cannot be integrated into building materials or blended with standard Portland cement due to structural breakdown risks.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The coking process drives off volatile matter and moisture from coal without letting it burn, leaving behind strong carbon structures used for smelting iron ore into steel.
- **Statement 2 is incorrect:** Fly ash is highly useful and can be blended as a partial replacement for Portland cement in concrete mixtures. It is also widely used to manufacture strong, eco-friendly construction bricks, helping to recycle industrial waste.

6. Consider the following statements regarding fuel gases utilized in domestic and transport sectors:

1. Liquefied Petroleum Gas (LPG) is a flammable hydrocarbon mixture consisting primarily of propane, butane, and isobutane, containing added ethyl mercaptan to give it a distinct odor for rapid leak detection.
2. Compressed Natural Gas (CNG) consists primarily of methane stored under high pressure, serving as a lower-emission, cleaner-burning alternative to gasoline and diesel engines.
3. Within the extraction industry, sweet gas denotes natural gas processing lines that are free from or contain very low concentrations of toxic, corrosive hydrogen sulfide, whereas sour gas contains significant amounts of it.

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

Correct Answer: (d)

Explanation: All three statements are correct. Pure LPG and methane are naturally odorless; ethyl mercaptan is explicitly blended into commercial cylinders for safety. Sour gas requires industrial sweetening treatment plants to scrub out dangerous H_2S before it can be fed into commercial supply pipelines.

7. Based on industrial combustion data, which of the following sequences accurately lists the fuels in descending order based on their standard Calorific Value (from HIGHEST heat output per unit mass to the LOWEST)?

(a) LPG -->Methane -->Petrol / Diesel / Kerosene -->Coal
(b) Petrol -->LPG -->Methane -->Wood -->Cow Dung
(c) Methane -->Coal -->Diesel -->Biogas -->Kerosene
(d) Coal -->LPG -->Kerosene -->Biogas -->Wood

Correct Answer: (a)

Explanation: Calorific value indicates how much thermal energy a fuel yields when burned completely (kJ/kg). Evaluating the given datasets shows the accurate descending order in option (a):

- **LPG:** 55,000 kJ/kg
- **Methane:** 50,000kJ/kg
- **Petrol / Diesel / Kerosene:** 45,000kJ/kg
- **Biogas:** 40,000kJ/kg
- **Coal:** 33,000kJ/kg
- **Wood:** 22,000kJ/kg
- **Cow Dung:** 8,000kJ/kg

8. Consider the following statements regarding solar energy harvesting technologies:

1. Solar Photovoltaic (PV) panels generate electricity directly from solar radiation using semiconductor cells, making them suitable for residential and commercial electrical grids.
2. Solar thermal panels absorb sunlight to heat a working fluid, capturing thermal energy directly for applications such as space heating or domestic hot water systems rather than direct electrical conversion.

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

Correct Answer: (c)

Explanation: Both statements are correct. The core distinction lies in the form of energy harvested: Solar PV utilizes quantum interactions within silicon layers to output electrons (electricity), while solar thermal configurations use mirrors or collectors to absorb infrared heat waves directly into water or glycol loops.

9. Consider the following statements regarding solar-powered water pumping systems:

1. A solar water pumping system integrates an electric pump with a solar photovoltaic (PV) array that harvests sunlight to generate the necessary driving power.
2. These solar-powered arrays can run a variety of pump configurations, including surface pumps, deep-well submersible units, Direct Current (DC) motor systems, Alternating Current (AC) induction motors, centrifugal setups, and positive-displacement piston pumps.

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

Correct Answer: (c)

Explanation: Both statements are correct. Solar water pumping networks are versatile and scalable. Depending on the depth of the water table and agricultural needs, the electricity from the solar array can power either DC motors directly (without an inverter) or AC systems, using either centrifugal force or mechanical piston configurations.

10. Consider the following statements regarding the strategic objectives highlighted in the National Geothermal Energy Policy:

1. The policy targets unlocking an estimated 10,600 MW potential of clean geothermal energy to provide dependable, continuous base-load power to the national grid.
2. To encourage exploration, the policy allows up to 100% Foreign Direct Investment (FDI) via automatic routes alongside fiscal incentives like tax holidays, green bonds, and viability gap funding (VGF).
3. To protect long-term capital investments, supported geothermal extraction projects are granted an absolute maximum commercial lease tenure of 5 years, with zero extensions allowed.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Geothermal power serves as an excellent base-load alternative because it operates continuously, independent of shifting weather patterns. The policy introduces fiscal incentives and opens up FDI options to de-risk high up-front drilling costs.
- **Statement 3 is incorrect:** Geothermal infrastructure requires long operation windows to amortize capital costs. The policy supports projects for an initial duration of 30 years, providing options to extend agreements based on resource availability, not limiting them to a strict 5-year maximum.

Conventional and Alternative Energy

1. Consider the following statements regarding gas hydrates:

1. They are crystalline, ice-like mineral compounds where gas molecules are chemically bonded to water molecules rather than physically trapped.
2. Gas hydrates occur exclusively in tropical terrestrial ecosystems under conditions of high ambient temperature and fluctuating low atmospheric pressures.
3. Methane hydrates serve as a major focus for global energy exploration, representing a vast, untapped potential reservoir of natural gas.

Which of the statements given above is/are correct?

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** Gas hydrates are clathrate compounds where gas molecules (primarily methane) are physically trapped inside a cage-like structure of water molecules, rather than chemically bonded.
- **Statement 2 is incorrect:** They form under specific conditions of low temperature and high pressure. Consequently, they are found in deep-sea continental margins and arctic permafrost regions, not tropical terrestrial ecosystems.
- **Statement 3 is correct:** Methane hydrates are highly abundant, and extraction technologies are being researched globally as they hold massive reserves of cleaner-burning natural gas.

2. Consider the following statements:

1. Biomass Cogeneration refers to the simultaneous, thermodynamic production of usable electricity and heat from organic matter, commonly utilized in sugar milling industries.
2. Biomass Gasification is a thermochemical process that converts solid biomass into a gaseous fuel mixture (syngas), using feedstocks such as coconut shells, groundnut shells, and rice husks.
3. Incineration involves the biological decomposition of urban waste materials under freezing temperatures to convert the entire raw volume into liquid methane with zero ash residues.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Cogeneration improves energy efficiency in sugar mills by using sugarcane bagasse to generate both process heat and power. Gasification safely processes agricultural residues like rice husks and shells into synthesis gas (carbon monoxide and hydrogen).
- **Statement 3 is incorrect:** Incineration is a high-temperature thermal combustion process used to burn waste and reduce its volume. It produces ash, flue gas, and heat (used for waste-to-energy generation), not a freezing biological reaction that yields liquid methane.

3. Consider the following statements regarding Polycrack technology:

1. It utilizes a heterogeneous catalytic process to convert multiple types of waste feedstocks simultaneously into hydrocarbon liquid fuels, gas, carbon, and water.
2. The entire chemical process requires high-level segregation of raw waste and mandatory pre-drying of municipal solid waste before feeding it into the reactor.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** Polycrack is an innovative thermo-catalytic conversion process that processes diverse waste matrixes (plastics, organic waste, electronic waste) into useful petroleum-grade liquid fuels and gases.
- **Statement 2 is incorrect:** A key industrial advantage of Polycrack technology is its ability to process unsegregated and wet waste directly. It does not require intensive sorting or pre-drying of waste, making it highly efficient.

4. Consider the following table regarding different generations of biofuels:

	Biofuel Generation	**Key Feedstock and Production Characteristics**

1.	First Generation	Derived from consumable food crops like starch, sugar, and vegetable oil; known as conventional biofuels.
2.	Second Generation	Derived from sustainable non-food feedstocks, forest residues, and wood; known as cellulosic-ethanol.
3.	Third Generation	Extracted from high-yielding algae cultures; also known as algae fuel or oilage.
4.	Fourth Generation	Produced using advanced genetically engineered organisms like modified algae and cyanobacteria to maximize carbon capture.

How many of the rows presented above are correctly matched?
(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (d)
Explanation:
All four rows are matched correctly. Biofuel generations trace an evolutionary path designed to minimize conflicts with food security. First-generation fuels compete directly with agriculture. Second-generation fuels utilize non-edible organic waste. Third-generation fuels introduce high-yield marine algae, and fourth-generation fuels use synthetic biology and genetic engineering to convert solar energy and carbon dioxide directly into fuel.

5. Consider the following statements regarding the integration of Methanol in petrol:
1. Methanol, historically termed wood alcohol, can be clean-synthesized from diverse resources including natural gas, coal gasification, or industrial biomass.
2. The commercial designations M5 and M15 denote automotive fuel mixtures containing 5% and 15% volume of pure methanol blended into gasoline, respectively.
3. Methanol blending lowers the fuel octane rating, which causes engine knocking and reduces overall thermal efficiency compared to unblended petrol.

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

Correct Answer: (a)
Explanation:

- **Statements 1 and 2 are correct:** Methanol is a versatile liquid fuel that can be produced from domestic resources like coal and biomass. Blends like M15 are being systematically introduced to reduce oil import costs and carbon emissions.

- **Statement 3 is incorrect:** Methanol blending actually increases the octane rating of the fuel. A higher octane rating improves anti-knock properties and engine performance, though adjustments are needed to counter its corrosive effects on standard rubber gaskets and fuel lines.

6. Consider the following statements regarding Ethanol blending in India:

1. Fuel-grade ethanol is an alcohol compound primarily produced through the industrial fermentation of simple sugars present in crops like sugarcane, corn, and sugar beet.
2. The deployment of high-concentration ethanol fuel blends can be run seamlessly in any conventional petrol engine without requiring structural modifications to fuel lines or injection blocks.
3. Increasing the volume of food crops used for ethanol production has sparked global debate over food security versus fuel diversification.

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

Correct Answer: (c)

Explanation:

- **Statements 1 and 3 are correct:** Ethanol burns cleaner than raw gasoline, helping to lower greenhouse gas emissions. However, scaling up first-generation ethanol relies heavily on diverting food crops, creating a policy trade-off between energy production and agricultural food security.
- **Statement 2 is incorrect:** High ethanol blends like E85 cannot be used in standard conventional engines. They require dedicated modifications to the fuel infrastructure and engine components because ethanol is highly corrosive to standard plastics and metals, and has a different air-fuel ratio requirement.

7. Consider the following table regarding different types of biofuels:

Row	Biofuel Type	Technical Composition	Production Method & Core Operational Advantage
1.	**Bioethanol**	Primarily Ethanol	Fermentation of starch/sugars; features higher energy density per unit volume than pure petrol.
2.	**Biodiesel**	Fatty Acid Methyl Esters (FAME)	Transesterification of oils/fats; yields fewer particulate emissions than petroleum diesel.
3.	**Biobutanol**	Butanol	Fermentation of starches; offers the highest energy content among standard gasoline alternatives.
4.	**Biohydrogen**	Elemental Hydrogen	Pyrolysis, gasification, or biological fermentation; acts as a zero-carbon emission alternative.

How many of the rows presented above are correctly matched?

(a) Only one row

(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (c)
Explanation:

- **Rows 2, 3, and 4 are correctly matched:** Biodiesel is produced via transesterification and burns cleaner than fossil diesel. Biobutanol has a long four-carbon chain that provides a high energy density close to gasoline, and biohydrogen offers a clean, zero-emission fuel source.
- **Row 1 is incorrectly matched:** While its composition and fermentation method are correct, Bioethanol has a **lower energy content (around 33% less) than pure petrol**, not higher. More ethanol is needed to match the driving range of standard gasoline.

8. Consider the following statements regarding Flex-Fuel Vehicles (FFVs):

1. FFVs are engineered with advanced engine management and fuel systems that dynamically detect the exact ratio of the fuel blend and automatically adjust the internal combustion parameters.
2. These vehicles are designed to operate flexibly across varying combinations of gasoline and biofuels, and can run entirely on 100% unblended petrol when biofuels are unavailable.
3. The structural design incorporates corrosion-resistant alloys and specialized polymers to prevent structural degradation caused by the corrosive nature of high-concentration ethanol or methanol blends.

Which of the statements given above is/are correct?
(a) 1 only
(b) 1 and 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Correct Answer: (d)
Explanation: All three statements are correct. Flex-Fuel Vehicles look similar to standard vehicles but feature updated power management software, optimized fuel sensors, and durable, corrosion-resistant fuel lines. This allows them to switch seamlessly between standard gasoline and high-biofuel blends (like E85 or M85).

9. Consider the following statements regarding the production of hydrogen:

1. Grey Hydrogen is synthesized via Steam Methane Reforming (SMR) at temperatures between 700°C and 1000°C, releasing all generated carbon dioxide directly into the atmosphere.
2. Blue Hydrogen utilizes an identical SMR thermochemical reaction using fossil fuel inputs, but it integrates Carbon Capture and Storage (CCS) technologies to isolate and store the carbon emissions.
3. Green Hydrogen is produced by passing electricity through a water-splitting cell (electrolysis), and it must rely exclusively on nuclear fission power grids to ensure a zero-carbon footprint.

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

Correct Answer: (a)
Explanation:

- **Statements 1 and 2 are correct:** Grey and Blue hydrogen both rely on fossil fuels (methane) for production. The key difference is that Blue hydrogen incorporates carbon capture systems to prevent carbon dioxide from entering the atmosphere.
- **Statement 3 is incorrect:** Green hydrogen is produced through water electrolysis powered by renewable energy sources like solar, wind, or hydropower, rather than nuclear power grids.

10. Consider the following statements regarding the regulatory waivers announced under India's National Green Hydrogen Mission:

1. Standalone production plants manufacturing green hydrogen or green ammonia via water electrolysis are required to undergo a full, mandatory Environmental Impact Assessment (EIA) clearance under the Notification 2006 framework before starting operations.
2. Renewable energy generation plants configured to supply electricity to green hydrogen production units must wait a minimum of 25 years after commissioning to apply for waivers on Inter-State Transmission System (ISTS) charges.
3. The Approved List of Models & Manufacturers (ALMM) for solar modules applies strictly to all renewable installations built inside Special Economic Zones (SEZs) or Export Oriented Units (EOUs), even if they supply power exclusively to adjacent green hydrogen plants.

Which of the statements given above is/are correct?

(a) 1 and 2 only
(b) 3 only
(c) 1 and 3 only
(d) None of the statements

Correct Answer: (d)

Explanation: All statements are incorrect.

- **Statement 1 is incorrect:** Standalone green hydrogen and ammonia plants using water electrolysis are completely exempt from the prior environmental clearance requirements of the EIA Notification 2006 to speed up project development.
- **Statement 2 is incorrect:** Projects commissioned on or before December 31, 2030, receive an immediate, full 25-year waiver on Inter-State Transmission System (ISTS) charges from day one, rather than having to wait 25 years.
- **Statement 3 is incorrect:** The ALMM for solar modules and RLMM for wind turbines do not apply to renewable energy plants located inside an SEZ or EOU that supply power exclusively to co-located green hydrogen units. This allows developers to source components flexibly and reduce production costs.

Conventional and Alternative Energy-II

1. Consider the following statements regarding energy conversion devices:

1. In a fuel cell, fuel undergoes reduction at the anode to release free electrons, while an oxidant combines with protons at the cathode to generate water.
2. During the charging cycle of a standard storage battery, external electrical energy forces active ions to migrate from the cathode back to the anode.
3. Unlike standard batteries, fuel cells convert chemical energy directly into electrical energy without relying on a distinct internal electrolyte barrier.

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

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** In a fuel cell, the fuel (typically hydrogen) undergoes oxidation at the anode, not reduction, to release electrons and protons. Reduction happens at the cathode, where electrons and protons combine with oxygen to form water.
- **Statement 2 is correct:** During the discharge cycle of a battery, ions move from the anode to the cathode to generate a current. When charging, this chemical process is reversed by an external voltage, driving ions from the cathode back to the anode.
- **Statement 3 is incorrect:** Fuel cells, like batteries, require an electrolyte barrier to separate the anode and cathode. This electrolyte selectively allows protons to pass through while forcing electrons to travel along an external circuit to generate electricity.

2. Consider the following statements regarding India's energy storage infrastructure:

1. Advanced Chemistry Cells (ACCs) are designed to store electric energy using mechanical potential configurations to completely eliminate chemical degradation.
2. The National Programme on Advanced Chemistry Cell (ACC) Battery Storage mandates a 100% export target.
3. Under the associated Production-Linked Incentive (PLI) scheme, the government offers financial incentives exclusively to foreign sovereign entities to build battery manufacturing plants in India.

Which of the statements given above is/are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1, 2 and 3
(d) None of the statements

Correct Answer: (d)
Explanation

- **All statements are incorrect:**
    - **Statement 1 is incorrect:** ACCs store electric energy through advanced chemical processes, not mechanical potential configurations. They are electrochemical systems, such as advanced lithium-ion chemistries.
    - **Statement 2 is incorrect:** The primary goal of the National Programme on ACC Battery Storage is to satisfy domestic demand for electric vehicles and renewable energy storage, thereby decreasing India's reliance on imports.
    - **Statement 3 is incorrect:** The PLI scheme is structured to encourage domestic manufacturing by domestic, foreign, or joint-venture corporate companies. It aims to develop local supply chains, attract private capital, and scale up domestic production capacities.

3. Which one of the following combinations correctly identifies the standard architectural components used in a Sodium-Ion battery cell?
(a) Anode: Graphite; Cathode: Pure Metallic Lithium; Electrolyte: Aqueous Zinc Sulfate
(b) Anode: Hard Carbons; Cathode: Layered Oxides; Electrolyte: Sodium Salt in an Organic Solvent
(c) Anode: Silicon Nanowires; Cathode: Polyborate Crystals; Electrolyte: Liquid Hydrogen Fuel
(d) Anode: Cadmium Compounds; Cathode: Carbon Composites; Electrolyte: Sulfuric Acid Solution

Correct Answer: (b)

Explanation

- Sodium-ion batteries are a promising alternative to lithium-ion systems due to the high abundance and lower cost of sodium raw materials. They operate on a similar intercalation mechanism where sodium ions shuttle between electrodes.
- Their specific chemistry requires hard carbons at the anode (since standard graphite cannot easily hold larger sodium ions), layered transition-metal oxides or polyanionic compounds at the cathode, and a specialized sodium salt dissolved in a non-aqueous organic solvent as the electrolyte.

4. Consider the following statements regarding Lithium-Ion battery cells:

1. During the charging cycle, lithium ions move through the internal electrolyte from the positive cathode to the negative anode.
2. Cobalt, lithium, and nickel are the primary metallic elements used to construct the anode, determining the overall safety and cost of the battery cell.
3. Graphite is a highly versatile carbon material that is used exclusively in the anode structure of electric vehicle lithium-ion batteries.
4. The porous separator membrane inside the cell is designed to enable the continuous flow of electrons while completely blocking ion transport to maximize power.

Which of the statements given above are correct?

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

Correct Answer: (a)

Explanation

- **Statement 1 is correct:** When charging a lithium-ion battery, lithium ions are de-intercalated from the cathode and travel through the electrolyte to embed themselves into the anode structure.
- **Statement 2 is incorrect:** Cobalt, lithium, and nickel are utilized to form the cathode (positive electrode), not the anode. The cathode composition determines the energy density, lifespan, and cost of electric vehicle batteries.
- **Statement 3 is correct:** Graphite is used exclusively in the anode (negative electrode) due to its layered structure, which safely stores and releases lithium ions during cycling.
- **Statement 4 is incorrect:** The porous separator does the exact opposite: it is an electronic insulator that blocks electron flow to prevent short circuits, while allowing the smooth transport of ions.

5. Consider the following statements regarding mechanical energy storage devices:

1. Gravity batteries capture and store energy by lowering heavy masses during peak generation and elevating them during low production periods.
2. These energy storage systems utilize heavy masses, mechanical cranes or elevators, and a generator-linked release mechanism to convert gravitational potential energy into electricity.

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

Correct Answer: (b)
Detailed Explanation

- **Statement 1 is incorrect:** Gravity batteries work by elevating heavy masses (using surplus power from wind or solar grids) to store energy as gravitational potential energy. They lower these masses to spin a generator and release electricity when the grid experiences high power demand.
- **Statement 2 is correct:** The core infrastructure requires heavy weights, a mechanical structure like cranes, shafts, or elevators to raise them, and a generator/motor assembly that converts kinetic energy back into grid electricity during descent.

6. Consider the following statements regarding the real-world deployment of Hydrogen Fuel Cells:

1. At the anode of a hydrogen fuel cell, hydrogen molecules split into protons and electrons, creating a usable electric current through an external circuit.
2. Hydrogen fuel cells are limited to low-power portable electronics and cannot be deployed in heavy-duty commercial transport or stationary building grids.
3. These fuel cell networks can be integrated with variable renewable systems like solar or wind power to balance fluctuating grid supplies.

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

Correct Answer: (c)
Detailed Explanation

- **Statements 1 and 3 are correct:** Hydrogen splitting at the anode provides the electrons that drive the electric circuit. Because hydrogen can be stored long-term as a compressed gas, it serves as an excellent balancing medium. It can store excess energy from solar or wind farms and convert it back into electricity when generation drops.
- **Statement 2 is incorrect:** Hydrogen fuel cells are highly scalable. They are well-suited for heavy-duty, long-range transportation (such as commercial trucks, trains, and maritime ships) and stationary backup power grids, making them a versatile alternative to fossil fuels.

7. Consider the following statements regarding advanced bio-energy systems:

1. Microbial Fuel Cells (MFCs) leverage inorganic chemical catalysts rather than living microorganisms to convert chemical bonds into electricity.
2. In an MFC, specialized bacteria colonize the anode and oxidize organic compounds, generating free electrons and protons in the process.
3. Due to their high-power output density, MFC arrays serve as the primary source of propulsion energy for commercial supersonic aircraft.

Which of the statements given above are correct?

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

Correct Answer: (b)
Detailed Explanation

- **Statement 1 is incorrect:** MFCs rely on living microorganisms (bacteria) as biocatalysts to break down organic substrate materials, eliminating the need for expensive precious metal catalysts.
- **Statement 2 is correct:** The biological action takes place at the anode, where electrochemically active bacteria digest organic matter, transferring electrons to the electrode surface and releasing protons into the solution.
- **Statement 3 is incorrect:** MFCs typically produce a low power density. They are not suitable for high-power industrial propulsion like aircraft. Instead, they are used for wastewater treatment (cleaning organic pollutants while generating localized power), low-power environmental biosensors, and remote monitoring equipment.

8. Consider the following statements regarding nuclear fusion research initiatives:

1. The International Thermonuclear Experimental Reactor (ITER) utilizes a tokamak configuration to confine superheated plasma using powerful magnetic fields.
2. India's domestic nuclear fusion research and experimental tokamak developments are spearheaded by the Institute for Plasma Research (IPR) in Gandhinagar, Gujarat.
3. ADITYA was India's first indigenously designed and built tokamak, which was later upgraded into the operational ADITYA-U system.
4. The Steady State Superconducting Tokamak (SST-1) at IPR utilizes advanced superconducting magnets to study steady-state plasma operations.

Which of the statements given above are correct?

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

Correct Answer: (d)

Explanation

- All four statements are correct. The tokamak concept uses a torus-shaped magnetic field configuration to isolate high-temperature plasma from reactor walls, which is essential for sustaining a fusion reaction between deuterium and tritium.
- India is a full member state of the global ITER project. Locally, the IPR has successfully engineered and operated the ADITYA-U and SST-1 facilities, building the technological foundation for future fusion reactors like the planned SST-2.

9. Consider the following statements regarding low-energy nuclear reactions:

1. Cold fusion describes a hypothetical nuclear reaction that takes place at or close to ambient room temperatures, contrasting with the high-temperature fusion seen in stars.
2. There is currently a universally accepted, peer-reviewed theoretical model and widespread scientific replication verifying cold fusion energy production.

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

Correct Answer: (a)

Detailed Explanation

- **Statement 1 is correct:** Cold fusion is a conceptual form of nuclear energy generation. Unlike hot fusion, which requires temperatures of millions of degrees to overcome the electrostatic repulsion between atomic nuclei, cold fusion aims to initiate reactions near room temperature.
- **Statement 2 is incorrect:** There is no accepted theoretical model or reproducible experimental evidence for cold fusion within the mainstream scientific community. Most initial claims have failed rigorous verification and peer-review trials, leaving the concept on the fringes of nuclear physics.

10. Consider the following statements regarding the structural components of a standard nuclear power reactor:

1. Control rods are constructed from neutron-absorbing materials like boron or cadmium to regulate the rate of the fission chain reaction.
2. The primary function of a nuclear moderator is to speed up fast-moving neutrons to ensure they escape the reactor core without splitting heavy fuel atoms.
3. Materials such as heavy water, helium gas, or ordinary water can serve as a coolant to transfer thermal energy away from the reactor core.
4. The steam generator acts as a safety barrier by turning liquid fuel directly into gaseous plasma to drive electrical turbines.

Which of the statements given above are correct?

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

Correct Answer: (a)

Explanation

- **Statement 1 is correct:** Control rods manage the reactor's power output. By sliding into the core, they absorb excess neutrons, slowing or stopping the fission chain reaction as needed.
- **Statement 2 is incorrect:** The moderator is designed to slow down fast neutrons, turning them into thermal neutrons. Slower neutrons have a much higher probability of being captured by Uranium-235 nuclei to sustain steady fission.
- **Statement 3 is correct:** Coolants carry the intense heat generated by nuclear fission away from the fuel rods, preventing meltdowns and delivering thermal energy to power generation units.
- **Statement 4 is incorrect:** The steam generator does not process liquid fuel or create plasma. It is a heat exchanger that transfers heat from the isolated reactor coolant loop to a separate water loop, turning water into clean steam to drive electrical turbines.

Nuclear Energy

1. Consider the following statements regarding Pressurized Heavy Water Reactors (PHWRs):

1. They utilize heavy water (deuterium oxide, D_2O) to serve simultaneously as the core coolant and the neutron moderator.
2. PHWR blocks require highly enriched uranium fuel containing over 20% Uranium-235 to maintain steady fission chain reactions.
3. Boron-based control rods are mechanically adjusted within the reactor core to regulate total power output by absorbing excess neutrons.

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

Correct Answer: (c)
Explanation

- **Statements 1 and 3 are correct:** PHWRs use heavy water (D_2O) as both a coolant to carry away heat and a moderator to slow down fast neutrons. Control rods made of neutron-absorbing materials like Boron or Cadmium regulate or halt the fission chain reaction.
- **Statement 2 is incorrect:** A defining feature of PHWR design is its ability to run on natural, unenriched uranium (which consists mostly of Uranium-238 with only about 0.7% fissile Uranium-235). The excellent neutron economy of heavy water moderators makes expensive enrichment facilities unnecessary.

2. Consider the following statements regarding Small Modular Reactors (SMRs):

1. SMRs are defined as advanced commercial nuclear reactors maintaining a maximum electrical power generation capacity profile of up to 300 MW(e) per unit.
2. Their compact design allows for complete structural fabrication inside a factory before being transported to a site for rapid deployment.

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

Correct Answer: (c)
Explanation

- Both statements are correct. SMRs represent a major innovation in nuclear energy. They address the high capital costs and long construction timelines of traditional, large-scale nuclear facilities by providing a smaller footprint, easier scaling, and modular construction.

3. Consider the following statements regarding Gas-Cooled Reactors (GCRs):

1. GCRs use high-velocity gases, such as helium or carbon dioxide, as a coolant to transfer thermal energy from the reactor core.
2. Because gas coolants are prone to chemical breakdown at high temperatures, GCR thermal efficiencies are strictly capped at 15%.

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

Correct Answer: (a)
Explanation

- **Statement 1 is correct:** GCR architectures use inert or stable gases like helium or carbon dioxide to absorb and move heat from the reactor core to the steam turbines.
- **Statement 2 is incorrect:** GCRs operate at high temperatures, which allows them to achieve high thermal efficiencies of up to 50%. Because they generate high temperatures safely, these reactors can

also support secondary industrial applications, such as high-efficiency water desalination and thermochemical hydrogen production.

4. Consider the following statements regarding Light Water Reactors (LWRs):

1. LWRs rely on ordinary water (H_2O) to function as both the core coolant fluid and the primary neutron moderator.
2. In a Boiling Water Reactor (BWR), high-pressure water is kept from boiling in a primary loop, transferring its heat to a separate secondary loop to generate steam.

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

Correct Answer: (a)

Explanation

- **Statement 1 is correct:** LWRs use ordinary, highly purified water as both a coolant and a moderator. This distinguishes them from reactors that use heavy water (D_2O) or liquid metals.
- **Statement 2 is incorrect:** The statement describes a Pressurized Water Reactor (PWR), not a Boiling Water Reactor (BWR). In a BWR, water boils directly inside the reactor core to produce steam that drives the turbine. A PWR keeps the primary coolant under high pressure to prevent boiling, using a steam generator to pass heat to a secondary water circuit.

5. Consider the following statements regarding Fast Reactors:

1. Fast reactors utilize high-energy, unmoderated fast neutrons to convert non-fissile Uranium-238 into fissile Plutonium-239 through a process called fuel breeding.
2. These systems require large amounts of heavy water moderators to increase the velocity of fast neutrons for efficient interactions with Uranium-238.

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

Correct Answer: (a)

Explanation

- **Statement 1 is correct:** Fast reactors do not slow down neutrons. Instead, they use fast neutrons to sustain fission and transmute abundant, non-fissile Uranium-238 into fissile Plutonium-239, breeding more fuel than they consume.
- **Statement 2 is incorrect:** Fast reactors operate without any neutron moderators. Adding a moderator like heavy water or ordinary water would slow down the neutrons into the thermal spectrum, preventing the breeding reactions with Uranium-238.

6. Consider the following statements regarding Radioisotope Thermoelectric Generators (RTGs):

1. RTGs convert the thermal energy released by the natural decay of radioactive isotopes directly into electricity without using moving parts.
2. The operational generation of electrical current in an RTG relies on creating a temperature difference across thermoelectric materials, leveraging the Seebeck effect.

3. Liquid Hydrogen is the most commonly used radioisotope heat source in space-bound RTGs due to its long, multi-century radioactive decay half-life.

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

Correct Answer: (a)

Explanation

- **Statements 1 and 2 are correct:** RTGs are highly reliable, solid-state power sources often used in deep-space missions. They use the Seebeck effect to convert the heat from natural radioactive decay directly into electricity across a specialized thermocouple framework, removing the need for mechanical turbines.
- **Statement 3 is incorrect:** Liquid hydrogen is a non-radioactive chemical rocket fuel, not a radioactive isotope. The most common isotope used in RTGs is Plutonium-238 because its high thermal energy output, safe alpha-radiation profile, and favorable 87.7-year half-life provide steady power for decades.

7. Consider the following statements regarding the developmental stages of India's domestic nuclear energy framework:

1. Stage I relies on Pressurized Heavy Water Reactors (PHWRs) fueled by natural uranium to generate electricity while producing Plutonium-239 as a spent-fuel byproduct.
2. Stage II utilizes Fast Breeder Reactors (FBRs) fueled by Plutonium-239 to breed additional plutonium from a blanketing layer of Uranium-238.
3. India's first commercial, domestic 500 MWe Fast Breeder Reactor (PFBR), constructed at Kalpakkam in Tamil Nadu, successfully commenced its core fuel loading phase on March 4, 2024.
4. Stage III is designed as a long-term strategy to utilize India's extensive domestic thorium reserves, using advanced reactors to breed fissile Uranium-233 from Thorium-232.

Which of the statements given above are correct?

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

Correct Answer: (d)

Explanation

- All four statements are correct. India’s three-stage nuclear strategy was designed by Homi J. Bhabha to maximize energy independence by making step-by-step use of the country's limited uranium and abundant thorium reserves. Stage I produces plutonium fuel, Stage II scales up plutonium breeding while producing Uranium-233, and Stage III deploys self-sustaining thorium-cycle reactors.

8. Consider the following statements regarding Stage III of India's nuclear program:

1. The primary goal of Stage III is to utilize Thorium-232 as a fertile blanket material, transmuting it into fissile Uranium-233 to tap into India's vast thorium reserves.
2. India holds a major global share of thorium resources, with large concentrations of monazite sands found along its coastal plains.

3. The public sector enterprise Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI), under the Department of Atomic Energy, was established explicitly to manage Stage I commercial light-water reactor imports.
4. Thorium-232 can sustain a commercial nuclear fission chain reaction directly inside a reactor without requiring any external fissile starter fuel.

Which of the statements given above are correct?

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

Correct Answer: (a)

Explanation

- **Statements 1 and 2 are correct:** India holds approximately 25% of global thorium reserves, mostly in monazite sands along coastal stretches like Kerala and Tamil Nadu. Converting fertile Thorium-232 into fissile Uranium-233 forms the core of India's long-term energy strategy.
- **Statement 3 is incorrect:** BHAVINI was set up specifically to guide Stage II of the nuclear program, focusing on building and operating fast breeder reactors (like the PFBR at Kalpakkam), not managing Stage I light-water reactor imports.
- **Statement 4 is incorrect:** Thorium-232 is fertile, not fissile. It cannot sustain a nuclear chain reaction on its own. It must first be placed inside a reactor alongside a fissile driver fuel (like Plutonium-239 or Uranium-235) to absorb neutrons and transform into fissile Uranium-233.

9. Consider the following statements regarding nuclear safety systems:

1. The Atomic Energy Regulatory Board (AERB) operates as an independent body in India, responsible for enforcing safety standards and issuing licenses for nuclear facilities.
2. The International Atomic Energy Agency (IAEA) serves as a global governing body with direct legal authority to shut down domestic nuclear plants within sovereign member states.
3. The World Association of Nuclear Operators (WANO) is a non-governmental international body that promotes safety and collaboration among nuclear power plant operators worldwide.

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

Correct Answer: (c)

Explanation

- **Statements 1 and 3 are correct:** The AERB oversees nuclear and radiation safety regulations across India. WANO connects commercial operators globally to share best practices and conduct peer reviews to improve safety standards.
- **Statement 2 is incorrect:** The IAEA does not have sovereign legal authority to enforce laws or order the shutdown of domestic nuclear facilities within member states. It functions as an advisory and monitoring organization, providing safety guidelines and verification safeguards that countries adopt voluntarily through bilateral agreements.

10. Consider the following statements regarding nuclear fuel resources:

1. India ranks as the world's largest producer of uranium ore, mining over 85% of global reserves from domestic deposits.

2. Natural uranium consists of approximately 99.3% non-fissile Uranium-238 and only about 0.7% fissile Uranium-235.
3. Low-Enriched Uranium (LEU) features a Uranium-235 concentration increased above natural levels but kept below 20%, serving as fuel for commercial nuclear power plants.
4. Highly Enriched Uranium (HEU) contains a Uranium-235 concentration of 20% or higher, and has historically been used in military applications and nuclear weapons.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation

- **Statements 2, 3, and 4 are correct:** Natural uranium requires enrichment because standard light-water reactors need a higher concentration of fissile U-235 (3-5% LEU) to maintain fission. Concentrations of 20% or more are classified as HEU, which is used in specialized research reactors or military weapons.
- **Statement 1 is incorrect:** India is **not** the world's largest producer of uranium (ranking 15th in estimated reserves). India relies on imports from international partners like Kazakhstan, Russia, and Australia to fuel its growing commercial nuclear fleet.

Nuclear Energy-I

1. This heavy, naturally occurring radioactive element is predominantly found inside coastal monazite beach sands, zircon, and ilmenite placer deposits. While inland pegmatite reserves exist, its highest geographic concentrations are distributed along the coastal stretches of Andhra Pradesh (31%), Tamil Nadu (22%), and Odisha (20%). Identify this specific fuel resource:

(a) Actinates-225
(b) Thorium
(c) Highly Enriched Uranium
(d) Polonium-210

Correct Answer: (b)

Explanation:

- India holds some of the world's largest reserves of Thorium, which is a foundational component of the nation's long-term three-stage nuclear energy roadmap.
- Thorium is found in heavy mineral sand assemblages like monazite, zircon, and ilmenite. Geographically, its largest placer deposits are distributed along India's eastern and southern coasts. State-wise mapping data indicates that Andhra Pradesh holds the largest share (31%), followed by Tamil Nadu (22%), Odisha (20%), and Kerala (12%).

2. Consider the following comparative matrix between Thorium and Uranium systems:

Row	Aspect	Thorium	Uranium

1.	Nuclear Reactor Use	Specifically integrated into Advanced Heavy Water Reactors (AHWRs).	Widely deployed in Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs).
2.	Fertile Material	Thorium-232 transutes into fissile Uranium-233.	Uranium-238 transmutes into fissile Plutonium-239.
3.	Proliferation Risks	Lower weapon-grade extraction risks due to non-fissile natural states.	Higher proliferation concerns in traditional open/closed fuel cycles.
4.	Fuel Cycle Output	Produces alpha-emitting waste that requires high-velocity moderators.	Leaves a spent fuel stream containing diverse radioactive fission products.

How many of the rows presented above are correctly matched?
(a) Only one row
(b) Only two rows
(c) Only three rows
(d) All four rows

Correct Answer: (c)
Explanation:

- **Rows 1, 2, and 3 are correctly matched:** Thorium and Uranium are both fertile isotopes that require neutron absorption to yield fissile fuels (U-233 and Pu-239, respectively). Thorium is highly suited for India's domestic AHWR designs and offers lower nuclear proliferation risks compared to standard Uranium enrichment pathways.
- **Row 4 is incorrectly matched:** The fuel cycle output properties for Thorium do not involve alpha-emitting waste requiring high-velocity moderators. Instead, the Thorium fuel cycle operates by breeding fissile Uranium-233, which produces significantly lower volumes of long-lived transuranic nuclear waste compared to the conventional Uranium-Plutonium fuel cycle.

3. Consider the following statements regarding the evolution of India's nuclear energy program:
1. The Tata Institute of Fundamental Research (TIFR) was established in 1945 by Homi J. Bhabha to lay the scientific foundation for nuclear research.
2. The early structural milestone of connecting India's commercial nuclear power grid to the Tarapur Atomic Power Station was achieved in 1969.
3. India's historic first peaceful nuclear explosive test, code-named "Smiling Buddha," was conducted in the year 1954.
4. The Nuclear Power Corporation of India Limited (NPCIL), which manages the operations of commercial nuclear power reactors, was created during the pre-independence phase in 1940.

Which of the statements given above are correct?
(a) 1 and 2 only
(b) 2 and 4 only
(c) 1, 3 and 4
(d) 1 and 4 only

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** TIFR (1945), the Atomic Energy Commission (1948), and the Department of Atomic Energy (1954) formed the early institutional framework of India's nuclear program. The commissioning of the Tarapur plant in 1969 marked the official beginning of commercial nuclear power generation in the country.
- **Statement 3 is incorrect:** The Smiling Buddha nuclear test at Pokhran was conducted in **1974**, not 1954.
- **Statement 4 is incorrect:** NPCIL was established as a public sector enterprise under the Department of Atomic Energy in 1987, not 1940.

4. Match the following scientific organizations with their core institutional mandates:

Column I (Institution)	Column II (Primary Functional Mandate)
A. DAE	1. Premier multidisciplinary facility executing peaceful applications of nuclear science.
B. BARC	2. Apex administrative department overseeing nuclear energy programs and policy.
C. GCNEP	3. Field agency responsible for exploration, resource assessment, and mapping of atomic minerals.
D. AMD	4. Global facility facilitating international collaboration, expert exchanges, and advanced training.

Which of the following options represents the correct matching pairs?

(a) A-1, B-2, C-3, D-4
(b) A-2, B-1, C-4, D-3
(c) A-2, B-4, C-1, D-3
(d) A-3, B-1, C-4, D-2

Correct Answer: (b)

Explanation:

1. **DAE (Department of Atomic Energy - Pair 2):** Functions directly under the Prime Minister of India as the executive department managing all nuclear operations, safety regulations, and corporate entities.
2. **BARC (Bhabha Atomic Research Centre - Pair 1):** Based in Trombay, it serves as India's premier multi-disciplinary nuclear research facility, working on areas from reactor design to nuclear medicine.
3. **GCNEP (Global Centre for Nuclear Energy Partnership - Pair 4):** Located in Haryana, it promotes international cooperation through safety research, training programs, and professional exchanges.
4. **AMD (Atomic Minerals Directorate for Exploration and Research - Pair 3):** Headquartered in Hyderabad, it focuses on surveying, exploring, and mapping commercial-grade atomic mineral deposits like uranium and thorium across India.

5. Consider the following statements regarding the command and control architecture of India's strategic deterrent:

1. The Nuclear Command Authority (NCA) is an elite dual-council structure comprising an Executive Council chaired by the Prime Minister and a Political Council chaired by the National Security Advisor.
2. The Strategic Forces Command (SFC) serves as the operational military custodian responsible for executing nuclear policy decisions under direct command authorization.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** The leadership of the two councils within the NCA is reversed in the statement. The Political Council is chaired by the Prime Minister (and is the sole body authorized to greenlight nuclear weapons use), while the Executive Council is chaired by the National Security Advisor to provide strategic input and execute instructions from the Political Council.
- **Statement 2 is correct:** The Strategic Forces Command (SFC) is part of India's Tri-Services Command framework. It manages, maintains, and exercises operational control over the country's nuclear delivery systems and stockpiles.

6. Consider the following statements regarding global nuclear non-proliferation treaties:

1. The Comprehensive Nuclear-Test-Ban Treaty (CTBT) aims to ban all nuclear explosions globally, but it has not entered into legal force because several key nations have failed to ratify it.
2. The International Atomic Energy Agency (IAEA) uses localized verification safeguards to monitor civil nuclear facilities and enforce compliance with Non-Proliferation Treaty (NPT) agreements.
3. The Convention on Nuclear Safety (CNS) is a legally binding international treaty designed to regulate and maintain high safety benchmarks at civilian, land-based nuclear power plants.
4. India signed and ratified the Non-Proliferation Treaty (NPT) during its initial drafting phase to secure access to global enriched uranium supply chains.

Which of the statements given above are correct?

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

Correct Answer: (c)

Explanation:

- **Statements 1, 2, and 3 are correct:** The CTBT requires ratification by specific nuclear-capable states listed in its Annex 2 before it can enter into force. The IAEA monitors civilian facilities through safeguards to confirm they are used for peaceful purposes, and the CNS sets international safety benchmarks for civilian power reactors.
- **Statement 4 is incorrect: India is not a signatory to the NPT**. India has consistently declined to sign the treaty, arguing that it creates a discriminatory division between recognized nuclear-weapon states and non-nuclear-weapon states.

7. Consider the following statements regarding the Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, 2025:

1. The SHANTI Act consolidates India's nuclear regulatory framework by completely repealing the Atomic Energy Act of 1962 and the Civil Liability for Nuclear Damage Act of 2010.
2. The Act maintains a strict public monopoly, completely banning private entities and joint ventures from fuel fabrication, refining, or enrichment activities.
3. Under this act, the Atomic Energy Regulatory Board (AERB) is stripped of its statutory authority and placed entirely under the administrative control of private operators.
4. The new civil liability framework removes all operator liability caps, shifting financial responsibility for nuclear incidents entirely onto equipment suppliers.

Which of the statements given above is/are correct?

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The SHANTI Act of 2025 creates a single, unified legal framework by consolidating past laws and repealing both the Atomic Energy Act (1962) and the Civil Liability for Nuclear Damage Act (2010).
- **Statement 2 is incorrect:** The Act allows for private sector participation. Private companies and joint ventures can participate in plant operations, power generation, and activities like fuel fabrication and uranium enrichment up to approved thresholds.
- **Statement 3 is incorrect:** The Act strengthens the AERB by granting it explicit statutory status and making it answerable directly to Parliament rather than solely to the executive branch.
- **Statement 4 is incorrect:** The Act sets graded liability caps for operators (e.g., ₹3,000 crore for large facilities, ₹100 crore for SMRs), with the government covering any liabilities above those limits via a dedicated fund. Notably, it completely removes supplier liability, preventing claims against suppliers for equipment defects.

8. Consider the following statements regarding Proton Exchange Membrane (PEM) fuel cells:

1. India's first indigenous hydrogen fuel cell passenger vessel utilizes a Low-Temperature Proton Exchange Membrane (LT-PEM) fuel cell system for zero-emission marine propulsion.
2. Inside a PEM fuel cell system, hydrogen fuel enters the cathode terminal where a catalyst splits it into protons and electrons to generate power.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** India's first domestic hydrogen-powered passenger vessel, deployed in Varanasi, features a custom marine LT-PEM fuel cell system that produces electricity cleanly without combustion.
- **Statement 2 is incorrect:** Hydrogen fuel enters the anode terminal, not the cathode. At the anode, a catalyst (typically platinum) splits the hydrogen molecule into protons and electrons. The electrons

flow through an external circuit to generate an electric current, while the protons pass through the membrane to the cathode to combine with oxygen and form water.

9. This landmark bilateral arms control treaty, which entered into force in 2011, caps the deployed strategic nuclear warheads of its two superpower signatories at 1,550 units each while placing strict verifiable limits on intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and heavy bombers. Identify this agreement:
(a) The INF Accord
(b) The START Treaty
(c) The New START Treaty
(d) The Salt-II Framework

Correct Answer: (c)
Explanation:

- The New Strategic Arms Reduction Treaty (New START) is a critical bilateral arms control agreement between the United States and the Russian Federation. It limits deployed strategic nuclear arsenals and establishes verification mechanisms, such as on-site inspections and data exchanges, to maintain strategic stability.

10. Consider the following statements regarding India's strategic maritime infrastructure:
1. INS Aridaman is an advanced, indigenously built nuclear-powered ballistic missile submarine (SSBN) developed as part of the Arihant-class fleet under the Advanced Technology Vessel (ATV) program.
2. The development of India's SSBN capability relies on a collaborative framework involving the Defence Research & Development Organisation (DRDO), private sector firms, and strategic technical assistance from Russia.

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

Correct Answer: (c)
Explanation:

- Both statements are correct. The ATV program is a successful model of public-private cooperation and international technical partnership. Inducting advanced nuclear-powered ballistic missile submarines like INS Arihant, INS Arighaat, and INS Aridaman strengthens India's naval capabilities and completes its nuclear triad, providing a secure second-strike deterrent.

Miscellaneous Applications

1. Consider the following statements regarding Project UNNATI:
1. It is a dedicated capacity-building initiative launched by the Indian Space Research Organisation (ISRO) with a focus on deep-space exploration and lunar orbiter assembly.
2. The program's main objective is to enhance the skills of international participants, particularly from developing nations, in assembly, integration, and testing of nanosatellites.
3. The initiative was conceptualized to commemorate the 50th anniversary of the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50).

Which of the statements given above is/are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 3 only
(d) 1, 2 and 3

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** Project UNNATI (Unispace Nanosatellite Assembly & Training by ISRO) is specific to nanosatellite development, not deep-space exploration or lunar orbiters.
- **Statement 2 is correct:** The initiative provides comprehensive hands-on training to scientists, engineers, and official representatives from developing nations, improving their capabilities in building, integrating, and analyzing small-scale nanosatellites.
- **Statement 3 is correct:** India announced this program at Vienna during the UNISPACE+50 symposium to promote international cooperation and peaceful uses of outer space by sharing its technical facilities.

2. Consider the following statements regarding Metal-Organic Frameworks (MOFs), for which the 2025 Nobel Prize in Chemistry was recognized:
1. MOFs are synthetic materials constructed by linking metal ions with organic (carbon-based) molecules to form highly porous, three-dimensional structures.
2. Unlike traditional hard materials, such as zeolites, MOFs are structurally dynamic and can flexibly expand or contract based on their surrounding environment.
3. Due to their customizable design, MOFs are actively being tested for environmental applications like capturing Carbon Dioxide and harvesting water from desert air.
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

Correct Answer: (d)
Explanation:

- **Statements 1, 2, and 3 are all correct:** Metal-Organic Frameworks (MOFs) are highly advanced crystalline materials composed of metallic nodes linked together by organic struts. Their high internal surface area and structural flexibility set them apart from rigid, naturally occurring mineral structures like zeolites.
- Because researchers can customize their pore size and chemical functionality down to the molecular level, they are highly effective for environmental engineering applications. These include storing gases, selectively capturing carbon from industrial emissions, and collecting clean drinking water from low-humidity desert air.

3. Consider the following statements regarding the 2025 Nobel Prize in Physics:
1. It was awarded for demonstrating macroscopic quantum tunnelling and energy quantisation in electric circuits.
2. The experiments proved that bizarre quantum behaviours can be scaled up to systems observable on a human scale.

3. The research forms the foundational basis for developing modern superconducting quantum computers and sensors.

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

Correct Answer: (d)

Explanation:

- **Statements 1, 2, and 3 are all correct:** Historically, quantum mechanics was thought to apply only to subatomic particles like electrons and atoms. The breakthrough experiments honored by the 2025 Nobel Prize in Physics proved that quantum states, such as quantized energy levels and macroscopic quantum tunneling, can manifest in larger, human-engineered superconducting electronic circuits.
- Demonstrating that macro-scale currents can obey quantum rules laid the groundwork for constructing Josephson junctions, SQUID sensors, and the superconducting qubits used to process information in modern quantum computers.

4. Consider the following statements regarding Superconductivity:

1. Superconductivity is a physical phenomenon where certain materials exhibit zero electrical resistance and completely expel internal magnetic fields when cooled below a specific critical temperature.
2. In this state, materials conduct electrical currents with a steady, fractional thermal energy loss, making them moderately more efficient than conventional copper cabling.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** Superconductivity is defined by two key characteristics: the complete absence of electrical resistance and the active expulsion of magnetic fields, known as the Meissner effect. Both occur when a material drops below its critical threshold temperature.
- **Statement 2 is incorrect:** In a true superconducting state, electrical current flows with absolutely zero energy loss or thermal dissipation. It does not exhibit fractional loss. This makes these materials highly efficient channels for electricity transmission, high-field electromagnets, and advanced scientific sensors.

5. Consider the following statements regarding Electrostatic Precipitators (ESPs):

1. ESPs are filtration devices that use high-voltage electrostatic charges to charge, attract, and remove fine particulate matter from industrial exhaust gases.
2. The operational physics of an ESP relies primarily on high-intensity sound wave vibration patterns to break down and shatter ash particles.

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

Correct Answer: (a)
Explanation:

- **Statement 1 is correct:** ESPs are highly efficient air pollution control devices used in industrial facilities like thermal power plants. They pass dirty exhaust gases through an electric field, imparting a negative charge to fly ash and particulate matter. These charged particles are then pulled out of the gas stream by positively charged collection plates.
- **Statement 2 is incorrect:** The system operates on the principles of electrostatics and electromagnetism, not sound waves or acoustic vibrations. It extracts particulates by utilizing electric fields and charge differentials, leaving the exhaust gas clean.

6. This device, integrated into vehicle exhaust systems, converts hazardous automotive pollutants like carbon monoxide and nitrogen oxides into less harmful emissions like carbon dioxide, nitrogen and water by accelerating chemical reactions without consuming its own internal precious metal components. Identify this technology:
(a) Centrifugal Scrubber
(b) Electrostatic Precipitator
(c) Catalytic Converter
(d) Cyclone Separator

Correct Answer: (c)
Explanation:

- Catalytic converters are essential for managing vehicle emissions. They pass hot exhaust gases over a honeycomb structure coated with precious metal catalysts, such as platinum, palladium, and rhodium.
- This structure triggers simultaneous reduction and oxidation reactions. It breaks down toxic nitrogen oxides into harmless nitrogen gas, while converting poisonous carbon monoxide and unburnt hydrocarbons into carbon dioxide and water vapor before they leave the tailpipe.

7. Consider the following statements regarding high-speed transportation systems:
1. Maglev systems utilize powerful electromagnetic forces to levitate and propel trains above a guide track, significantly increasing speeds by eliminating physical track friction.
2. Hyperloop technology involves launching passenger pods through low-pressure, near-vacuum tubes to drastically reduce aerodynamic drag.
3. Asia's longest vacuum-sealed Hyperloop test track facility, measuring 422 meters, was developed indigenously at the IIT Madras Discovery Campus.
4. Gujarat's Deendayal Port (Kandla) has adopted linear induction motor (LIM) technology to explore cargo maglev systems for automated freight logistics.
Which of the statements given above are correct?
(a) 1 and 3 only
(b) 2 and 4 only
(c) 1, 2 and 4 only
(d) 1, 2, 3 and 4

Correct Answer: (d)
Explanation:

- All four statements are correct. Maglev and Hyperloop systems represent the next generation of high-speed mass transit. Maglev eliminates ground friction, while Hyperloop cuts down on air resistance by operating inside a low-pressure tube network.

- India is actively testing these technologies. Examples include the 422-meter test facility built by Avishkar Hyperloop and TuTr Hyperloop at IIT Madras, alongside projects evaluating the feasibility of using linear induction motor configurations for cargo transport at major ports.

8. Consider the following statements regarding autonomous and connected vehicle technologies:

1. Autonomous navigation systems rely on LiDAR and RADAR sensor arrays, which emit and capture light and radio waves respectively to map environments and detect obstacles.
2. Connected vehicle technology uses radio frequency communication and wireless networking to enable real-time Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) data exchange.
3. LiDAR systems operate by projecting high-frequency acoustic ultrasound waves, making them highly effective in zero-visibility deep mud environments.
4. Vehicle-to-Infrastructure (V2I) communication pathways are strictly analog, prohibiting any digital data interactions with smart traffic grid systems.

Which of the statements given above are correct?

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Autonomous driving requires a combination of sensors and connectivity. LiDAR uses pulsed laser light to generate precise 3D maps of the vehicle's surroundings, while RADAR uses radio waves to track the speed and distance of objects. Connected vehicle protocols use cellular or dedicated short-range radio frequencies to coordinate movements with nearby cars (V2V) and traffic signals (V2I).
- **Statement 3 is incorrect:** LiDAR stands for Light Detection and Ranging; it uses light waves (laser beams), not acoustic ultrasound waves.
- **Statement 4 is incorrect:** V2I networks are fully digital, allowing vehicles to exchange high-speed data with digital traffic systems to optimize city traffic flow and improve safety.

9. Consider the following statements regarding alternative powertrain vehicle platforms:

1. Full Battery Electric Vehicles (BEVs) operate without an internal combustion engine, relying solely on rechargeable battery packs to achieve zero tailpipe emissions.
2. Hydrogen Fuel Cell Vehicles (FCEVs) generate electricity onboard through an electrochemical reaction between hydrogen and oxygen, releasing only water vapor and heat.
3. Fuel Cell Electric Hybrid Vehicles (FCE-HVs) integrate both an onboard fuel cell stack and a secondary energy storage battery pack to maximize driving range and efficiency.
4. Regenerative braking systems improve efficiency by reversing the electric propulsion motor process, turning kinetic energy back into storable electricity during deceleration.
5. India's alternative powertrain initiatives are designed to support the National Electric Mobility Mission Plan (NEMMP) and the National Green Hydrogen Mission.

Which of the statements given above are correct?

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

Correct Answer: (d)
Explanation:

- All five statements are correct. Shifting away from conventional petroleum internal combustion engines requires a variety of technologies. BEVs remove emissions from the tailpipe entirely, while FCEVs provide long range and fast refueling for heavy-duty shipping and transit. Hybrid models and regenerative braking systems capture energy that would otherwise be lost as heat during braking, storing it to maximize overall vehicle efficiency. These advancements align with India's national sustainability initiatives.

10. Consider the following statements regarding the Agnite propulsion engine:
1. Designed by an Indian private space startup, Agnite is the world's largest single-piece, 3D-printed booster engine.
2. Both the Agnite and Agnilet systems are engineered as high-performance, 3D-printed semi-cryogenic engines.
3. The structural body of the Agnite engine is fabricated using Inconel, a specialized superalloy designed to withstand extreme temperatures and high pressures.
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

Correct Answer: (d)
Explanation:

- **Statements 1, 2, and 3 are all correct:** Developed by Agnikul Cosmos, the Agnite engine is a major milestone for India's private space sector. Fabricating a rocket engine as a single, 3D-printed piece removes the need for complex welds and joins, reducing the risk of structural failure.
- It uses Inconel, an oxidation- and corrosion-resistant nickel-chromium superalloy that maintains its structural strength under the extreme heat and pressure of semi-cryogenic rocket combustion. These engines are designed to power the booster stage of the company's Agnibaan launch vehicle.

Miscellaneous Applications-II

1. Match Column I (Name of the Treaty/Convention/Agreement) with Column II (Description):

Treaty/Convention/Agreement	Description
A. TRIPS Agreement	1. Establishes a global framework for protecting industrial property, including patents and trademarks.
B. Lisbon Agreement	2. Administered by the WTO, it establishes enforceable minimum standards for IPR, including compulsory licensing.
C. Berne Convention	3. Provides a specialized international registration framework for the protection of appellations of origin.

D. Paris Convention	4. Ensures automatic, worldwide copyright protection for literary and artistic works without requiring formal registration.

Which of the following options represents the correct matching pairs?

(a) A-2, B-3, C-4, D-1
(b) A-1, B-4, C-3, D-2
(c) A-2, B-4, C-3, D-1
(d) A-3, B-2, C-4, D-1

Correct Answer: (a)

Explanation:

- **TRIPS Agreement (Pair 2):** Administered by the World Trade Organization (WTO), it ties intellectual property protection to international trade rules and establishes mandatory minimum enforcement standards for member states.
- **Lisbon Agreement (Pair 3):** Administered by the World Intellectual Property Organization (WIPO), it focuses specifically on protecting appellations of origin and their geographical indications across borders.
- **Berne Convention (Pair 4):** Deals with copyright protection. Its core principle is "automatic protection," meaning creative works are protected internationally from the moment of creation without mandatory copyright registration.
- **Paris Convention (Pair 1):** One of the oldest IPR treaties, it handles industrial property in its broadest sense, covering inventions, utilities, designs, trademarks, and trade names.

2. Consider the following statements regarding Small Language Models (SLMs) in artificial intelligence:

1. SLMs are built on fundamentally different non-neural network architectures to avoid the use of Transformer attention mechanisms.
2. The primary technical metric separating SLMs from Large Language Models (LLMs) is parameter count, with SLMs typically configured under 30 billion parameters.
3. SLMs can be systematically optimized from larger pre-trained architectures using compression techniques like knowledge distillation, pruning, and quantization.
4. Due to their low memory footprint, SLMs are incapable of on-device (edge) deployment and must rely entirely on external, high-bandwidth cloud servers.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 2 and 3 are correct:** SLMs maintain a smaller footprint (typically under 10–30 billion parameters compared to the hundreds of billions or trillions in frontier models like GPT-4). They are often optimized using knowledge distillation (training a compact student model to replicate a larger teacher model), pruning (removing redundant neural weights), and quantization (reducing numerical precision to save memory).
- **Statement 1 is incorrect:** SLMs share the exact same underlying neural architecture as LLMs, relying heavily on modern Transformer networks.

- **Statement 4 is incorrect:** A key advantage of SLMs is their ability to run locally on edge devices (smartphones, laptops, and IoT hardware) without an active internet connection, which keeps user data private.

3. Consider the following statements regarding the National Supercomputing Mission (NSM):

1. The mission connects national academic and research institutions into a single high-performance computing grid.
2. The supercomputing assets under the NSM are networked on a dedicated grid built over the infrastructure of the National Knowledge Network (NKN).
3. The mission is executed as a standalone corporate initiative managed exclusively by private tech consortia without Central Government oversight.

Which of the statements given above are correct?

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** The NSM establishes a secure, high-speed supercomputing grid across India's premier academic and R&D centers, leveraging the high-bandwidth backbone of the National Knowledge Network (NKN).
- **Statement 3 is incorrect:** The NSM is jointly steered by two government bodies: the Department of Science and Technology (DST) and the Ministry of Electronics and Information Technology (MeitY). It is implemented by the Center for Development of Advanced Computing (C-DAC), Pune, and the Indian Institute of Science (IISc), Bengaluru.

4. Consider the following statements regarding Food Irradiation technology:

1. It is a physical preservation technique where packed or bulk food commodities are exposed to controlled amounts of ionizing radiant energy.
2. The primary process relies on radiolysis, which splits water molecules inside pathogens and insects to disrupt their biological functions.
3. To protect the public from residual radioactive contamination, the process strictly forbids using gamma rays emitted by Cobalt-60 sources.

Which of the statements given above is/are correct?

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Food irradiation uses ionizing radiation to extend shelf life and control pests. A key mechanism is the radiolysis of water, where radiant energy splits water molecules inside the cells of insects or micro-organisms, producing reactive components that neutralize them without altering the food's quality.

- **Statement 3 is incorrect:** Approved methods for food irradiation include gamma rays from radioactive Cobalt-60, alongside high-energy X-rays and electron beams generated by electrical accelerators. None of these methods make the food itself radioactive.

5. This material consists of a single layer of carbon atoms arranged in a two-dimensional hexagonal honeycomb lattice. Known for its performance metrics, it can stretch by up to 20-25% of its length, conducts electricity better than copper, and exhibits mechanical tensile strength roughly 200 times stronger than steel by weight. Identify this material:
(a) Fullerene
(b) Graphene
(c) Boron Nitride Nanotubes
(d) Carbonatite Intrusions

Correct Answer: (b)
Explanation:

- Graphene is a versatile nanomaterial. Its unique single-atom-thick 2D structure gives it exceptional electrical conductivity, thermal performance, elasticity, and mechanical strength.
- These properties make it useful for an array of advanced applications, from high-sensitivity environmental sensors and high-density electric vehicle batteries to water desalination filters.

6. Consider the following statements regarding Project Glasswing:
1. Project Glasswing is a multi-company AI coalition aimed at securing critical global software infrastructure by autonomously detecting and patching software vulnerabilities.
2. The framework utilizes specialized, unreleased frontier AI models to autonomously discover zero-day vulnerabilities and generate fixed code to patch them.

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

Correct Answer: (c)
Explanation:

- Both statements are correct. Project Glasswing brings together major technology firms (including Anthropic, AWS, Apple, Google, and Microsoft) to address cybersecurity challenges using advanced AI.
- By using next-generation models like Claude Mythos Preview, the project aims to identify zero-day software vulnerabilities—flaws unknown to the developers—and write clean patch code to secure systems faster than human teams can.

7. Consider the following statements regarding the Phenome India National Biobank:
1. The repository is designed to store high-resolution genomic, lifestyle, and clinical data from diverse populations to assist in early diagnosis and gene-guided therapies.
2. The facility was established under the Phenome India-CSIR Health Cohort Knowledgebase (PI-Check) project.
3. An organism's phenome represents its complete internal genetic sequence, which remains unaffected by environmental factors or lifestyle variables.

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

Correct Answer: (a)
Explanation:

- **Statements 1 and 2 are correct:** The National Biobank at CSIR-IGIB collects genetic, lifestyle, and medical histories to build a high-resolution data pool tailored to Indian genetic diversity. This data helps fuel AI diagnostics and personalized precision medicine.
- **Statement 3 is incorrect:** A phenome is the complete set of phenotypes (observable physical traits, developmental processes, and behaviors) of an organism. An organism's phenotype is shaped by both its underlying genotype and the environmental conditions it experiences over time.

8. Consider the following statements regarding the National Biofoundry Network:

1. A biofoundry operates as an automated facility that designs, constructs, and optimizes engineered organisms by integrating gene-editing workflows with high-throughput biomanufacturing.
2. The National Biofoundry Network was established as a core component to support India's BioE3 (Biotechnology for Economy, Environment and Employment) Policy.

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

Correct Answer: (c)
Explanation:

- Both statements are correct. Launched under the Department of Biotechnology's (DBT) BioE3 Policy, the National Biofoundry Network serves as a key infrastructure driver.
- By automating DNA synthesis and testing, it helps scale lab discoveries into commercial technologies across sectors like precision biothreat therapeutics, carbon capture utilization, and alternative proteins.

9. Consider the following statements regarding the Diverse Epigenetic Epidemiology Partnership (DEEP) project:

1. Epigenetics focuses on studying how behaviors and environmental factors trigger changes that alter the underlying core DNA sequence of an individual.
2. The DEEP project is a multi-year international research collaboration designed to explore how genomic and environmental diversity influence disease risks across different global populations.

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

Correct Answer: (b)
Explanation:

- **Statement 1 is incorrect:** Epigenetic changes do not alter the underlying DNA sequence. Instead, they add or remove chemical tags on the DNA that change how the cell reads the sequence, meaning these modifications are often reversible.
- **Statement 2 is correct:** The DEEP project brings together international bodies (including the University of Bristol and CSIR-CCMB) to study how genetic and environmental diversity affect health and disease risks worldwide.

10. Which of the following statements about the Vikram3201 processor is/are correct?

1. It is an advanced version of the indigenously designed 16-bit VIKRAM1601 microprocessor, which is integrated into the avionics systems of ISRO's launch vehicles.
2. It is a fully "Make-in-India" 32-bit microprocessor qualified to operate reliably under the harsh environmental conditions of spaceflight.

Select the answer using the code given below:

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

Correct Answer: (c)

Explanation:

- Both statements are correct. Unveiled at Semicon India, the Vikram3201 microprocessor represents a major step forward for India's space hardware.
- Developed by the Vikram Sarabhai Space Centre (VSSC) alongside the Semiconductor Laboratory (SCL) in Chandigarh, this 32-bit upgrade builds on the proven 16-bit VIKRAM1601 architecture. It is built to withstand extreme vibration, thermal shifts, and radiation during launch and spaceflight.

Miscellaneous Applications-III

1. Consider the following statements regarding Neutrinos and Dark Matter:

1. Neutrinos are subatomic particles that carry a net positive electrical charge and are heavily diverted by interstellar magnetic fields.
2. Unlike dark matter, ordinary baryonic matter actively interacts with electromagnetic radiation, making it visible across the cosmos.
3. Both dark matter and ordinary matter possess mass and exert a measurable gravitational force on surrounding celestial bodies.

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

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** Neutrinos are often referred to as ghost particles because they have zero electrical charge, zero size, and a tiny mass. Because they are electrically neutral, they travel in completely straight lines from their source and are completely undisturbed by even the strongest magnetic fields.

- **Statement 2 is correct:** Ordinary matter (baryonic matter) includes gas, dust, stars, and planets. It interacts with electromagnetic radiation (light), whereas dark matter constitutes roughly 27% of the cosmos but remains completely invisible because it does not absorb, reflect, or emit light.
- **Statement 3 is correct:** Despite their compositional differences, both ordinary matter and dark matter share the basic properties of matter: they possess mass, take up space, and exert a gravitational pull on one another.

2. Consider the following statements regarding Fast Radio Bursts (FRBs):

1. Fast Radio Bursts (FRBs) are high-energy blasts of electromagnetic radiation in the form of radio waves that typically originate from galaxies far beyond the Milky Way.
2. As FRBs travel through space, their signal compresses into a single unified wavelength, hiding the distribution of matter along their cosmic trajectory.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** FRBs are brief, intense pulses of radio waves lasting from a fraction of a millisecond to a few seconds, mostly originating from deep extragalactic space.
- **Statement 2 is incorrect:** Instead of compressing, FRBs disperse into different wavelengths as they travel through the universe, similar to how a prism splits sunlight into a spectrum. The degree of this dispersion tells scientists exactly how much matter the signal encountered along its path. This makes FRBs reliable cosmic flashlights for mapping the matter distribution of the cosmic web.

3. The World Health Organization (WHO) launched a targeted initiative to combat non-communicable diseases (NCDs) and obesity by encouraging member states to implement specialized health taxes that would raise retail prices by at least 50% by the year 2035. This initiative targets three specific unhealthy consumer commodities: tobacco, alcohol, and sugary drinks. Identify this initiative:

(a) The 50-by-35 Accord
(b) The NCD Fiscal Pact
(c) The 3 By 35 Initiative
(d) The Global Health Tax Framework

Correct Answer: (c)

Explanation:

- The 3 By 35 Initiative was developed by the WHO to tackle population-level obesity, diabetes, cardiovascular conditions, and other non-communicable diseases (NCDs).
- By raising the prices of tobacco, alcohol, and sugar-sweetened beverages by at least 50% through health taxes by 2035, the WHO aims to curb consumption of these products. This strategy is recognized as one of the most cost-effective fiscal tools available for public health intervention.

4. Consider the following statements regarding Step-and-Shoot Proton Arc Therapy (SPArc):

1. SPArc is an advanced radiation therapy technique that destroys cancer cells or halts their growth by directly damaging their cellular DNA structures.

2. The primary operational benefit of SPArc is its ability to deliver precise proton arcs that target tumor volumes while minimizing radiation exposure to the surrounding healthy tissue.

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

Correct Answer: (c)

Explanation:

- Both statements are correct. SPArc represents a significant leap forward in precision oncology. Recently used to treat a rare Adenoid Cystic Carcinoma (ACC), this approach improves dose-planning quality for complex tumor locations, such as head, neck, and brain cancers, by delivering a tightly focused radiation dose that spares nearby critical organs.

5. Consider the following statements regarding the GSAT-7R (CMS-03) satellite:

1. It is an advanced military communications satellite launched into Geostationary Orbit to provide secure, multi-band voice, video, and data transmission.
2. The satellite extends India's maritime domain awareness and secure communication networks across the Indian Ocean Region, reaching up to 2,000 kilometers from the nation's coastline.
3. Designed as a brand-new orbital capability, it operates independently without replacing any pre-existing naval communications infrastructure.

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

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Launched by ISRO using the LVM3 rocket, GSAT-7R provides encrypted multi-band communications across the Indian landmass and the Indian Ocean Region. This network links naval ships, submarines, aircraft, and strategic Operations Centers.
- **Statement 3 is incorrect:** The satellite does not operate as an isolated addition; it is a direct replacement for the aging GSAT-7 (Rukmini) satellite, upgrading India's long-term maritime communications infrastructure with a 15-year operational lifespan.

6. Match the Directed Energy Weapon (DEW) systems in Column I with their respective country of origin in Column II:

Column I (DEW System)	Column II (Country of Origin)
A. DragonFire	1. United States of America
B. HELIOS	2. India
C. Silent Hunter	3. United Kingdom

D. IDD&IS Mk2A	4. China

Select the correct matching options using the codes given below:
(a) A-1, B-3, C-4, D-2
(b) A-3, B-1, C-4, D-2
(c) A-3, B-4, C-1, D-2
(d) A-2, B-1, C-4, D-3

Correct Answer: (b)
Explanation:

- **A-3 (DragonFire -> United Kingdom):** DragonFire is the UK's advanced laser directed energy weapon (LDEW) technology demonstrator. It is engineered to track, lock onto, and neutralize airborne and maritime threats with extreme precision at the speed of light.
- **B-1 (HELIOS -> United States of America):** Developed by Lockheed Martin for the US Navy, HELIOS (High Energy Laser with Integrated Optical-dazzler and Surveillance) is a weapon system that combines high-energy laser interception, tactical organic long-range intelligence, and an optical dazzler to blind adversarial sensors.
- **C-4 (Silent Hunter -> China):** Silent Hunter is a mobile, electrically powered, laser-based air defense system built by China. It is specialized for low-altitude tactical defense, particularly for seeking out and neutralizing low-flying, low-speed unmanned aerial vehicles (UAVs).
- **D-2 (IDD&IS Mk2A -> India):** Developed indigenously by the Defence Research and Development Organisation (DRDO), the Integrated Drone Detection and Interdiction System (IDD&IS) Mk2A serves as a strategic anti-drone asset. It integrates multiple sensory feeds for comprehensive detection and deploys both soft-kill (jamming/spoofing) and hard-kill (kinetic/laser countermeasure) options against hostile drone systems.

7. Consider the following statements regarding Thorium Molten Salt Reactors (TMSR):
1. TMSR technology is a fourth-generation nuclear energy design that utilizes high-temperature molten salt as its primary coolant, eliminating the need for high-pressure water cooling.
2. In its natural state, the sole naturally occurring isotope, Thorium-232, is a highly fissile material that can sustain a nuclear chain reaction without any initial transmutation.
3. MSRs feature passive safety systems, such as a solid salt plug that automatically melts to drain the liquid fuel and halt the reaction if temperatures exceed safe limits.
4. Thorium is roughly three times less abundant in nature than uranium, which makes it a rare and highly restricted fuel resource worldwide.

Which of the statements given above are correct?
(a) 1 and 2 only
(b) 2 and 4 only
(c) 1 and 3 only
(d) 3 and 4 only

Correct Answer: (c)
Explanation:

- **Statements 1 and 3 are correct:** TMSR systems operate at normal atmospheric pressure without the risk of high-pressure steam explosions. They rely on passive safety features, like a freeze plug that melts during a power loss or overheating event to drain the fuel salt into secure holding tanks, stopping the reaction automatically.

- **Statement 2 is incorrect:** Thorium-232 is fertile, not fissile. It cannot sustain a chain reaction on its own and must first absorb neutrons in a reactor to transmute into fissile Uranium-233 fuel.
- **Statement 4 is incorrect:** Thorium is actually three times more abundant in nature than uranium. However, its widespread adoption is currently limited by high extraction costs and the complex technology required to manage the thorium fuel cycle.

8. Consider the following statements regarding Black Mass Recovery technology:

1. Black Mass is a valuable, dark, powdery mixture of critical minerals—including lithium, cobalt, and nickel—extracted from recycled, end-of-life lithium-ion batteries.
2. The recovery process relies exclusively on dry mechanical crushing, making it chemically impossible to incorporate liquid-based wet processing modes.

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

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** Black mass is the structural material left over after spent lithium-ion batteries are processed and shredded. It contains a high concentration of critical materials like lithium, nickel, and cobalt, which can be refined and reused to manufacture new clean energy products.
- **Statement 2 is incorrect:** The advanced indigenous technology supported by India's Technology Development Board (TDB) explicitly utilizes a dual-mode system that combines both wet and dry processing. This approach maximizes the extraction and recovery rate of pure elements while minimizing environmental pollution.

9. Consider the following statements regarding Sodium-Ion Batteries (SIBs) and Solid-State Batteries (SSBs):

1. SIBs function identically to lithium-ion configurations but transport charge using sodium ions, which generally results in a lower overall energy density than Lithium-Ion Batteries (LIBs).
2. Unlike liquid-electrolyte batteries, SIBs can be fully discharged and safely transported at zero voltage, significantly reducing transit fire risks.
3. Solid-state batteries replace volatile liquid electrolytes with solid alternatives, enabling faster recharging cycles and improved resistance to leakage or combustion.
4. Flow batteries are powered by redox reactions in which two liquid electrolytes pass ions through a porous membrane, allowing energy storage capacity to scale with the size of the external liquid tanks.

Which of the statements given above are correct?

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

Correct Answer: (d)

Explanation:

- All four statements are correct. These next-generation energy storage options address the key limitations of standard lithium-ion systems. SIBs leverage widely available sodium resources and offer safer transit options because they can be completely discharged to zero volts.

- At the same time, solid-state batteries (SSBs) eliminate volatile liquids to deliver higher energy densities and faster charging speeds, while flow batteries offer a modular solution for grid-scale storage by scaling capacity based on electrolyte tank volume.

10. Consider the following statements regarding solid-state and liquid-electrolyte flow batteries:

1. Solid-state batteries utilize a porous, liquid-infused separator membrane to exchange ions between the cell terminals.
2. Flow batteries separate their energy storage medium from the power-generating components, allowing operators to scale storage capacity simply by resizing the liquid electrolyte tanks.
3. A key safety advantage of solid-state batteries is that solid electrolytes are far less prone to leak or catch fire than the volatile liquid chemistry used in conventional batteries.
4. Vanadium redox systems are a prominent category of flow battery technology used for long-duration grid energy storage.

Which of the statements given above are correct?

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

Correct Answer: (b)

Explanation:

- **Statements 2, 3, and 4 are correct:** Flow batteries (such as vanadium redox, iron-salt, and zinc-bromine systems) store energy in external liquid tanks, meaning their capacity scales with tank size. Solid-state configurations replace flammable liquid components with stable solid electrolytes, which prevents dangerous thermal runaway and leakage while allowing more energy to be packed into less space.
- **Statement 1 is incorrect:** Solid-state batteries do away with liquid components entirely. They use a solid electrolyte layer that serves as both the ion conductor and the physical separator, removing the need for liquid-infused membranes.