

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO

T.B.C. : STS-K-TPT  
Serial No.:

Test Booklet Series

TEST BOOKLET

**Subject : Test 7 – ENERGY & AGRICULTURE**  
**Answer Key****Time Allowed : Two Hours****Maximum Marks : 200****INSTRUCTIONS**

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET DOES NOT HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GOT IT REPLACED BY A COMPLETE TEST BOOKLET.

**2. Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series A, B, C or D carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet. Any omission/discrepancy will render the Answer Sheet liable for rejection.**

3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside. DO NOT write anything else on the Test Booklet.

4. This Test Booklet contains 100/80 items (questions).

Each item is printed in English. Each item comprises of four responses (answers). You will select the response

which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you

consider the best. In any case, choose ONLY ONE response for each item.

5. You have to mark all your responses ONLY on the separate Answer Sheet provided. See directions in the Answer Sheet.

6. All items carry equal marks

7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.

8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator only the Answer Sheet. You are permitted to take away with you the Test Booklet.

9. Sheets for rough work are appended in the Test Booklet at the end.

**10. Penalty for wrong answers:**

THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE IN THE OBJECTIVE TYPE QUESTION PAPERS

(i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one third** if the marks assigned to that question will be deducted as penalty.

(ii) If a candidate gives more than one answer, it will be treated as a wrong answer even if one of the given answers happens to be correct and there will be same penalty as above to that question.

(iii) If a question is left blank, i.e., no answer is given by the candidate, there will be no penalty for that question.

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1. Match the following unconventional hydrocarbon resources with their characteristic resource forms:

List I (Resource Type)	List II (Description)
A. Shale Gas	1. Hydrocarbons occurring in marine sediments under high pressure and low temperature
B. Tight Oil	2. Oil trapped in low-permeability rock formations requiring hydraulic fracturing
C. Methane Hydrates	3. Natural gas trapped in fine-grained shale formations
D. Oil Sands	4. Bitumen mixed with sand, clay, and water

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-3, B-2, C-1, D-4

#### ■ Brief Answer Key

**A – Shale Gas:** Correct – Natural gas trapped in **fine-grained shale rock formations**.

**B – Tight Oil:** Correct – Oil found in **low-permeability rocks requiring hydraulic fracturing and horizontal drilling**.

**C – Methane Hydrates:** Correct – **Ice-like crystalline structures containing methane**, found in **deep ocean sediments or permafrost**.

**D – Oil Sands:** Correct – **Bitumen mixed with sand, clay, and water**, extracted through mining or in-situ methods.

2. Match the following Emerging solar energy technologies with their key characteristics:

List I (Technology)	List II (Feature)
A. Perovskite Solar Cells	1. Solar modules capable of capturing sunlight from both the front and rear surfaces
B. Floating Solar Farms	2. Solar installations deployed on water bodies

	to reduce land-use pressure and evaporation
C. Bifacial Solar Panels	3. Emerging photovoltaic technology known for flexible, lightweight, and potentially low-cost solar cells
D. Agrovoltatics	4. Integration of solar panels with agricultural activities on the same land

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-3, B-2, C-1, D-4

#### EXPLANATION

**A – Perovskite Solar Cells:** Correct – Emerging **low-cost, flexible photovoltaic technology** with high efficiency potential.

**B – Floating Solar Farms:** Correct – Solar panels installed on **reservoirs or lakes**, reducing **land use and water evaporation**.

**C – Bifacial Solar Panels:** Correct – Panels generate power from **both front and rear sides** using reflected light.

**D – Agrovoltatics:** Correct – **Co-location of solar panels and agriculture** to optimize land productivity.

3. With reference to the proposed “Battery Aadhaar” system in India, consider the following statements:

1. **Battery Aadhaar** proposes a **21-character Battery Pack Aadhaar Number (BPAN)** linked to a QR-based digital identity to track batteries across their lifecycle.
2. The system aims to record information such as **battery chemistry, raw materials, manufacturer details, safety certifications, and performance history**.
3. The initiative seeks to ensure **end-to-end traceability from manufacturing to recycling**, thereby improving safety and reducing counterfeit batteries.
4. The system is intended exclusively for **lead-acid batteries used in conventional automobiles**.

Which of the statements given above is/are correct?

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

✔ **Correct Answer: (a) 1, 2 and 3 only**

▮ **Brief Answer Key**

**Statement 1:** Correct – Battery Aadhaar proposes a **QR-linked 21-character Battery Pack Aadhaar Number (BPAN)** for identification.

**Statement 2:** Correct – The database captures **material composition, manufacturer details, battery chemistry, and safety certification data.**

**Statement 3:** Correct – It enables **lifecycle traceability from manufacturing to recycling**, improving safety and sustainability.

**Statement 4:** Incorrect – The system targets **EV and industrial batteries broadly**, not just lead-acid automotive batteries.

- ❑ The **Battery Aadhaar concept is proposed by the Ministry of Road Transport & Highways (MoRTH).**
- ❑ It complements India's **Battery Waste Management Rules, 2022** and **Extended Producer Responsibility (EPR)** framework.

4. Match the following energy-efficiency concepts in buildings with their appropriate descriptions:

List I (Concept)	List II (Description)
A. Net Zero Energy Building (NZE)	1. Retrofitting existing buildings to improve energy performance
B. Passive House Design	2. Architectural approach using insulation, airtightness, and thermal mass to minimize heating and cooling needs
C. Green Retrofitting	3. Building that generates as much energy as it consumes over a year
D. Demand Response System	4. Adjusting electricity consumption to reduce load during peak demand periods

Select the correct answer using the codes below:

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

✔ **Correct Answer: (b) A-3, B-2, C-1, D-4**

▮ **Brief Answer Key**

**A – Net Zero Energy Building:** Correct – Produces **as much energy as it consumes annually**, often using rooftop solar.

**B – Passive House Design:** Correct – Uses **insulation, airtight construction, and thermal mass** to reduce HVAC energy demand.

**C – Green Retrofitting:** Correct – **Upgrading existing buildings** to improve energy efficiency and sustainability.

**D – Demand Response System:** Correct – **Shifts or reduces electricity use during peak demand** to balance the grid.

Recent developments relevant for exam preparation:

- India promotes energy-efficient buildings through the **Energy Conservation Building Code (ECBC)** issued by the **Bureau of Energy Efficiency (BEE).**
- **Net Zero Energy Buildings** are increasingly used in **government campuses and green infrastructure projects.**
- **Demand Response systems** are becoming important with **smart grids and renewable energy integration.**
- India is moving toward **Net-Zero emissions by 2070**, making building energy efficiency a key policy area.

5. Match the following emerging energy technologies with their appropriate application areas:

List I (Technology)	List II (Application Area)
A. Antiferroelectric RAM Storage	1. Wastewater treatment and biosensing through bio-electrochemical processes
B. Flywheel Energy Storage	2. Stabilization of power grids through frequency regulation

C. Microbial Fuel Cells (MFCs)	3. High-density energy storage systems suitable for microgrid applications
D. Vehicle-to-Grid (V2G) Technology	4. Using electric vehicles as distributed or mobile energy sources

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-3, B-2, C-1, D-4

#### ■ Brief Answer Key

**A – Antiferroelectric RAM Storage:** Correct – Offers **high-density and fast-response energy storage**, potentially useful in advanced microgrid systems.

**B – Flywheel Energy Storage:** Correct – Used for **rapid grid stabilization and frequency regulation**.

**C – Microbial Fuel Cells:** Correct – Generate electricity from **organic waste and wastewater via microbial activity**.

**D – Vehicle-to-Grid (V2G):** Correct – Allows **EV batteries to supply electricity back to the grid or act as mobile power sources**.

6. With reference to bifacial solar photovoltaic (PV) panels, consider the following statements:

1. Bifacial solar panels can generate electricity by capturing sunlight on **both the front and rear surfaces of the module**.
2. This technology is **restricted mainly to rooftop solar installations** and is not suitable for large utility-scale solar farms.
3. The capacity of these panels to capture **reflected (albedo) light from surfaces such as snow, sand, or water** can enhance their electricity generation efficiency.

Which of the statements given above is/are correct?

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

✔ Correct Answer: (a) 1 and 3 only

#### ■ Brief Answer Key

**Statement 1:** Correct – Bifacial modules generate power from **both sides**, increasing overall energy yield.

**Statement 2:** Incorrect – Bifacial panels are **widely used in large utility-scale solar parks**, not just rooftops.

**Statement 3:** Correct – **Albedo (reflected light)** from surfaces like snow, sand, or water improves output.

- **Bifacial solar modules are increasingly deployed in utility-scale solar parks** because they improve energy yield by **5–20% depending on ground reflectivity**.
- They are commonly mounted on **elevated structures or single-axis trackers** to maximize rear-side light capture.
- The technology is increasingly used in **floating solar projects and desert solar parks** where reflected light enhances performance.

7. With reference to agrovoltaic systems, consider the following statements:

1. Agrovoltaics refers to the **simultaneous use of land for agricultural cultivation and solar power generation by installing solar panels above or alongside crops**.
2. The presence of solar panels can **modify microclimatic conditions such as shade, soil moisture, and temperature**, which may improve crop productivity in certain cases.
3. Agrovoltaic systems are designed **primarily for large-scale commercial agriculture and do not focus on electricity generation**.

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) 1 and 2 only

#### ■ Brief Answer Key

**Statement 1:** Correct – Agrovoltaics enables **dual land use: agriculture and solar energy production on the same land**.

**Statement 2:** Correct – Panels can create **microclimatic benefits such as reduced**

evaporation and moderated temperatures, which may enhance crop yields.

**Statement 3:** Incorrect – Agrovoltatics aims to **combine food production and renewable energy generation**, not replace energy production.

Recent developments that make the topic exam-relevant:

- Agrovoltatics is being promoted to **reduce land-use conflicts between solar parks and agriculture**.
- It is increasingly linked to **agrivoltaic models under distributed solar schemes**, including **PM-KUSUM** in India.
- Studies show agrovoltaic systems can **improve water-use efficiency and provide additional income to farmers**.

8. Match the following emerging energy technologies with their distinctive features:

List I (Technology)	List II (Feature)
A. Supercapacitors	1. Generates electricity using differences in salt concentration between freshwater and seawater
B. Osmotic (Blue) Energy	2. High power density with very fast charge-discharge capability
C. Liquid Metal Battery	3. Uses molten metal electrodes suitable for large-scale grid energy storage
D. Microbial Fuel Cell	4. Produces electricity through metabolic activity of microorganisms

Select the correct answer using the codes below:

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

**Correct Answer: (a) A-2, B-1, C-3, D-4**

#### **Brief Answer Key**

**A – Supercapacitors:** Correct – Provide **high power density and ultra-fast charge-discharge cycles**.

**B – Osmotic (Blue) Energy:** Correct – Generates electricity from **salinity gradient between freshwater and seawater**.

**C – Liquid Metal Battery:** Correct – Uses **molten metal electrodes**, designed for **grid-scale energy storage**.

**D – Microbial Fuel Cell:** Correct – **Bacteria break down organic matter to generate electricity**.

9. With reference to critical minerals and evolving global supply-chain strategies, consider the following statements:

1. The concept of **“Ethical Cobalt”** has emerged due to concerns regarding **artisanal mining practices and the use of child labour in cobalt mining**, particularly in the **Democratic Republic of Congo**.
2. **Friendshoring** refers to sourcing critical minerals and manufacturing inputs from **trusted geopolitical partners to reduce supply-chain vulnerabilities**.
3. **Reshoring** refers to relocating manufacturing or supply chains **back to the home country or closer to domestic markets**.

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) 1, 2 and 3**

#### **Brief Answer Key**

**Statement 1:** Correct – Ethical cobalt initiatives aim to address **human rights concerns in artisanal mining in the DR Congo**, which dominates global cobalt production.

**Statement 2:** Correct – Friendshoring means **shifting supply chains toward trusted geopolitical partners**, not merely countries with FTAs.

**Statement 3:** Correct – Reshoring involves **bringing manufacturing and supply chains back to the domestic economy**.

Important developments for upcoming exams:

- The **Democratic Republic of Congo produces about 70% of global cobalt**, making ethical sourcing a

major concern for EV battery supply chains.

- Global strategies like **friendshoring, nearshoring, and reshoring** are increasingly used to reduce **dependence on concentrated mineral supply chains**.
- India is actively pursuing **critical mineral partnerships and supply-chain diversification** as part of its **Critical Minerals Strategy (2023)**.

10. A **powertrain** refers to the system of components in a vehicle that generates power and transmits it to the wheels, including the engine/motor, transmission, and related systems. Match the following types of alternative powertrain vehicles with their key characteristics:

List I (Vehicle Type)	List II (Characteristic)
A. Battery Electric Vehicle (BEV)	1. Uses hydrogen fuel cells to generate electricity onboard
B. Hybrid Electric Vehicle (HEV)	2. Uses electricity stored in batteries and does not have a conventional combustion engine
C. Plug-in Hybrid Electric Vehicle (PHEV)	3. Combines petrol engine with battery, charged through engine operation and regenerative braking
D. Fuel Cell Electric Vehicle (FCEV)	4. Combines electric battery and petrol engine with the ability to charge externally

Select the correct answer using the codes below:

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

✔ **Correct Answer: (a) A-2, B-3, C-4, D-1**

#### 📖 Brief Answer Key

**A – BEV:** Correct – Runs **entirely on electricity stored in batteries**, with no internal combustion engine.

**B – HEV:** Correct – Combines **petrol engine and battery**, where battery is charged through engine operation and regenerative braking.

**C – PHEV:** Correct – Hybrid system where **battery can also be charged externally from the grid**.

**D – FCEV:** Correct – Uses **hydrogen fuel cells to produce electricity onboard**, emitting only water vapor.

Important developments relevant for exams:

- **Battery Electric Vehicles (BEVs)** dominate global EV markets due to improvements in **lithium-ion batteries**.
- **Hydrogen Fuel Cell Vehicles (FCEVs)** are being explored for **heavy transport and long-distance mobility**.
- Governments, including India, promote EV adoption through schemes such as **FAME (Faster Adoption and Manufacturing of Electric Vehicles)**.

11. Which of the following can function as decentralized energy storage systems?

1. Home battery storage systems
2. Community battery banks
3. Microgrid energy storage
4. Electric vehicle batteries used for grid services

Select the correct answer using the code below:

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

✔ **Correct Answer: (d) 1, 2, 3 and 4**

**Decentralized (distributed) energy storage** refers to small-scale storage systems located close to the point of electricity consumption rather than centralized grid-level storage.

#### 📖 Brief Answer Key

- **1:** Correct – Home batteries store energy locally for household use.
- **2:** Correct – Community battery banks store electricity for neighbourhood-level consumption.
- **3:** Correct – Microgrids often include **local energy storage systems**.
- **4:** Correct – EV batteries can provide **grid services via Vehicle-to-Grid (V2G)** systems.

12. Match the following emerging energy frontiers with their distinctive features:

List I (Energy Frontier)	List II (Feature)
A. Space-Based Solar Power (SBSP)	1. Uses artificial fracturing to access heat from deep geothermal reservoirs
B. Enhanced Geothermal Systems (EGS)	2. Concept of transmitting solar energy collected in space to Earth using microwave or laser beams
C. Seafloor Mining	3. Extraction of methane hydrates and critical minerals from ocean floors
D. Digital Oilfields	4. Real-time optimization of hydrocarbon extraction using AI, sensors, and IoT technologies

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-2, B-1, C-3, D-4

#### 📄 Brief Answer Key

**A – Space-Based Solar Power:** Correct – Envisions **collecting solar energy in space and transmitting it to Earth via microwave or laser beams.**

**B – Enhanced Geothermal Systems:** Correct – Uses **artificial fracturing to enhance permeability in hot dry rocks** to extract geothermal energy.

**C – Seafloor Mining:** Correct – Targets **methane hydrates and deep-sea minerals such as cobalt, nickel, and rare earth elements.**

**D – Digital Oilfields:** Correct – Utilizes **AI, sensors, and IoT for real-time monitoring and optimization of oil and gas extraction.**

13. **With reference to the use of remote sensing and satellite-based imaging in energy and mineral exploration, consider the following statements:**

1. **LiDAR and hyperspectral imaging** are used to identify surface features and geological indicators associated with mineral deposits.
2. These technologies can be deployed through **satellites as well as aerial platforms such as drones and aircraft.**

3. Remote sensing techniques can **directly determine the exact volume of hydrocarbon reserves located underground.**

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: (a) 1 and 2 only

#### 📄 Brief Answer Key

**Statement 1:** Correct – **LiDAR and hyperspectral sensors detect geological signatures, mineral alterations, and surface structures** useful for exploration.

**Statement 2:** Correct – Remote sensing data can be collected via **satellites, aircraft, and drones.**

**Statement 3:** Incorrect – Remote sensing helps **identify potential resource zones**, but **accurate volume estimation requires seismic surveys and drilling.**

14. **Which of the following are used for energy storage?**

1. Pumped hydro storage
2. Flywheel systems
3. Molten salt tanks
4. Supercapacitors

Select the correct answer:

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

Answer: d

#### Explanation :

**1. Pumped Hydro Storage:** Correct – Stores excess electricity by pumping water to higher reservoirs; largest grid-scale storage globally.

**2. Flywheel Systems:** Correct – Store energy as **rotational kinetic energy** for rapid charge-discharge applications.

**3. Molten Salt Tanks:** Correct – Used in **Concentrated Solar Power (CSP)** plants for thermal energy storage.

**4. Supercapacitors:** Correct – Store electrical energy via **electrostatic charge**, enabling very fast charging and discharging.

15. With reference to lithium resources and extraction technologies, consider the following statements:

- Direct Lithium Extraction (DLE)** technology is mainly designed to extract lithium directly from **lithium-rich brine deposits**, reducing evaporation time compared to traditional salt-flat methods.
- The region known as the **“Lithium Triangle”** lies in **Bolivia, Chile, and Argentina**, which together account for a major share of the world’s lithium resources.
- India’s first major lithium resource discovery was reported from **Reasi district of Jammu & Kashmir**.

Which of the statements given above is/are correct?

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

✔ **Correct Answer: (c) 1, 2 and 3**

**Explanation**

**Statement 1 — Correct : Direct Lithium Extraction (DLE)** is an emerging technology that extracts lithium from **brine sources** using adsorption, ion-exchange, or solvent extraction.

**Statement 2 — Correct : The Lithium Triangle** is located in the **Andes region** of:

Country	Key Lithium Basin
Bolivia	Salar de Uyuni
Chile	Salar de Atacama
Argentina	Salar del Hombre Muerto

**Statement 3 — Correct : In 2023**, the **Geological Survey of India (GSI)** identified **5.9 million tonnes of inferred lithium resources** in **Salal-Haimana area, Reasi district, Jammu & Kashmir**.

16. Match the following energy storage categories with their storage principle and example:

List I (Category)	List II (Storage Principle)	List III (Example)
A. Mechanical	1. Heat storage	a. Flywheels
B. Thermal	2. Kinetic or potential energy	b. Molten salt

C. Electrical	3. Electric or magnetic fields	c. Supercapacitors
D. Chemical	4. Energy stored in molecules	d. Hydrogen

Select the correct answer using the codes below:

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

✔ **Correct Answer: (a)**

**Brief Answer Key**

- A – Mechanical:** Stores energy as **kinetic/potential energy** (e.g., flywheels).
- B – Thermal:** Stores energy as **heat** (e.g., molten salt in solar plants).
- C – Electrical:** Stores energy in **electric/magnetic fields** (e.g., supercapacitors).
- D – Chemical:** Stores energy in **molecular bonds** (e.g., hydrogen).

17. With reference to energy storage technologies, consider the following statements:

- Pumped hydro storage and gravity towers store energy by lifting mass against gravity.
- Supercapacitors store energy through chemical reactions similar to lithium-ion batteries.
- Molten salt storage systems are widely used in concentrated solar power plants.
- Hydrogen can function as a chemical medium for long-term energy storage.

Which of the statements given above are correct?

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

✔ **Correct Answer: (b)**

**Brief Answer Key**

**Statement 1:** Correct – Gravitational storage includes pumped hydro and gravity towers.

Statement 2: Incorrect – Supercapacitors store energy electrostatically, not via chemical reactions.

Statement 3: Correct – Molten salt is used in CSP plants for thermal energy storage.

Statement 4: Correct – Hydrogen acts as a long-duration chemical energy storage medium.

**18. With reference to the concept of Second-Life Battery Storage, consider the following statements:**

1. It refers to the **chemical recycling of lithium and other battery materials to manufacture new batteries.**
2. It involves **reusing retired electric-vehicle batteries for applications that require lower power demand, such as stationary energy storage.**
3. It can **reduce electronic waste and improve the overall lifecycle efficiency of battery systems.**

Which of the statements given above is/are correct?

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

✔ **Correct Answer: (b) 2 and 3 only**

#### 📖 **Brief Answer Key**

**Statement 1:** Incorrect – Chemical recovery of lithium is **battery recycling**, not second-life usage.

**Statement 2:** Correct – Second-life systems reuse **EV batteries (typically with ~70–80% capacity remaining)** for stationary storage.

**Statement 3:** Correct – Reuse reduces **battery waste and improves lifecycle economics** before final recycling.

**Second-Life Battery Storage** refers to the **reuse of retired batteries—especially from electric vehicles—after their capacity drops below the level required for vehicle use but is still adequate for other applications.** These batteries are repurposed for **less demanding uses such as stationary energy storage, grid balancing, or renewable energy backup.** This approach **extends battery lifespan and reduces electronic waste before the batteries are finally recycled.**

**19. With reference to a Building Energy Management System (BEMS), consider the following statements:**

1. It is an automated system that monitors and controls a building's energy-consuming systems such as lighting, heating, ventilation, and air conditioning.
2. It helps optimize energy consumption in buildings through sensors, controllers, and data analytics.
3. It is primarily designed to store surplus electrical energy generated within a building for later use.

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) 1 and 2 only**

#### 📖 **Brief Answer Key**

**Statement 1:** Correct – BEMS monitors and controls systems like **HVAC, lighting, and appliances** to improve energy efficiency.

**Statement 2:** Correct – It uses **sensors, automation, and analytics** to optimize energy use.

**Statement 3:** Incorrect – **Energy storage is performed by batteries or other storage systems**, not by BEMS itself.

**20. With reference to gravity-based energy storage systems, consider the following statements:**

1. These systems store energy by **lifting heavy masses to a higher elevation using surplus electricity and releasing the stored energy when the mass descends.**
2. They typically generate electricity during discharge by converting **gravitational potential energy into mechanical and then electrical energy.**
3. Some modern systems employ **mechanically lifted blocks or weights, such as concrete masses, to store energy.**

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) 3 only

✔ **Correct Answer: (c) 1, 2 and 3**

📌 **Brief Answer Key**

**Statement 1:** Correct – Energy is stored as **gravitational potential energy by lifting heavy masses**.

**Statement 2:** Correct – During discharge, potential energy converts to **mechanical motion and then electricity via generators**.

**Statement 3:** Correct – Systems like **Energy Vault** use **concrete blocks or heavy weights** as the storage medium.

21. **With reference to emerging innovations in solar energy systems, consider the following statements:**

1. **Floating solar power plants**, installed on water bodies such as reservoirs, can help reduce water evaporation while generating electricity.
2. **Bifacial solar panels** are capable of producing electricity from both direct sunlight and reflected or diffused light.
3. **Agrovoltatics** refers to the installation of solar panels in desert regions to maximize solar radiation exposure.

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) 1 and 2 only**

📌 **Brief Answer Key**

**Statement 1:** Correct – Floating solar panels reduce **water evaporation and algae growth** while generating electricity.

**Statement 2:** Correct – Bifacial panels generate power from **both front sunlight and rear-side reflected/diffuse light**, improving efficiency.

**Statement 3:** Incorrect – **Agrovoltatics** involves **co-locating agriculture and solar panels on the same land**, not desert solar farms.

22. **With reference to the application of Artificial Intelligence (AI) in seismic imaging and subsurface exploration, consider the following statements:**

1. The integration of **Artificial Intelligence in seismic imaging** improves the accuracy of subsurface models used in the exploration of hydrocarbons and geothermal energy resources.
2. Machine learning algorithms used in seismic interpretation **completely eliminate the need for seismic data acquisition using geophysical surveys**.
3. The use of AI in seismic data processing can **reduce exploration time and assist in faster decision-making in resource exploration**.

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: (c) 1 and 3 only**

**Explanation**

**Statement 1:** Correct – AI improves **subsurface modelling and seismic interpretation**, aiding exploration of **oil, gas, and geothermal resources**.

**Statement 2:** Incorrect – AI **analyzes seismic survey data**; it does not replace the need for seismic wave data collection.

**Statement 3:** Correct – AI helps **process large seismic datasets faster**, reducing exploration time and improving decision-making.

23. **Match the following emerging energy trends with their most appropriate description:**

List I (Concept)	List II (Description)
A. Virtual Power Plants (VPPs)	1. Produced using renewable electricity through electrolysis of water

B. Energy-as-a-Service (EaaS)	2. Subscription-based energy supply model where users need not own energy infrastructure
C. Green Hydrogen	3. Networked aggregation and AI-enabled coordination of decentralized energy resources
D. Carbon Capture Utilization and Storage (CCUS)	4. Capturing carbon dioxide emissions and storing or using them in industrial processes

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-3, B-2, C-1, D-4

#### ☰ Brief Answer Key

**A – Virtual Power Plants:** Correct – Digitally aggregate **distributed energy resources (solar, batteries, EVs)** using AI and grid management systems.

**B – Energy-as-a-Service:** Correct – **Subscription/contract model** where consumers pay for energy services rather than owning infrastructure.

**C – Green Hydrogen:** Correct – Produced through **electrolysis using renewable electricity**, emitting no CO<sub>2</sub> during production.

**D – CCUS:** Correct – Captures **CO<sub>2</sub> from industrial sources** and stores it underground or uses it in industrial applications.

24. Match the following battery minerals with the country that is a major global producer:

List I (Mineral)	List II (Major Producer Country)
A. Lithium	1. Democratic Republic of Congo
B. Cobalt	2. Indonesia
C. Nickel	3. China

D. Graphite	4. Australia
E. Manganese	5. South Africa

Select the correct answer using the codes below:

- (a) A-4, B-1, C-2, D-3, E-5
- (b) A-1, B-4, C-2, D-3, E-5
- (c) A-4, B-2, C-1, D-3, E-5
- (d) A-3, B-1, C-4, D-2, E-5

✔ Correct Answer: (a) A-4, B-1, C-2, D-3, E-5

#### ☰ Brief Answer Key

**A – Lithium:** Correct – **Australia** is currently the world's largest lithium producer (hard-rock spodumene).

**B – Cobalt:** Correct – **DR Congo** accounts for the majority of global cobalt production.

**C – Nickel:** Correct – **Indonesia** is the leading global producer of nickel.

**D – Graphite:** Correct – **China dominates graphite production and processing.**

**E – Manganese:** Correct – **South Africa is one of the largest producers and exporters.**

25. With reference to international initiatives and policies related to critical minerals and battery supply chains, consider the following statements:

1. The **Mineral Security Partnership (MSP)** is a multilateral initiative led by the **United States** to diversify global supply chains for critical minerals and reduce overdependence on a few dominant suppliers.
2. **Battery Passports** are digital records designed to track the **origin, sustainability credentials, and lifecycle information of batteries and their components.**
3. India has entered into **agreements with countries such as Argentina and Bolivia** to facilitate cooperation in the sourcing of lithium and other critical minerals.

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) 2 and 3 only

**Brief Answer Key**

**Statement 1:** Incorrect – The **Mineral Security Partnership (MSP)** is primarily **led by the United States**, not the EU.

**Statement 2:** Correct – Battery passports provide **traceability and sustainability information across the battery lifecycle**.

**Statement 3:** Correct – India has pursued **international partnerships, including with Argentina and Bolivia**, for securing lithium and other critical minerals.

26. Match the following energy storage technologies with their key characteristics:

List I (Technology)	List II (Characteristic)
A. Flow Batteries	1. Electrochemical storage using oxygen from air as the cathode reactant
B. Zinc–Air Batteries	2. Storage of rotational kinetic energy with rapid response capability
C. Flywheel Energy Storage	3. Energy stored in liquid electrolytes kept in external tanks, scalable for grid storage
D. Phase Change Materials	4. Storage of thermal energy during the transition of a material between different phases

Select the correct answer using the codes below:

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

✓ **Correct Answer: (a) A-3, B-1, C-2, D-4**

**Brief Answer Key**

**A – Flow Batteries:** Correct – Use **liquid electrolytes stored in external tanks**, allowing scalable grid-level energy storage.

**B – Zinc–Air Batteries:** Correct – Use **oxygen from air as the cathode reactant**, enabling high energy density.

**C – Flywheel Energy Storage:** Correct – Stores energy as **rotational kinetic energy with very fast response times**.

**D – Phase Change Materials:** Correct – Store **thermal energy during phase transitions such as solid–liquid change**.

27. Match the following innovations in energy exploration with their associated technological applications:

List I (Innovation)	List II (Technology / Application)
A. Plasma Pulse Technology	1. Uses microbial activity to enhance extraction of hydrocarbons from reservoirs
B. Microbial Enhanced Oil Recovery (MEOR)	2. Uses high-energy shockwaves to unclog pores in oil-bearing rocks and improve flow
C. Enhanced Geothermal Systems (EGS)	3. Uses advanced modelling and engineering to create or enhance permeability in hot dry rock reservoirs
D. Marine Energy Mapping	4. Uses underwater sensors, drones, and remote sensing to map ocean energy potential

Select the correct answer using the codes below:

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

✓ **Correct Answer: (a) A-2, B-1, C-3, D-4**

**Brief Answer Key**

**A – Plasma Pulse Technology:** Correct – Uses **shockwaves to unclog oil-bearing rock pores**, enhancing oil recovery.

**B – Microbial Enhanced Oil Recovery:** Correct – Uses **microorganisms to improve oil extraction from reservoirs**.

**C – Enhanced Geothermal Systems:** Correct – **Engineers permeability in hot dry rocks** using modelling and stimulation techniques.

**D – Marine Energy Mapping:** Correct – Uses **underwater drones and sensors to assess ocean energy resources** such as tidal and wave energy.

Important developments relevant for exams:

- **Enhanced Geothermal Systems (EGS)** are gaining attention as a **next-generation geothermal technology** for regions lacking natural hydrothermal reservoirs.
- **Microbial Enhanced Oil Recovery (MEOR)** is considered a **low-cost and**

**environmentally friendly tertiary recovery method.**

- **Marine energy mapping** is important for identifying potential sites for **tidal, wave, and ocean thermal energy projects.**
- Technologies like **AI-based subsurface modelling and advanced seismic imaging** are increasingly used in energy exploration.

28. **With reference to Perovskite Solar Cells, consider the following statements:**

1. Perovskite solar cells are lightweight and can be fabricated on flexible substrates, enabling their use on a variety of surfaces.
2. These solar cells are relatively low-cost to manufacture but currently have lower efficiency than conventional silicon-based solar cells.
3. Perovskite-based photovoltaic technology is approaching commercial scalability and has demonstrated high efficiency, making it a promising next-generation solar technology.

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) 1 and 3 only**

**Brief Answer Key**

**Statement 1:** Correct – Perovskite solar cells can be **flexible, lightweight, and printable**, allowing deployment on diverse surfaces.

**Statement 2:** Incorrect – Although low-cost, **perovskite cells have achieved efficiencies comparable to or even higher than silicon in laboratory conditions.**

**Statement 3:** Correct – Rapid improvements in **efficiency and tandem-cell technology** are bringing them closer to commercialization.

29. **With reference to nickel resources and their role in modern battery technologies, consider the following statements:**

1. **Class 1 nickel**, which has high purity, is widely used in the manufacturing of lithium-ion batteries.

2. **Indonesia**, despite being the world's largest producer of nickel, continues to export a significant portion of its **raw nickel ore.**
3. **High Pressure Acid Leaching (HPAL)** is a processing method used to extract nickel from **laterite nickel ores.**

Which of the statements given above is/are correct?

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

**Correct Answer: (a) 1 and 3 only**

**Brief Answer Key**

**Statement 1:** Correct – **Class 1 nickel (≥99% purity)** is required for **EV battery cathodes such as NMC and NCA chemistries.**

**Statement 2:** Incorrect – Indonesia has **banned the export of raw nickel ore** to promote domestic refining and battery supply chains.

**Statement 3:** Correct – **HPAL technology** is commonly used to process **laterite nickel ores** to produce battery-grade nickel.

30. **With reference to Smart Grids in the power sector, consider the following statements:**

1. Smart grids integrate **digital communication technologies, sensors, and automated control systems** to improve the efficiency and reliability of electricity distribution.
2. They facilitate **two-way communication between electricity providers and consumers**, enabling demand-side management and real-time monitoring.
3. Smart grids eliminate the need for **renewable energy integration and decentralized power generation** by centralizing electricity supply.

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) 1 and 2 only**

### ■ Brief Answer Key

**Statement 1:** Correct – Smart grids use **digital technologies, sensors, and automation** to optimize electricity generation, transmission, and distribution.

**Statement 2:** Correct – They enable **two-way information and power flow**, allowing real-time monitoring and demand-response systems.

**Statement 3:** Incorrect – Smart grids actually **support integration of renewable energy and decentralized generation**, not eliminate them.

31. Match the following categories of energy storage technologies with their typical examples:

List I (Storage Type)	List II (Example)
A. Electrochemical Storage	1. Hydrogen storage
B. Mechanical Storage	2. Lithium-ion batteries
C. Thermal Storage	3. Pumped hydro and compressed air
D. Chemical Storage	4. Molten salt storage

Select the correct answer using the codes below:

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

✓ **Correct Answer: (a) A-2, B-3, C-4, D-1**

### ■ Brief Answer Key

- **A – Electrochemical:** Lithium-ion batteries store energy through chemical reactions.
- **B – Mechanical:** Pumped hydro and compressed air store energy as **mechanical potential energy**.
- **C – Thermal:** Molten salt stores **heat energy** for later electricity generation.
- **D – Chemical:** Hydrogen stores energy in **chemical bonds** for later use.

32. Match the following emerging energy technologies with their respective applications:

List I (Technology)	List II (Application)
A. Thermoacoustic Energy Storage	1. Converts temperature gradients into acoustic waves to generate or store energy
B. Microbial Fuel Cells (MFCs)	2. Generates electricity during wastewater treatment through microbial activity
C. Supercapacitors	3. High power density storage used in applications such as regenerative braking in electric vehicles
D. Sand Battery	4. Long-duration thermal energy storage used in district heating systems

Select the correct answer using the codes below:

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

✓ **Correct Answer: (a) A-1, B-2, C-3, D-4**

### ■ Brief Answer Key

**A – Thermoacoustic Energy Storage:**

Correct – Converts **heat gradients into acoustic energy**, a developing technology for energy conversion.

**B – Microbial Fuel Cells:** Correct – Produce **electricity through microbial metabolism during wastewater treatment**.

**C – Supercapacitors:** Correct – Provide **high power density and rapid charge-discharge**, useful in **EV regenerative braking systems**.

**D – Sand Battery:** Correct – Stores **thermal energy in heated sand**, enabling **long-duration heat storage for district heating**.

Recent developments improving exam relevance:

- **Sand batteries** have been piloted in **Finland** for storing surplus renewable heat for **district heating networks**.
- **Supercapacitors** are increasingly used in **hybrid vehicles, grid stabilization, and power backup systems**.
- **Microbial fuel cells** are explored for **waste-to-energy systems and sustainable wastewater treatment**.

33. Match the following energy storage technologies with their typical storage duration:

List I (Technology)	List II (Typical Duration)
A. Supercapacitors	1. Weeks to months
B. Batteries	2. Seconds
C. Pumped Hydro Storage	3. Minutes to hours
D. Hydrogen Energy Storage	4. Hours to days

Select the correct answer using the codes below:

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

✔ Correct Answer: (a) A-2, B-3, C-4, D-1

#### ☰ Brief Answer Key

**A – Supercapacitors:** Correct – Provide **very short-duration storage (seconds)** with extremely fast charge-discharge.

**B – Batteries:** Correct – Typically store energy for **minutes to hours**, suitable for EVs and grid balancing.

**C – Pumped Hydro Storage:** Correct – Provides **medium-duration storage (hours to days)**.

**D – Hydrogen Storage:** Correct – Enables **long-duration storage (weeks to months)**, useful for seasonal energy storage.

34. With reference to Fuel Cell technology, consider the following statements:

1. A fuel cell generates electricity through an **electrochemical reaction between hydrogen and oxygen** without combustion.
2. The only by-products of hydrogen fuel cells are **water and heat**.
3. Fuel cells require **external charging from the electricity grid** to operate.

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) 1 and 2 only

#### ☰ Brief Answer Key

- **Statement 1:** Correct – Fuel cells convert **chemical energy directly into electricity** via electrochemical reactions.
- **Statement 2:** Correct – Hydrogen fuel cells produce **water and heat as by-products**.
- **Statement 3:** Incorrect – Fuel cells generate electricity **as long as hydrogen fuel is supplied**, not by external charging.

35. With reference to unconventional hydrocarbon resources and their exploration in India, consider the following statements:

1. India's **National Gas Hydrate Program (NGHP)** has identified methane hydrate deposits in regions such as the **Krishna-Godavari Basin, Mahanadi Basin, and the Andaman Sea**.
2. Methane hydrates are considered a potential future energy resource because they contain **large quantities of methane trapped within ice-like crystalline structures**.
3. The extraction of **shale gas and tight oil** generally relies on technologies such as **horizontal drilling and hydraulic fracturing**.

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) 1, 2 and 3

#### ☰ Brief Answer Key

**Statement 1:** Correct – NGHP exploration has identified hydrate-bearing sediments in **KG Basin, Mahanadi Basin, and Andaman offshore region**.

**Statement 2:** Correct – Methane hydrates contain **vast methane reserves trapped in ice-like structures**, making them a potential future energy source.

**Statement 3:** Correct – **Hydraulic fracturing and horizontal drilling** are key technologies used to extract shale gas and tight oil from low-permeability rocks.

36. With reference to manganese and its role in modern battery technologies, consider the following statements:

1. **LMNO (Lithium Manganese Nickel Oxide)** and **LMFP (Lithium Manganese Iron Phosphate)** battery chemistries utilize manganese-rich cathode materials.
2. One of India's major manganese-producing regions is located in **Madhya Pradesh**, particularly around the **Balaghat belt**.
3. **High-Purity Manganese Sulphate (HPMSM)** is primarily used in the **anode** component of lithium-ion batteries.

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: (a) 1 and 2 only**

📖 **Brief Answer Key**

**Statement 1:** Correct – LMNO and LMFP batteries use **manganese-rich cathodes**, improving thermal stability and reducing reliance on cobalt.

**Statement 2:** Correct – **Balaghat (Madhya Pradesh)** is among India's major manganese-producing areas.

**Statement 3:** Incorrect – **High-Purity Manganese Sulphate is used in cathode materials**, not anodes.

37. Match the following minerals with their commonly used extraction or processing technique:

List I (Mineral)	List II (Extraction Method)
A. Lithium	1. Brine evaporation or hard-rock (spodumene) mining
B. Nickel	2. High Pressure Acid Leaching (HPAL)
C. Graphite	3. Open-pit or underground mining of carbon-rich ore
D. Rare Earth Elements	4. Chemical/solvent extraction from monazite or other rare-earth bearing minerals

Select the correct answer using the codes below:

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

✔ **Correct Answer: (a) A-1, B-2, C-3, D-4**

📖 **Brief Answer Key**

**A – Lithium:** Correct – Extracted from **salt-brine evaporation (Chile/Argentina)** or **hard-rock spodumene mining (Australia)**.

**B – Nickel:** Correct – Laterite nickel ores are commonly processed using **High Pressure Acid Leaching (HPAL)**.

**C – Graphite:** Correct – Typically mined through **open-pit or underground mining** of graphite-bearing rock.

**D – Rare Earth Elements:** Correct – Extracted through **chemical separation/solvent extraction from minerals such as monazite or bastnäsite**.

38. Which of the following best describes the functioning of a hydrogen fuel cell?

- (a) It stores electricity chemically inside rechargeable batteries.  
 (b) It generates electricity through an electrochemical reaction between hydrogen and oxygen.  
 (c) It produces electricity by burning hydrogen in an internal combustion engine.  
 (d) It converts solar energy into electrical energy using photovoltaic cells.

✔ **Correct Answer: (b)**

📖 **Brief Answer Key**

Hydrogen fuel cells generate electricity through an **electrochemical reaction between hydrogen and oxygen**, producing **electricity, water, and heat** without combustion.

39. Match the following battery types with their typical applications:

List I (Battery Type)	List II (Typical Application)
A. Lead-acid Battery	1. Flashlights and remote controls
B. Dry Cell Battery	2. Automobiles for starter batteries
C. Alkaline Battery	3. Household electronics and toys
D. Lithium-ion Battery	4. Electric vehicles and smartphones

E. Solid-state Battery	5. Next-generation EV and high-safety applications
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Select the correct answer using the codes below:

- (a) A-2, B-1, C-3, D-4, E-5
- (b) A-1, B-2, C-3, D-4, E-5
- (c) A-2, B-3, C-1, D-4, E-5
- (d) A-3, B-1, C-2, D-4, E-5

✔ **Correct Answer: (a) A-2, B-1, C-3, D-4, E-5**

#### 📄 Brief Answer Key

**A – Lead-acid:** Used in **automobile starter batteries**.

**B – Dry Cell:** Common in **flashlights and small portable devices**.

**C – Alkaline:** Used in **household electronics and toys**.

**D – Lithium-ion:** Dominant in **smartphones, laptops, and electric vehicles**.

**E – Solid-state:** Emerging **next-generation EV battery technology with higher safety**.

40. **Molten salt storage is a technology used in certain renewable energy systems to store energy in the form of heat. With reference to Molten Salt Energy Storage, consider the following statements:**

1. Molten salt storage is commonly used in **concentrated solar power (CSP) plants** to store thermal energy.
2. The stored heat can be used later to **generate electricity even when sunlight is not available**.
3. Molten salt storage primarily stores energy in the form of **electrical charge similar to batteries**.

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) 1 and 2 only**

#### Explanation

**Statement 1:** Correct – Molten salt storage is widely used in **Concentrated Solar Power plants**.

**Statement 2:** Correct – Stored thermal energy allows **electricity generation after sunset**.

**Statement 3:** Incorrect – It stores **thermal energy (heat)**, not electrical energy like batteries.

41. **With reference to Primary and Secondary batteries, consider the following statements:**

1. **Primary batteries** are designed for single use and cannot be recharged once their chemical energy is exhausted.
2. **Secondary batteries** can be recharged and used multiple times by reversing the electrochemical reactions.
3. Lead-acid batteries and lithium-ion batteries are examples of **primary batteries**.

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) 1 and 2 only**

#### 📄 Brief Answer Key

**Statement 1:** Correct – Primary batteries are **non-rechargeable**, e.g., zinc-carbon or alkaline dry cells.

**Statement 2:** Correct – Secondary batteries are **rechargeable**, e.g., lead-acid and lithium-ion batteries.

**Statement 3:** Incorrect – Lead-acid and lithium-ion are **secondary (rechargeable) batteries**, not primary batteries.

42. **Spodumene, Petalite, and Lepidolite are important ores of which one of the following minerals?**

- (a) Cobalt
- (b) Lithium
- (c) Manganese
- (d) Nickel

✔ **Correct Answer: (b) Lithium**

☰ **Brief Answer Key**

**Spodumene, Petalite, and Lepidolite** are **lithium-bearing minerals** commonly mined for lithium used in **lithium-ion batteries and energy storage technologies**.

43. **With reference to the chemical properties of Lithium, consider the following statements:**

1. Lithium is a soft metal that can be cut with a knife and has very low density.
2. Lithium is highly reactive and is therefore often stored under mineral oil.
3. Lithium occurs freely in nature in elemental form and is commonly found in native deposits.
4. Lithium is among the few metals that can float on water due to its very low density.

Which of the statements given above are correct?

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

✔ **Correct Answer: (a) 1, 2 and 4 only**

☰ **Brief Answer Key**

**Statement 1:** Correct – Lithium is **soft and has very low density** among metals.

**Statement 2:** Correct – It is **highly reactive and flammable**, hence stored in **mineral oil**.

**Statement 3:** Incorrect – Lithium **does not occur freely in nature**; it exists in **combined forms such as minerals and brines**.

**Statement 4:** Correct – Lithium can **float on water due to its low density**, similar to sodium and potassium.

44. **Erythrite, Glaucodot, Skutterudite, Carrollite, Linnaeite, and Asbolite** are **important ores of which one of the following minerals?**

- (a) Nickel  
(b) Cobalt  
(c) Manganese  
(d) Lithium

✔ **Correct Answer: (b) Cobalt**

☰ **Brief Answer Key**

**Erythrite, Glaucodot, Skutterudite, Carrollite, Linnaeite, and Asbolite** are **cobalt-bearing minerals** commonly associated with **nickel-copper deposits** and are important sources of cobalt used in **battery cathodes, superalloys, and industrial catalysts**.

45. **With reference to critical minerals important for the global energy transition, consider the following statements:**

1. Elements such as **neodymium, lithium, cobalt, and vanadium** play an important role in technologies related to renewable energy and electric mobility.
2. Rare earth elements are widely used in the manufacture of **permanent magnets used in wind turbines and electric vehicle motors**.
3. The growing importance of critical minerals is expected to shift global geopolitics from **oil-producing economies to mineral-rich economies**.

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) 1, 2 and 3**

☰ **Brief Answer Key**

**Statement 1:** Correct – Minerals like **lithium, cobalt, vanadium, and rare earth elements** are essential for **batteries, EVs, and renewable energy technologies**.

**Statement 2:** Correct – Rare earth elements such as **neodymium and dysprosium** are used in **high-performance permanent magnets** for wind turbines and EV motors.

**Statement 3:** Correct – Energy transition is shifting geopolitical focus from **oil resources to critical mineral supply chains**.

46. **With reference to nuclear fission and uranium enrichment, consider the following statements:**

1. **Critical mass** refers to the minimum quantity of fissile material required to sustain a self-sustaining nuclear chain reaction.

- Weapon-grade uranium** generally contains uranium enriched to about **90% or more of the isotope U-235**.
- Nuclear power reactors typically use **low-enriched uranium**, usually enriched to about **3–5% U-235**.
- Uranium found in nature contains **more than 50% of the fissile isotope U-235**.

Which of the statements given above are correct?

- 1, 2 and 3 only
- 1 and 2 only
- 2, 3 and 4 only
- 1, 2, 3 and 4

**Correct Answer: (a) 1, 2 and 3 only**

#### **Brief Answer Key**

**Statement 1:** Correct – **Critical mass** is the minimum amount of fissile material needed to maintain a **self-sustaining chain reaction**.

**Statement 2:** Correct – **Weapon-grade uranium** typically contains  $\geq 90\%$  **U-235**.

**Statement 3:** Correct – Most civilian nuclear reactors use **low-enriched uranium (3–5% U-235)**.

**Statement 4:** Incorrect – Natural uranium contains **only about 0.7% U-235**, with most being **U-238 (~99.3%)**.

**47. With reference to Vanadium Redox Flow Batteries (VRFB), consider the following statements:**

- In a Vanadium Redox Flow Battery, energy is stored in **liquid electrolytes containing vanadium ions kept in external tanks**.
- The energy storage capacity of such batteries can be increased by **increasing the volume of electrolyte stored in the tanks**.
- These batteries are primarily designed for **short-duration energy storage in small portable electronic devices**.

Which of the statements given above is/are correct?

- 1 and 2 only
- 2 only
- 1 and 3 only
- 1, 2 and 3

**Correct Answer: (a) 1 and 2 only**

#### **Definition: Flow Battery**

A **Flow Battery** is an electrochemical energy storage system in which **energy is stored in liquid electrolytes kept in external tanks**

**and circulated through an electrochemical cell during charging and discharging.**

Unlike conventional batteries, the **energy capacity depends on the size of the electrolyte tanks**, while the **power output depends on the cell stack**, making them suitable for **large-scale grid energy storage**

#### **Explanation**

**Statement 1:** Correct – VRFB stores energy in **vanadium-based liquid electrolytes circulated between external tanks and electrochemical cells**.

**Statement 2:** Correct – The storage capacity can be increased simply by **increasing electrolyte tank size**, making it scalable for grid storage.

**Statement 3:** Incorrect – Flow batteries are mainly used for **large-scale stationary energy storage**, not portable electronics.

**48. With reference to Sodium-ion batteries, consider the following statements:**

- Sodium-ion batteries use **sodium ions instead of lithium ions as the charge carrier** during electrochemical reactions.
- Sodium is **more abundant and widely available in nature** compared to lithium.
- Sodium-ion batteries currently have **higher energy density than lithium-ion batteries**, making them the dominant technology for electric vehicles.

Which of the statements given above is/are correct?

- 1 and 2 only
- 2 only
- 1 and 3 only
- 1, 2 and 3

**Correct Answer: (a) 1 and 2 only**

#### **Brief Answer Key**

**Statement 1:** Correct – Sodium-ion batteries operate similarly to lithium-ion batteries but use **sodium ions for charge transfer**.

**Statement 2:** Correct – Sodium is **abundant and inexpensive**, often derived from common salts.

**Statement 3:** Incorrect – Sodium-ion batteries generally have **lower energy density than lithium-ion batteries**, though

they are cheaper and suitable for grid storage.

49. **With reference to India's participation in international nuclear and weapons control frameworks, consider the following statements:**

1. India is a member of the **Missile Technology Control Regime (MTCR)** and the **Wassenaar Arrangement**.
2. India is a member of the **Nuclear Suppliers Group (NSG)**.
3. India is a signatory to both the **Biological Weapons Convention (BWC)** and the **Chemical Weapons Convention (CWC)**.
4. India is not a signatory to the **Nuclear Non-Proliferation Treaty (NPT)** and the **Comprehensive Nuclear-Test-Ban Treaty (CTBT)**.

Which of the statements given above are correct?

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

✓ **Correct Answer: (a) 1, 3 and 4 only**

EXPLANATION

**Statement 1:** Correct – India is a member of **MTCR (2016)** and **Wassenaar Arrangement (2017)**.

**Statement 2:** Incorrect – India is **not yet a member of the Nuclear Suppliers Group (NSG)**.

**Statement 3:** Correct – India is a signatory to **BWC (1974)** and **CWC (1996)**.

**Statement 4:** Correct – India has **not signed NPT and CTBT**, citing concerns about discriminatory nuclear regimes.

50. **With reference to India's Three-Stage Nuclear Power Programme, consider the following statements:**

1. The first stage uses **Pressurized Heavy Water Reactors (PHWRs)** fueled by natural uranium to produce electricity and plutonium.
2. The second stage involves **Fast Breeder Reactors (FBRs)** that use plutonium and produce fissile material such as **U-233 from thorium**.
3. The third stage is designed to utilize **thorium-based fuel cycles**, with U-

233 acting as the primary fissile material.

Which of the statements given above are correct?

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

✓ **Correct Answer: (c) 1, 2 and 3**

EXPLANATION

**Statement 1:** Correct – **PHWRs using natural uranium** produce plutonium as a by-product.

**Statement 2:** Correct – **Fast Breeder Reactors** use plutonium fuel and help convert **thorium into U-233**.

**Statement 3:** Correct – The final stage uses **thorium-based reactors fueled by U-233**, exploiting India's large thorium reserves.

## AGRICULTURE

1. Match the following cultivation systems with their characteristics and typical applications:

List I (System)	List II (Principle)	List III (Common Application)
A. Hydroponics	1. Plants grown in nutrient-rich water without soil	a. Urban vertical farming
B. Aquaponics	2. Integrated system combining fish farming and plant cultivation	b. Circular food production systems
C. Aeroponics	3. Plant roots suspended in air and misted with nutrient solution	c. High-efficiency controlled environment agriculture
D. Geoponics	4. Traditional cultivation using soil as the growth medium	d. Conventional agriculture
E. Fogponics	5. Nutrients delivered to plant roots through ultra-fine nutrient fog	e. Advanced plant propagation and research

Select the correct answer using the code below:

- (a) A-1-a, B-2-b, C-3-c, D-4-d, E-5-e  
 (b) A-2-a, B-1-b, C-3-c, D-4-d, E-5-e  
 (c) A-1-b, B-2-a, C-4-c, D-3-d, E-5-e  
 (d) A-1-a, B-3-b, C-2-c, D-4-d, E-5-e

✓ **Correct Answer: (a)**

### ☰ Brief Answer Key

**Hydroponics:** Plants grown **without soil using nutrient solution**; widely used in **urban vertical farming**.

**Aquaponics:** Combines **aquaculture (fish farming) with hydroponics**, forming a **closed-loop ecosystem**.

**Aeroponics:** Plant roots **hang in air and receive nutrient mist**, enabling **high oxygen availability and rapid growth**.

**Geoponics:** **Traditional soil-based agriculture**.

**Fogponics:** Advanced form of aeroponics where **nutrients are delivered as ultra-fine fog**, improving nutrient absorption.

☐ **Aeroponics and hydroponics** have been promoted in India through **ICAR and urban farming initiatives**.

☐ **Aquaponics** is increasingly discussed under **sustainable and circular agriculture models**.

☐ **Fogponics** is emerging in **space agriculture and high-tech greenhouse farming**, making it a potential **future technology for controlled agriculture systems**.

2. With reference to emerging bio-based materials and technologies, consider the following statements:

**1. Bioplastics** are plastics derived wholly or partly from renewable biomass such as corn starch, sugarcane, or cellulose.

**2. Bio-olefins** are hydrocarbon molecules produced from biological feedstocks and can serve as building blocks for polymers and chemicals.

**3. Biochar** is produced by pyrolysis of biomass in limited oxygen and is widely used for improving soil fertility and carbon sequestration.

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) 1, 2 and 3**

### ☰ Brief Answer Key

**Statement 1:** Correct – **Bioplastics** are made from renewable biological sources and are promoted to reduce dependence on fossil-fuel plastics.

**Statement 2:** Correct – **Bio-olefins** (such as bio-ethylene and bio-propylene) are produced from **bio-ethanol or biomass feedstocks** and used in green chemical industries.

**Statement 3:** Correct – **Biochar** is produced via **pyrolysis of biomass** and helps in **soil improvement, water retention, and carbon sequestration**.

3. With reference to **Zero Budget Natural Farming (ZBNF)**, consider the following pairs:

<b>Input</b>	<b>Primary Use</b>
1. Jeevamrut	(a) Liquid bio-activator to enrich soil microbes
2. Beejamrut	(b) Seed treatment to protect against fungal and pest infections
3. <b>Ghanjeevamrut</b>	(c) Solid microbial compost used as a soil amendment

Answer: D. 1, 2 and 3

**Explanation:**

- **Jeevamrut:** A fermented microbial **liquid** preparation made using cow dung, cow urine, jaggery, gram flour, and soil. Used to **boost microbial activity** in the soil.
- **Beejamrut:** Used for **seed treatment**, protecting against seed-borne diseases and enhancing germination.
- **Ghanjeevamrut:** A **solid form** of Jeevamrut, used as **soil amendment** or mixed with compost for field application.

4. With reference to plant-based feedstocks explored for biodiesel production in India, consider the following pairs:

<b>Plant Species</b>	<b>Characteristic / Relevance for Biodiesel</b>
1. <i>Jatropha curcas</i>	Traditional non-edible oilseed plant promoted for biodiesel production
2. <i>Pongamia pinnata</i> (Karanja)	Leguminous tree producing oil-rich seeds used in biofuel
3. Castor ( <i>Ricinus communis</i> )	Oil extracted but rarely preferred for biodiesel due to high ricinoleic acid content
4. Neem ( <i>Azadirachta indica</i> )	Oil with pesticidal properties that has also been explored as a biofuel source

**Which of the pairs given above are correctly matched?**

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

✓ **Correct Answer: (d) 1, 2, 3 and 4**

**EXPLANATION**

- 1. Jatropha curcas:** Correct — Non-edible oilseed widely promoted under India’s early **National Biodiesel Mission**.
- 2. Pongamia pinnata:** Correct — Oil-bearing **leguminous tree (Karanja)** used for biodiesel and sustainable biofuel plantations.
- 3. Castor (Ricinus communis):** Correct — Castor oil can be processed but is **less preferred for biodiesel due to ricinoleic acid and industrial uses**.
- 4. Neem (Azadirachta indica):** Correct — Neem oil is mainly pesticidal but **research has explored it as a biodiesel feedstock**.

- India’s **National Biofuel Policy (2018, amended 2022)** promotes **non-edible oilseeds for biodiesel**.
- Major potential feedstocks discussed in policy and research include **Jatropha, Pongamia, Mahua, Neem, and Castor**.
- India is simultaneously expanding **ethanol blending (E20 target by 2025–26)** alongside biodiesel development.

5. With reference to **Biofloc Technology (BFT)** used in aquaculture, consider the following statements:

1. Biofloc technology utilizes microorganisms to **convert toxic nitrogenous wastes such as ammonia into microbial biomass**, which can serve as a protein source for aquatic species.
2. Biofloc systems operate with **low aeration requirements and are best suited for low-density aquaculture systems**.
3. The adoption of BFT can **reduce dependence on commercial fish feed and improve sustainability in intensive inland aquaculture**.

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) 1 and 3 only**

📄 **Brief Answer Key**

**Statement 1:** Correct — BFT converts **ammonia and other nitrogenous wastes**

into microbial protein through bacterial activity.

**Statement 2:** Incorrect — Biofloc systems require **continuous aeration and are usually used in high-density aquaculture systems.**

**Statement 3:** Correct — Microbial flocs serve as **supplementary feed**, reducing the need for commercial feed and enhancing sustainability.

**6. With reference to the Minimum Support Price (MSP) system in India, consider the following statements:**

1. The Government of India announces MSPs for **22 mandated crops** based on the recommendations of the **Commission for Agricultural Costs and Prices (CACP).**
2. The mandated crops include **14 Kharif crops, 6 Rabi crops, and 2 commercial crops.**
3. MSP for **toria and de-husked coconut** is fixed independently and is not linked to the MSP of any other crop.

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

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 **Correct Answer: (a) 1 and 2 only**

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#### **Brief Answer Key**

**Statement 1:** Correct – MSP is announced for **22 mandated crops** based on recommendations of **CACP**, after consultations with states and ministries.

**Statement 2:** Correct – These include **14 Kharif crops, 6 Rabi crops, and 2 commercial crops (jute and copra).**

**Statement 3:** Incorrect – MSP for **toria and de-husked coconut** are derived from the **MSP of rapeseed & mustard and copra respectively**, not fixed independently.

**7. With reference to the cultivation and trade of groundnut (peanut) in India, consider the following statements:**

1. Groundnut in India is predominantly cultivated as a **Kharif crop**, though it is also grown in the Rabi and summer seasons in certain regions.
2. **Gujarat is the largest producer of groundnut in India**, followed by states such as Rajasthan, Tamil Nadu, and Andhra Pradesh.
3. India is among the **major exporters of groundnut and groundnut oil**, supplying markets in Southeast Asia and Europe.

Which of the statements given above are correct?

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

 **Correct Answer: (d) 1, 2 and 3**

#### **Brief Answer Key**

**Statement 1:** Correct – Groundnut is mainly a **Kharif oilseed crop**, though **Rabi and summer cultivation occurs in irrigated areas.**

**Statement 2:** Correct – **Gujarat leads groundnut production** in India.

**Statement 3:** Correct – India exports **groundnut kernels and processed products**, including oil, to several international markets.

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#### **UPSC-Relevant Updates (Strengthening the Question)**

- Groundnut is one of the **major oilseed crops in India**, important under the **National Mission on Edible Oils–Oilseeds (NMEO–Oilseeds).**
- India is among the **largest producers of groundnut globally**, with **China and India leading production.**
- Groundnut products exported from India include **kernels, oil, roasted peanuts, and peanut butter**, contributing to agricultural export earnings.

8. With reference to the Food Corporation of India (FCI), consider the following statements:

1. The Food Corporation of India was established under the **Food Corporations Act, 1964**.
2. One of the primary responsibilities of FCI is to **procure foodgrains and maintain buffer stocks on behalf of the Government of India**.
3. FCI plays a key role in implementing the **National Food Security Act, 2013** by supplying foodgrains for distribution through the **Public Distribution System (PDS)**.

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) 1, 2 and 3**

📄 **Brief Answer Key**

**Statement 1:** Correct — FCI was established in **1965 under the Food Corporations Act, 1964**, not under the Essential Commodities Act.

**Statement 2:** Correct — FCI **procures foodgrains at MSP and maintains buffer stocks** to ensure food security.

**Statement 3:** Correct — FCI supplies grains to states for distribution under the **Public Distribution System (PDS) under NFSA, 2013**.

9. With reference to the phenomenon termed “Dark Oxygen”, consider the following statements:

1. “Dark oxygen” refers to the production of oxygen **in the absence of sunlight**, particularly in deep-sea environments.
2. It is believed to occur through **chemical or microbial processes associated with deep-sea minerals**, contributing to oxygen availability in deep-ocean ecosystems.
3. The production of dark oxygen primarily occurs through **photosynthesis driven by sunlight**.

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: (a) 1 and 2 only**

📄 **Brief Answer Key**

**Statement 1:** Correct — Dark oxygen refers to **oxygen generation without sunlight**, recently observed in deep-sea environments.

**Statement 2:** Correct — It is associated with **electrochemical or microbial reactions around polymetallic nodules on the ocean floor**.

**Statement 3:** Incorrect — Dark oxygen is **not produced through photosynthesis**, which requires sunlight.

10. With reference to cotton production and trade in India, consider the following statements:

1. India is among the **largest producers of cotton in the world** and has the largest area under cotton cultivation.
2. The **Cotton Corporation of India (CCI)** undertakes procurement operations to support farmers when market prices fall below the **Minimum Support Price (MSP)**.
3. India exports a significant share of its cotton mainly to **countries such as Bangladesh, Vietnam, and China**.

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) 1, 2 and 3**

📄 **Brief Answer Key**

**Statement 1:** Correct — India is **one of the largest cotton producers globally** and has the **largest area under cotton cultivation**.

**Statement 2:** Correct — The **Cotton Corporation of India (CCI)** procures cotton under the **MSP mechanism** to stabilize prices.

**Statement 3:** Correct — Major export destinations include **Bangladesh, Vietnam, and China**, which have large textile industries.

11. With reference to the cultivation and production of Masur (lentil) in India, consider the following statements:

1. Masur, being a leguminous crop, helps **fix atmospheric nitrogen and improves soil fertility**.
2. India is **fully self-sufficient in lentil production** and does not depend on imports to meet domestic demand.
3. **Uttar Pradesh is among the leading producers of lentils** in India.

Which of the statements given above are correct?

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

✔ **Correct Answer: (a) 1 and 3 only**

📄 **Brief Answer Key**

**Statement 1:** Correct — Lentils are **leguminous crops capable of nitrogen fixation**, which enhances soil fertility.

**Statement 2:** Incorrect — India **still imports pulses**, including lentils, from countries such as **Canada and Australia** to meet domestic demand.

**Statement 3:** Correct — **Uttar Pradesh is one of the major lentil-producing states**, along with **Madhya Pradesh and Bihar**.

12. With reference to certain plantation crops in India, consider the following pairs:

Crop	Associated Detail
1. Rubber	Regulated by the Rubber Board headquartered in Kottayam, Kerala
2. Arecanut	Predominantly cultivated in the coastal and hilly regions of Karnataka and Kerala
3. Cocoa	Commonly grown as an intercrop under coconut plantations in states such as Kerala, Tamil Nadu, and Andhra Pradesh

Which of the pairs given above are correctly matched?

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

✔ **Correct Answer: (d) 1, 2 and 3**

📄 **Brief Answer Key**

**Pair 1:** Correct — The **Rubber Board**, functioning under the Ministry of Commerce & Industry, is headquartered in **Kottayam, Kerala**, and regulates the rubber sector.

**Pair 2:** Correct — **Karnataka and Kerala** are major producers of arecanut, cultivated mainly in **coastal and hilly regions with high rainfall**.

**Pair 3:** Correct — **Cocoa is typically cultivated as an intercrop**, especially under **coconut and arecanut plantations** in southern states.

- **Rubber production in India** is concentrated mainly in **Kerala and the North-East (Tripura, Assam, Meghalaya)** due to expansion policies.
- **Cocoa cultivation** has grown under **integrated plantation systems** supported by the **National Horticulture Mission**.
- **Arecanut** production is dominated by **Karnataka**, which contributes **over 60% of India's output**.

13. With reference to recent trends in India's maize sector, consider the following statements:

1. In recent years, India has **shifted from being a net exporter to a net importer of maize** due to rising domestic demand.
2. The **poultry feed industry and ethanol blending programme** have significantly increased the domestic demand for maize.
3. India's maize exports have **risen sharply in the recent past**, increasing by more than 50% in the last year.

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) 1 and 2 only**

📄 **Brief Answer Key**

**Statement 1:** Correct — India has **recently imported maize** due to supply constraints and rising domestic demand.

**Statement 2:** Correct — Demand from **poultry feed and ethanol production** has increased maize consumption.

**Statement 3:** Incorrect — **Exports have declined**, not increased, due to higher domestic demand and tighter supplies.

14. Consider the following pairs regarding **jute cultivation and trade**:

1. Major producing state — West Bengal
2. Key importing country of Indian raw jute — Bangladesh
3. Major application — Gunny bags and eco-friendly packaging
4. Crop season — Kharif

How many of the above pairs are correctly matched?

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

✔ **Correct Answer: (d) All four pairs**

■ **Brief Answer Key**

**Pair 1:** Correct — **West Bengal is the largest producer of jute in India.**

**Pair 2:** Correct — **Bangladesh imports raw jute from India** for its jute industry.

**Pair 3:** Correct — Jute is widely used in **gunny bags, ropes, carpets, and biodegradable packaging.**

**Pair 4:** Correct — Jute is a **Kharif crop**, grown mainly in the **monsoon season.**

15. With reference to **Toria cultivation in India**, consider the following statements:

1. Toria is an **early-maturing variety of rapeseed-mustard**, typically grown during the **Rabi season.**
2. Toria cultivation is encouraged in **rainfed and low-irrigation regions**, including certain tribal and marginal farming areas.
3. Toria is often **sown immediately after the harvest of Kharif crops such as paddy** to make use of residual soil moisture.

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) 1, 2 and 3**

■ **Brief Answer Key**

**Statement 1:** Correct — Toria is a **short-duration rapeseed-mustard crop**, usually maturing in about **60–90 days.**

**Statement 2:** Correct — It is suitable for **low-input and rainfed farming systems**, making it useful for marginal areas.

**Statement 3:** Correct — Toria is often **grown after Kharif crops using residual moisture**, especially in eastern and northeastern India.

□ Toria is included under **rapeseed-mustard oilseed crops**, important for India's **National Mission on Edible Oils – Oilseeds (NMEO-OS).**

□ It is widely cultivated in **Assam, West Bengal, Bihar, Uttar Pradesh, and parts of Odisha** as a **short-duration oilseed crop** that fits into intensive cropping systems.

16. With reference to **tobacco cultivation and regulatory mechanisms in India**, consider the following statements:

1. India is among the **leading producers and exporters of tobacco in the world**, particularly of **Flue-Cured Virginia (FCV) tobacco.**
2. The **Tobacco Board of India**, responsible for regulating tobacco production and export of FCV tobacco, functions under the **Ministry of Commerce and Industry.**
3. **Andhra Pradesh is the largest producer of Flue-Cured Virginia (FCV) tobacco** in India.

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) 1, 2 and 3**

■ **Brief Answer Key**

**Statement 1:** Correct — India is among the **top global producers and exporters of tobacco**, especially **FCV tobacco** used in cigarettes.

**Statement 2:** Correct — The **Tobacco Board (established under the Tobacco Board Act, 1975)** functions under the **Ministry of Commerce & Industry**, not the Ministry of Health.

**Statement 3:** Correct — **Andhra Pradesh is the largest producer of FCV tobacco** in India, followed by **Karnataka**.

**17. With reference to palm oil production and policy initiatives in India, consider the following statements:**

1. India is the **largest importer of palm oil in the world**, sourcing the bulk of its imports mainly from **Indonesia and Malaysia**.
2. The **National Mission on Edible Oils – Oil Palm (NMEO-OP)** was launched to expand domestic oil palm cultivation and **reduce India's dependence on edible oil imports**.
3. Oil palm cultivation in India is **restricted only to coastal regions** because the crop cannot grow in inland areas or higher altitudes.

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) 1 and 2 only**

#### **Brief Answer Key**

**Statement 1:** Correct — India is the **largest global importer of palm oil**, mainly sourcing from **Indonesia and Malaysia**.

**Statement 2:** Correct — **NMEO-OP (launched in 2021)** aims to **expand oil palm area**, particularly in the **North-Eastern states and Andaman & Nicobar Islands**, to reduce edible oil import dependence.

**Statement 3:** Incorrect — Oil palm is **not limited to coastal regions**; it can also be cultivated in **suitable inland tropical regions** with adequate rainfall/irrigation.

- India imports **over 55–60% of its edible oil requirement**, with palm oil forming a major share.
- Under **NMEO-OP**, the government is promoting oil palm in **Northeast India and the Andaman & Nicobar Islands** due to favourable agro-climatic conditions.
- Oil palm is considered the **highest oil-yielding oilseed crop per hectare** globally.

**18. With reference to sugarcane cultivation and pricing mechanisms in India, consider the following statements:**

1. Sugarcane is a **long-duration crop** that requires **high water availability and significant fertilizer inputs**.
2. India is the **largest exporter of raw sugar in the world**.
3. The **Fair and Remunerative Price (FRP)** for sugarcane is **announced annually by the Central Government** on the recommendation of the **Commission for Agricultural Costs and Prices (CACP)**.

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) 1 and 3 only**

#### **Brief Answer Key**

**Statement 1:** Correct — Sugarcane is a **water-intensive crop** with a growing period of **10–18 months**, requiring high nutrient inputs.

**Statement 2:** Incorrect — While India is among the **largest sugar producers**, **Brazil is the largest exporter of raw sugar globally**.

**Statement 3:** Correct — The **FRP for sugarcane is fixed annually by the Central Government** based on **CACP recommendations**.

- Major sugarcane-producing states include **Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Gujarat**.
- Sugarcane is linked to **ethanol production under the Ethanol Blending Programme (EBP)** aimed at **20% ethanol blending by 2025–26**.

19. With reference to **Integrated Multi-Trophic Aquaculture (IMTA)**, consider the following statements:

1. IMTA involves cultivating species from different trophic levels in the same system to improve resource efficiency.
2. In IMTA systems, waste produced by one species serves as input (food or fertilizer) for another.
3. IMTA is widely adopted in freshwater ecosystems, especially in high-altitude cold-water lakes of northern India.

Which of the statements given above is/are correct?

**Options:** A. 1 and 2 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3

Correct Answer: A. 1 and 2 only

**Explanation:**

- **Statement 1 is correct:** IMTA integrates multiple species from **different trophic levels** — for example, **finfish, shellfish, and seaweed** — to use nutrients more efficiently.
- **Statement 2 is correct:** Waste from fed species (e.g., fish) is consumed or absorbed by **extractive species** (e.g., mollusks or seaweed), reducing environmental impact.
- **Statement 3 is incorrect:** IMTA is more common in **marine and coastal aquaculture**, not in **cold, high-altitude freshwater ecosystems**.

20. With reference to the **colour-based classification of hydrogen according to production pathways**, consider the following pairs:

Hydrogen Type	Production Method
1. Green Hydrogen	Produced through electrolysis of water using electricity generated from renewable energy sources
2. Blue Hydrogen	Produced from natural gas through steam methane reforming with carbon capture, utilisation and storage (CCUS)
3. Grey Hydrogen	Produced from fossil fuels such as natural gas through steam methane reforming without carbon capture
4. Pink Hydrogen	Produced through electrolysis of water using

	electricity generated from nuclear power
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Which of the pairs given above are correctly matched?

**Options**

- 1 and 2 only
- 1, 2 and 3 only
- 1, 3 and 4 only
- 1, 2, 3 and 4

**Correct Answer**

**D. 1, 2, 3 and 4**

Hydrogen Type	Explanation
<b>Green Hydrogen</b>	Produced using renewable electricity (solar, wind, hydro) for electrolysis of water; considered the cleanest form.
<b>Blue Hydrogen</b>	Derived from natural gas but emissions are captured through <b>Carbon Capture, Utilisation and Storage (CCUS)</b> .
<b>Grey Hydrogen</b>	Conventional hydrogen produced from fossil fuels without capturing CO <sub>2</sub> ; currently the most widely produced type globally.
<b>Pink Hydrogen</b>	Produced via electrolysis powered by <b>nuclear energy</b> .

Recent discussions in energy policy include additional hydrogen categories:

Hydrogen Type	Production Source
<b>Turquoise Hydrogen</b>	Produced via methane pyrolysis producing solid carbon instead of CO <sub>2</sub>
<b>Yellow Hydrogen</b>	Produced using electricity from mixed grid sources
<b>Brown/Black Hydrogen</b>	Produced from coal gasification

21. With reference to **Methane Hydrates**, consider the following statements:

1. Methane hydrates are crystalline solids in which methane molecules are trapped within a lattice of water ice under low temperature and high-pressure conditions.
2. They are found abundantly in deep ocean sediments and permafrost regions.

3. India has commercially exploited methane hydrates as a clean energy source since 2020.

Which of the statements given above is/are correct?

**Options:** A. 1 and 2 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3

Answer: A. 1 and 2 only

Explanation:

- **Statement 1 is correct:** Methane hydrates (also called **fire ice**) are **solid clathrate compounds** formed under **low temperature and high pressure**, where **methane gas is trapped** in a cage of water molecules.

- **Statement 2 is correct:** They are typically found in **deep-sea sediments** and **permafrost** regions — such as off the coast of **Japan, India, and the Arctic**.

- **Statement 3 is incorrect:** While India has **identified large reserves** (notably in the Krishna-Godavari Basin), **commercial extraction has not yet started** due to technological and environmental concerns.

22. With reference to **Coffee cultivation in India**, consider the following statements:

1. India primarily grows Arabica coffee, which is known for its mild flavor and is shade-grown.

2. Karnataka is the largest coffee-producing state in India, followed by Kerala and Tamil Nadu.

3. Robusta coffee has a higher caffeine content than Arabica and is mainly exported to West Asian countries.

Which of the statements given above is/are correct?

**Options:** A. 1 and 2 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3

Answer: D. 1, 2 and 3

Explanation:

- **Statement 1 is correct:** Arabica is milder, shade-grown, and cultivated in **cooler, higher-altitude** regions.

- **Statement 2 is correct:** Karnataka produces over **60%** of India's coffee, followed by **Kerala and Tamil Nadu**.

- **Statement 3 is correct:** Robusta contains **more caffeine** and is hardier, with significant exports to **West Asia and Europe**.

23. With reference to statutory **commodity boards** in India, consider the following statements:

1. The **Tea Board of India** is a statutory body under the Ministry of Commerce and Industry and is headquartered in Kolkata.

2. The **Coffee Board of India** functions under the Ministry of Agriculture and Farmers' Welfare and regulates coffee production and export.

3. Both boards are responsible for research, extension, and promotion of their respective commodities in domestic and international markets.

Which of the statements given above is/are correct?

**Options:** A. 1 and 2 only B. 1 and 3 only C. 2 and 3 only D. 1, 2 and 3

Answer: B. 1 and 3 only

Explanation:

- **Statement 1 is correct:** The **Tea Board of India**, established under the **Tea Act, 1953**, functions under the **Ministry of Commerce & Industry** and is headquartered in **Kolkata**.

- **Statement 2 is incorrect:** The **Coffee Board** is also under the **Ministry of Commerce & Industry**, not Agriculture.

- **Statement 3 is correct:** Both boards engage in **research, development, promotion, quality assurance, and export facilitation**.

24. With reference to the **Essential Commodities Act, 1955**, consider the following statements:

1. The Act empowers the **Central Government to regulate the production, supply, and distribution of certain commodities** to ensure their availability at fair prices.

2. Under the **Essential Commodities (Amendment) Act, 2020**, stock limits on agricultural commodities can be imposed only under extraordinary circumstances such as war, famine, or a sharp rise in prices.

3. The Act permanently lists commodities such as **cereals, pulses, edible oils, fertilizers, and petroleum products** as essential commodities that cannot be removed from the schedule.

Which of the statements given above is/are correct?

**Options:**

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

**Correct Answer: (b) 1 and 2 only**

### EXPLANATION

**Statement 1:** Correct — The Act allows the government to **control production, supply, storage, and distribution** of essential commodities to prevent hoarding and black marketing.

**Statement 2:** Correct — The **2020 amendment** restricts stock limits to **extraordinary situations** such as war, famine, natural calamities, or steep price rise.

**Statement 3:** Incorrect — The list of essential commodities **is not permanent**; the government can **add or remove items from the schedule**.

The **Essential Commodities (Amendment) Act, 2020** was part of the **three farm laws**, aimed at reducing excessive regulatory controls on agricultural markets.

Although **two farm laws were repealed in 2021**, the **ECA amendment provisions relating to stock limits continue to remain relevant in policy discussions**.

**25. With reference to India's rice production and export policy in recent years, consider the following statements:**

1. India's public rice stocks held with government agencies reached **more than 60 million tonnes around early 2025**, reflecting comfortable buffer availability.
2. The Government of India **lifted the ban on non-basmati white rice exports in 2024**, replacing it initially with a **Minimum Export Price (MEP) mechanism**.
3. India accounts for **less than one-fifth of global rice exports**.

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) 1 and 2 only**

### **Brief Answer Key (with Current Context)**

**Statement 1:** Correct – Government foodgrain stocks (with **FCI and other agencies**) crossed **~60 million tonnes in early 2025**, indicating comfortable reserves.

**Statement 2:** Correct – India **partially lifted the ban on non-basmati white rice exports in 2024**, initially replacing it with a **Minimum Export Price (MEP)** policy before further easing restrictions.

**Statement 3:** Incorrect – India is the **world's largest rice exporter and Rice producer ( In 2026, India surpassed China production )**

**26. With reference to Makhana (Fox Nut), consider the following statements:**

1. Makhana is obtained from the seeds of the aquatic plant **Euryale ferox**.
2. India is the **largest producer of makhana**, with Bihar accounting for the majority of production.
3. Makhana cultivation requires **saline coastal soil conditions** similar to mangrove ecosystems.

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) 1 and 2 only**

### **Brief Answer Key**

- **Statement 1:** Correct – Makhana comes from **Euryale ferox**, an aquatic plant grown in ponds and wetlands.
- **Statement 2:** Correct – **Bihar produces around 80–90% of India's makhana**.
- **Statement 3:** Incorrect – It grows in **freshwater ponds and wetlands**, not saline coastal soils.

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

27. With reference to the recently proposed Makhana Board in India, consider the following statements:

1. The Government of India has proposed a **Makhana Board in Bihar** to promote the production, processing, and export of makhana.
2. The board aims to support **farmers through value addition, branding, and market linkages**.
3. The initiative is primarily implemented under the **Marine Products Export Development Authority (MPEDA)**.

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: (a) 1 and 2 only**

**Brief Answer Key**

- **Statement 1:** Correct – The **Union Budget 2025–26** announced the establishment of a **Makhana Board in Bihar**.
- **Statement 2:** Correct – It aims to **improve value chains, processing, branding, and export promotion**.
- **Statement 3:** Incorrect – The board is **not under MPEDA**; it is meant to support **agriculture and food processing sectors**.

28. With reference to the cultivation and trade of Jowar (Sorghum) in India, consider the following statements:

1. **Maharashtra is the largest producer of jowar in India**, followed by states such as Karnataka and Madhya Pradesh.
2. India has witnessed a **noticeable decline in jowar exports in recent years**, partly due to higher domestic consumption and price fluctuations.
3. Jowar in India is grown in **both Kharif and Rabi seasons**, with the Rabi crop being prominent in the Deccan plateau.

Which of the statements given above are correct?

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

✓ **Correct Answer: (d) 1, 2 and 3**

**Brief Answer Key**

**Statement 1:** Correct – **Maharashtra is the leading producer** of jowar; major cultivation occurs in the **Deccan plateau region**.

**Statement 2:** Correct – Jowar exports are **relatively small and fluctuate**, with declines reported in some recent years due to domestic demand and market conditions.

**Statement 3:** Correct – Jowar is grown in **both Kharif and Rabi seasons**; the **Rabi jowar** of Maharashtra and Karnataka is considered **higher quality**.

□ **Sorghum (Jowar) is one of the major millets** promoted under the **International Year of Millets (2023)** and India's **Shree Anna initiative**.

□ Millets including jowar are emphasized in **climate-resilient agriculture** due to their **drought tolerance and low water requirement**.

29. With reference to Bajra (Pearl Millet) cultivation in India, consider the following statements:

1. **Rajasthan is the largest producer of Bajra in India**.
2. Bajra is mainly grown as a **Kharif crop under rainfed conditions**.
3. Bajra requires **cool and high-rainfall conditions similar to rice cultivation**.

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) 1 and 2 only**

**Brief Answer Key**

**Statement 1:** Correct – **Rajasthan is the largest producer of Bajra**, followed by states like Uttar Pradesh, Haryana, and Gujarat.

**Statement 2:** Correct – Bajra is primarily a **Kharif crop grown in semi-arid and rainfed regions**.

**Statement 3:** Incorrect – Bajra is **drought-resistant and suited to low rainfall**, unlike rice.

30. With reference to Nigerseed in India, consider the following statements:

1. Nigerseed is a traditional oilseed crop cultivated mostly by tribal communities.

2. India exports Nigerseed oil in large quantities to North America.

3. Nigerseed cultivation is promoted under the Tribal Sub Plan and NFSM.

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. 1 and 3 only

**Explanation:** Nigerseed is cultivated in tribal regions of Odisha, Chhattisgarh, and Madhya Pradesh. It is promoted under **special schemes**, but **exports are limited**, and not in large quantities to North America.

31. With reference to tea cultivation and the tea industry in India, consider the following statements:

1. The states of **Assam and West Bengal together contribute more than 70% of India's total tea production.**

2. India is the **largest exporter of tea in the world.**

3. **Darjeeling Tea** was the **first product in India to receive a Geographical Indication (GI) tag.**

Which of the statements given above is/are correct?

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

✓ **Correct Answer: (b) 1 and 3 only**

■ **Brief Answer Key**

**Statement 1:** Correct — Assam and West Bengal (especially **Darjeeling and Dooars-Terai**) together produce **over 70% of India's tea.**

**Statement 2:** Incorrect — **China is the largest tea exporter**; India is among the **major producers and exporters.**

**Statement 3:** Correct — **Darjeeling Tea received the first GI tag in India (2004–05)** under the GI Act, 1999.

32. With reference to certain traditional livelihood activities and agro-based industries in India, consider the following statements:

1. The **Honey Mission implemented by TRIFED** seeks to promote scientific beekeeping among tribal communities in order to enhance rural incomes and support pollination-based agriculture.

2. **Lac cultivation**, concentrated in states such as Jharkhand and Chhattisgarh, involves harvesting resin secreted by insects reared on host trees like **Palash and Kusum.**

3. India is the **largest producer of silk in the world**, and **Muga silk is produced mainly in Karnataka and Tamil Nadu.**

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: (a) 1 and 2 only**

■ **Brief Answer Key**

**Statement 1:** Correct — TRIFED's **Honey Mission** promotes scientific beekeeping among tribal communities to enhance **income and agricultural productivity through pollination.**

**Statement 2:** Correct — **Lac is a natural resin secreted by lac insects**, cultivated mainly in **Jharkhand, Chhattisgarh, and parts of Madhya Pradesh** on host trees like **Palash, Kusum, and Ber.**

**Statement 3:** Incorrect — While India is **one of the largest silk producers**, **Muga silk is exclusive to Assam**, not Karnataka or Tamil Nadu.

33. With reference to coconut cultivation and its value-added products in India, consider the following statements:

1. India is the **largest exporter of coconut oil in the world.**

2. **Kerala accounts for more than 45% of India's coconut production.**

3. **Neera (coconut sap) and coir fibre** are important value-added products derived from coconut.

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) 2 and 3 only**

📖 **Brief Answer Key**

**Statement 1:** Incorrect — Countries such as **Philippines and Indonesia dominate global coconut oil exports**, not India.

**Statement 2:** Correct — **Kerala contributes a major share (around 45%) of India's coconut production.**

**Statement 3:** Correct — **Neera (fresh sap) and coir fibre from coconut husk** are key value-added products.

34. **With reference to the role of coal in India's energy sector, consider the following statements:**

1. Coal continues to be the **largest source of electricity generation in India**, contributing roughly **around 70% of total power generation.**
2. India is the **second-largest producer of coal in the world** and among the **largest importers of coal globally.**
3. India has committed to **completely phasing out coal-based thermal power by 2035** under its national energy transition policies.

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) 1 and 2 only**

📖 **Brief Answer Key**

**Statement 1:** Correct — Coal still contributes **about 70% of India's electricity generation**, though the share is gradually declining with the expansion of renewables.

**Statement 2:** Correct — India is the **second-largest coal producer after China** and remains **one of the largest coal importers**, mainly for coking coal and certain grades of thermal coal.

**Statement 3:** Incorrect — India has **not announced a complete coal phase-out by 2035**. Instead, the strategy focuses on **gradual reduction in coal dependence**

**while expanding renewable energy capacity.**

35. **With reference to Sesamum (Sesame) cultivation and trade in India, consider the following statements:**

1. Sesamum is primarily cultivated as a **biofuel crop** in India.
2. India is among the **major exporters of sesame seeds**, supplying markets including **East Asia and the Middle East.**
3. **Odisha is one of the important sesame-producing states** in India.

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) 2 and 3 only**

📖 **Brief Answer Key**

**Statement 1:** Incorrect — Sesamum is mainly grown as an **oilseed crop for edible oil and food products**, not primarily for biofuel.

**Statement 2:** Correct — India is a **major exporter of sesame seeds**, with markets in **East Asia, the Middle East, and Europe.**

**Statement 3:** Correct — **Odisha is an important sesame-producing state**, along with states like **West Bengal, Gujarat, Rajasthan, and Uttar Pradesh.**

36. **With reference to sunflower cultivation and sunflower oil trade in India, consider the following statements:**

1. India meets a **large share of its sunflower oil consumption through imports** due to limited domestic production.
2. **Ukraine and Russia are among the major suppliers of sunflower oil to India.**
3. The **area and production of sunflower in India have shown a consistent rise in the past five years.**

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) 1 and 2 only**

☰ **Brief Answer Key**

**Statement 1:** Correct — India imports a **significant share of its sunflower oil**, as domestic production is relatively low.

**Statement 2:** Correct — **Ukraine and Russia dominate global sunflower oil exports** and are major suppliers to India.

**Statement 3:** Incorrect — **Sunflower cultivation in India has not consistently increased**; in fact, area and production have fluctuated or declined due to competition from other oilseeds and price issues.

**37. With reference to wheat cultivation and policy developments in India, consider the following statements:**

1. India is the **second-largest producer of wheat in the world**, after China.
2. Wheat is a **Rabi crop**, generally cultivated in regions with **cool winters and moderate rainfall**, especially in the alluvial plains of north India.
3. The Government of India has **recently lifted the export restrictions on wheat citing surplus production**.

Which of the statements given above are correct?

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

✓ **Correct Answer: (b) 1 and 2 only**

☰ **Brief Answer Key**

**Statement 1:** Correct — India is the **second-largest wheat producer globally**, after China.

**Statement 2:** Correct — Wheat is a **Rabi crop**, mainly grown in **alluvial soils of the Indo-Gangetic plains** under cool and dry conditions.

**Statement 3:** Incorrect — **Wheat export restrictions introduced in 2022 remain largely in place**, with limited exceptions, to ensure domestic food security and control prices.

**38. With reference to gram (chickpea) cultivation and trade in India, consider the following statements:**

1. India is the **largest producer of gram in the world** and also imports gram occasionally to meet domestic demand.
2. Gram is predominantly a **Rabi pulse crop**, usually cultivated under **rainfed conditions** in semi-arid regions.
3. **Madhya Pradesh is the leading gram-producing state in India**.

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) 1, 2 and 3**

☰ **Brief Answer Key**

**Statement 1:** Correct — India produces **around 65–70% of the world's chickpeas**, but still **imports small quantities** when domestic supply is insufficient.

**Statement 2:** Correct — Gram is mainly a **Rabi crop grown in rainfed conditions**, particularly in central and northern India.

**Statement 3:** Correct — **Madhya Pradesh is the largest producer**, followed by **Maharashtra, Rajasthan, and Uttar Pradesh**.

**39. With reference to soybean cultivation and trade in India, consider the following statements:**

1. Soybean is an important **oilseed crop** used for producing **edible oil as well as protein-rich soybean meal for animal feed**.
2. **Madhya Pradesh and Maharashtra together account for a dominant share of India's soybean production**, contributing more than three-fourths of the total output.
3. India freely imports **genetically modified (GM) soybeans for human consumption**, mainly from countries such as Argentina and Brazil.

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) 1 and 2 only**

📖 **Brief Answer Key**

**Statement 1:** Correct — Soybean is a **major oilseed crop** used for **edible oil extraction and high-protein animal feed (soymeal)**.

**Statement 2:** Correct — **Madhya Pradesh (largest producer) and Maharashtra together contribute the majority of India's soybean production.**

**Statement 3:** Incorrect — India **restricts imports of GM soybeans for direct human consumption**; limited imports may be permitted under **strict regulatory conditions for feed or processing.**

- Soybean is a **Kharif oilseed crop**, sown mainly during the **monsoon season**.
- India promotes oilseed production under the **National Mission on Edible Oils – Oilseeds (NMEO-OS)**.
- Soybean production is concentrated in the **“Soybean Belt” of central India**—primarily **Madhya Pradesh, Maharashtra, and Rajasthan**.

40. **Consider the following pairs regarding barley cultivation and uses in India:**

1. Major producing state — Rajasthan
2. Primary industrial use — Malt production for breweries
3. Major export destination — Middle East
4. Sowing season — Rabi season

How many of the above pairs are correctly matched?

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

✔ **Correct Answer: (d) All four pairs**

📖 **Brief Answer Key**

**Pair 1:** Correct — Rajasthan is among the **largest barley-producing states in India**.

**Pair 2:** Correct — Barley is widely used in **malting for beer and whisky production**.

**Pair 3:** Correct — India exports barley mainly to the **Middle East region**.

**Pair 4:** Correct — Barley is a **Rabi crop**, typically sown in **October–November**.

41. **With reference to Basmati rice production and Geographical Indication (GI) issues, consider the following statements:**

1. **India and Pakistan are widely recognized as the traditional producers of Basmati rice** in the Indo-Gangetic plains.
2. In India, the **GI tag for Basmati rice covers states such as Punjab, Haryana, Himachal Pradesh, Uttarakhand, Delhi, and parts of Uttar Pradesh and Jammu & Kashmir**.
3. In recent years, **India's attempt to obtain exclusive GI recognition for Basmati rice in the European Union has faced objections**, including from Pakistan.

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) 1 and 3 only**

📖 **Brief Answer Key**

**Statement 1:** Correct – **India and Pakistan are the traditional basmati-growing regions** in the Himalayan foothill belt.

**Statement 2:** Incorrect – The GI tag **does not include West Bengal**; it mainly covers **Punjab, Haryana, Himachal Pradesh, Uttarakhand, Delhi, and parts of UP and J&K**.

**Statement 3:** Correct – **EU GI registration attempts have faced objections**, particularly from **Pakistan**, which also claims basmati heritage.

42. **With reference to the Minimum Support Price (MSP) framework for oilseeds in India, consider the following statements:**

1. Groundnut and Soybean are **Kharif oilseed crops covered under MSP**.
2. Rapeseed–Mustard and Safflower are **Rabi oilseed crops covered under MSP**.
3. Flaxseed (Linseed) and Castor seed are **not among the oilseeds covered under MSP**.

Which of the statements given above is/are correct?

**Options:**

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

**Correct Answer: (d) 1, 2 and 3**

#### EXPLANATION

**Statement 1:** Correct — Groundnut and Soybean are **major Kharif oilseeds under MSP**.

**Statement 2:** Correct — **Rapeseed–Mustard and Safflower** are **Rabi oilseed crops covered under MSP**.

**Statement 3:** Correct — **Castor seed and Flaxseed (Linseed)** are **not part of the MSP-notified oilseed list**, even though they are cultivated oilseed crops in India.

The **7 MSP oilseeds** are:

- **Kharif:** Groundnut, Soybean, Sesamum, Sunflower, Nigerseed
- **Rabi:** Rapeseed–Mustard (Toria), Safflower

(Important trap: **Castor and Linseed are oilseeds but not under MSP.**)

43. With reference to the **National Agricultural Cooperative Marketing Federation of India (NAFED)**, consider the following statements:

1. NAFED is a statutory body under the Ministry of Agriculture and Farmers Welfare.
2. It is involved in the procurement and price stabilization of agricultural commodities, including pulses and oilseeds.
3. NAFED is one of the implementing agencies for Operation Greens and the Price Support Scheme (PSS).

Which of the statements given above is/are correct?

**Options:** A. 1 and 2 only B. 2 and 3 only C. 1 and 3 only D. 1, 2 and 3

**Answer: B. 2 and 3 only**

**Explanation:**

- **Statement 1 is incorrect: NAFED is a national-level cooperative set up in 1958, but not a statutory body. It is registered under the Multi-State Co-operative Societies Act.**
- **Statement 2 is correct: NAFED procures pulses, oilseeds, and other crops for buffer stock and price stabilization.**

- **Statement 3 is correct: NAFED is an implementing agency for Operation Greens, Price Support Scheme (PSS), and Market Intervention Scheme (MIS).**

44. With reference to the food processing sector in India, consider the following statements:

1. India is among the **largest producers of agricultural commodities globally** and ranks among the **top countries in food processing output, consumption, and exports**.
2. The food processing industry contributes **around 9–10% to India's Gross Domestic Product (GDP)** and includes activities such as grain milling, sugar processing, edible oil production, beverages, and dairy products.
3. The sector is considered **highly labour-intensive** and generally **requires lower capital investment compared to many heavy industries**.

Which of the statements given above is/are correct?

**Options:**

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

**Correct Answer: (d) 1, 2 and 3**

#### EXPLANATION

**Statement 1:** Correct — India is a **major global producer of food commodities** and ranks **around 5th in the global food processing sector** in terms of production and consumption.

**Statement 2:** Correct — The sector contributes **roughly 9–10% of GDP** when considering the broader food value chain.

**Statement 3:** Correct — Food processing is **labour-intensive and relatively less capital intensive**, contributing significantly to employment generation.

- PM Formalisation of Micro Food Processing Enterprises (PMFME) Scheme (2020)** to support **One District One Product (ODOP)** and strengthen small food processors.
- Production Linked Incentive (PLI) Scheme for Food Processing Industry (2021)** to boost **value-added food exports**.

□ India aims to **reduce post-harvest losses and increase value addition in agriculture**, improving farmer income.

45. **With reference to business integration strategies in industry and value chains, consider the following statements:**

1. **Backward integration** occurs when a company expands into activities related to its **suppliers or raw material sources**.
2. **Forward integration** refers to a firm expanding into **distribution, retail, or direct access to consumers**.
3. **Vertical integration** occurs when a firm operates across **multiple stages of the production and distribution chain**.
4. **Horizontal integration** refers to a company merging with or acquiring another company **within the same stage of the industry**.

Which of the statements given above are correct?

**Options:**

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

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✓ **Correct Answer: (d) 1, 2, 3 and 4**

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#### **EXPLANATION**

**Statement 1:** Correct — Backward integration means **control over input supply chains** (e.g., dairy firms organizing milk collection from farmers).

**Statement 2:** Correct — Forward integration expands toward **marketing, retail, or consumer access** (e.g., companies opening branded outlets).

**Statement 3:** Correct — Vertical integration combines **both backward and forward integration across the value chain**.

**Statement 4:** Correct — Horizontal integration involves **mergers or acquisitions within the same industry level** to expand market share.

46. **Consider the following crops:**

1. Arecanut
2. Barley
3. Coffee
4. Finger Millet (Ragi)
5. Groundnut

6. Sesamum (Til)
7. Turmeric

**The Government of India announces Minimum Support Prices (MSP) for which of the above crops on the recommendation of the Commission for Agricultural Costs and Prices (CACP)?**

- (a) 1, 2, 3 and 7 only
- (b) 2, 4, 5 and 6 only
- (c) 1, 4, 5 and 6 only
- (d) 1, 2, 3, 4, 5, 6 and 7

✓ **Correct Answer: (b) 2, 4, 5 and 6 only**

#### **EXPLANATION**

**2. Barley:** MSP crop — one of the **6 Rabi crops under MSP**.

**4. Finger Millet (Ragi):** MSP crop — a **nutri-cereal (millet) included in MSP under Kharif crops**.

**5. Groundnut:** MSP crop — a **major Kharif oilseed crop**.

**6. Sesamum (Til):** MSP crop — another **Kharif oilseed crop covered under MSP**.

**1. Arecanut:** Not under MSP.

**3. Coffee:** Plantation crop; **not covered under MSP**.

**7. Turmeric:** Spice crop; **not included in MSP list**.

47. **With reference to the climatic requirements for the cultivation of major food crops in India, consider the following statements:**

1. **Wheat cultivation requires high humidity and annual rainfall exceeding 100 cm.**
2. **Rice cultivation generally requires annual rainfall in the range of about 100 cm or more and thrives in warm, humid conditions.**

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

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✓ **Correct Answer: (b) 2 only**

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#### **EXPLANATION**

**Statement 1:** Incorrect — Wheat grows best in **cool and relatively dry climates** with **moderate rainfall (around 50–100 cm)** and **low humidity**, especially during ripening.

**Statement 2:** Correct — Rice is a **water-intensive crop** requiring **high rainfall (generally >100 cm)** or assured irrigation and **warm humid conditions**.

- **Wheat:** Rabi crop; ideal temperature **10–15°C during growth** and **21–26°C at ripening**.
- **Rice:** Kharif crop; requires **high temperature (20–35°C)** and abundant water supply.
- Rice cultivation is also possible in **low rainfall areas through irrigation (Punjab, Haryana)**—a frequent UPSC conceptual trap.

#### **Crop Rainfall Climate**

Wheat 50–100 cm Cool & dry

Rice >100 cm Warm & humid

48. **With reference to the Kisan Credit Card (KCC) Scheme in India, consider the following statements:**

1. The Kisan Credit Card (KCC) Scheme was launched in **1998–99** to provide farmers with **timely access to short-term institutional credit for agricultural operations**.
2. The KCC facility has been **extended to farmers engaged in fisheries and animal husbandry** to support their working capital requirements.

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) Both 1 and 2**

#### **EXPLANATION**

**Statement 1:** Correct — The **Kisan Credit Card Scheme was introduced in 1998–99** by the Government of India based on the recommendations of the **R.V. Gupta Committee** to provide **flexible credit for crop cultivation and related needs**.

**Statement 2:** Correct — In **2018–19**, the scheme was **expanded to include fisheries and animal husbandry farmers**, enabling them to access institutional credit.

49. **With reference to lac cultivation, sericulture, and rubber cultivation in India, consider the following statements:**

1. **Lac** is a natural resin secreted by insects such as *Kerria lacca* on host trees like **Kusum, Palash, and Ber**.
2. **Sericulture** refers to the cultivation of **silkworms for the production of silk**, and India is the **only country producing all four major varieties of natural silk**.
3. **Rubber cultivation** in India is mainly concentrated in **humid tropical regions**, with Kerala being the leading producer.

Which of the statements given above are correct?

**Options:**

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

✓ **Correct Answer: (d) 1, 2 and 3**

#### **EXPLANATION**

**Statement 1:** Correct — Lac is produced by the insect **Kerria lacca**, mainly on host trees **Kusum, Palash, and Ber**, with Jharkhand and Chhattisgarh being key regions.

**Statement 2:** Correct — Sericulture involves **rearing silkworms**, and India uniquely produces **Mulberry, Tasar, Eri, and Muga silk**.

**Statement 3:** Correct — Rubber cultivation requires **high rainfall and warm climate**, with **Kerala accounting for the largest share** of production.

- **Jharkhand is the largest producer of lac in India.**
- **Muga silk is exclusive to Assam**, a frequent UPSC fact-based question.
- Rubber cultivation is now **expanding to Northeast India (Tripura, Assam, Meghalaya)** under government promotion programs.

50. **With reference to the fruits and vegetables processing sector in India, consider the following statements:**

1. India is among the **largest producers of fruits and vegetables in the world**, accounting for a significant share of global horticulture output.
2. Less than **5% of fruits and vegetables produced in India are processed commercially**, which is considerably lower than the processing levels in many developed countries.
3. Mango and mango-based products constitute a **major share of India's processed fruit and vegetable exports**.

Which of the statements given above are correct?

**Options:**

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

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 **Correct Answer: (d) 1, 2 and 3**

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**EXPLANATION**

**Statement 1:** Correct — India is the **second-largest producer of fruits and vegetables globally**, after China.

**Statement 2:** Correct — Processing levels in India remain **very low (around 2–5%)**, compared to **60–70% in countries like the USA and Brazil**.

**Statement 3:** Correct — **Mango and mango-based products (pulp, concentrates, juices)** form a **large portion of India's processed fruit exports**.