R4589

Sub. Code
25MES2C1

M.Sc. DEGREE EXAMINATION, APRIL – 2026

Second Semester

Energy Science

HYDROGEN ENERGY SYSTEMS

(CBCS – 2025 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. Which hydrogen storage method offers the best compromise between safety and volumetric energy density for vehicular applications? (CO1, K1)

   (a) Cryogenic liquid hydrogen

   (b) Compressed gaseous hydrogen

   (c) Metal hydride storage

   (d) Underground cavern storage

2. Which property of hydrogen makes its storage technically challenging? (CO1, K2)

   (a) High molecular weight

   (b) Low volumetric energy density

   (c) Low calorific value

   (d) Toxic nature

3. The water—gas shift reaction is mainly used to (CO2, K2)

(a) Increase methane content

(b) Convert CO into CO_2 and H_2

(c) Remove sulfur

(d) Produce oxygen

4. Coal gasification differs from steam reforming mainly in terms of (CO2, K1)

(a) Reaction temperature

(b) Storage method

(c) Hydrogen purity

(d) Feedstock type

5. Fermentative hydrogen production mainly occurs under (CO3, K2)

(a) Aerobic conditions

(b) Anaerobic conditions

(c) Photochemical conditions

(d) Electrochemical conditions

6. Which of the following is a common co-product in fermentative hydrogen production? (CO3, K2)

(a) Oxygen (b) Methane

(c) Organic acids (d) Nitrogen

7. Which fuel cell uses a solid polymer electrolyte? (CO4, K1)

(a) PEMFC (b) AFC

(c) PAFC (d) MCFC

8. Direct methanol fuel cells differ from PEM fuel cells mainly in terms of (CO4, K2)

(a) Electrolyte material

(b) Fuel used

(c) Operating pressure

(d) Power output

9. Cryo-compressed hydrogen storage combines (CO5, K2)

(a) Chemical absorption and adsorption

(b) High pressure and cryogenic temperature

(c) Metal hydrides and polymers

(d) Liquid hydrogen and catalysts

10. Glass microspheres store hydrogen by (CO5, K1)

(a) Chemical reaction

(b) Electrochemical conversion

(c) Adsorption on surface

(d) Physical containment at high temperature

Part B (5 × 5 = 25)

Answer **all** questions not more than 500 words each.

11. (a) Explain different hydrogen production plants used for large-scale hydrogen generation. (CO1, K4)

Or

(b) Investigate the advantages and limitations of solar-based hydrogen production methods. (CO1, K5)

12. (a) Describe the role of natural gas as a feedstock for hydrogen production. (CO2, K4)

Or

(b) Explain the process of hydrogen production from coal gasification. (CO2, K4)

13. (a) Describe batch fermentation for biohydrogen production. (CO3, K4)

Or

(b) Illustrate the use of agricultural residues as carbon sources for hydrogen production. (CO3, K4)

14. (a) Explain the working principle of an alkaline fuel cell. (CO4, K4)

Or

(b) Evaluate the advantages and limitations of molten carbonate fuel cells. (CO4, K5)

15. (a) Explain chemical hydrogen storage using ammonia and carbohydrates. (CO5, K4)

Or

(b) Examine the working principle of cryo-compressed hydrogen storage systems. (CO5, K5)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1000 words each.

16. (a) Explain photoelectrochemical (PEC) water splitting for direct hydrogen production with a diagram. (CO1, K4)

Or

(b) Analyze direct hydrogen production routes and discuss their importance in a future hydrogen economy. (CO1, K5)

17. (a) Compare steam reforming of methane and partial oxidation of hydrocarbons for hydrogen production. (CO2, K4)

Or

(b) Evaluate the environmental and economic challenges associated with fossil-fuel-based hydrogen production. (CO2, K5)

18. (a) Explain photobiological and fermentative hydrogen production processes from biomass. (CO3, K4)

Or

(b) Describe the role of Thermotogales and other bacteria in biohydrogen production. (CO3, K5)

19. (a) Explain the construction, working, and applications of solid oxide fuel cells with suitable diagrams. (CO4, K4)

Or

(b) Assess the future prospects and technological challenges of fuel cells as sustainable energy devices. (CO4, K5)

20. (a) Explain physical hydrogen storage methods such as glass capillaryarrays, and microspheres. (CO5, K4)

Or

(b) Discuss the role of hydrogen storage technology in the development of hydrogen-powered vehicles. (CO5, K5)

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R4590

Sub. Code
25MES2C2

M.Sc. DEGREE EXAMINATION, APRIL – 2026

Second Semester

Energy Science

ENERGY STORAGE SYSTEMS

(CBCS – 2025 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. Energy storage is mainly required to (CO1, K2)

   (a) Increase fuel consumption

   (b) Match energy supply with demand

   (c) Reduce power generation

   (d) Eliminate renewable energy

2. Which of the following is an example of electrochemical energy storage? (CO1, K2)

   (a) Flywheel

   (b) Capacitor

   (c) Lithium-ion battery

   (d) Thermal tank

3. Which of the following is the active material of the positive plate in a lead–acid battery? (CO2, K2)

(a) Spongy lead

(b) Lead peroxide

(c) Dilute sulphuric acid

(d) Lead sulphate

4. SLI batteries are mainly used for (CO2, K2)

(a) Deep cycle applications

(b) Renewable energy storage

(c) Starting, and ignition in vehicles

(d) UPS systems

5. Which material is commonly used as an anode in lithium-ion batteries? (CO3, K1)

(a) Lithium metal

(b) Graphite

(c) Zinc

(d) Lead

6. The main advantage of metal—air batteries is (CO3, K2)

(a) Low energy density

(b) High internal resistance

(c) Short cycle life

(d) High theoretical energy density

7. Which component in a supercapacitor mainly determines its capacitance? (CO4, K2)

(a) Electrode surface area

(b) Current collector

(c) Separator

(d) External load

8. The most commonly used membrane in low-temperature fuel cells is (CO4, K1)

(a) Zirconia membrane

(b) Silica membrane

(c) Alumina membrane

(d) Nafion membrane

9. The main purpose of using a battery—supercapacitor hybrid system is to (CO5, K2)

(a) Reduce system voltage

(b) Increase fuel consumption

(c) Combine high energy Density

(d) Replace renewable energy

10. In a hybrid fuel cell-battery system, the battery is mainly used to (CO5, K1)

(a) Generate hydrogen

(b) Store oxygen

(c) Replace the fuel cell

(d) Supply peak power demand

Part B (5 × 5 = 25)

Answer **all** questions not more than 500 words each.

11. (a) Explain the need for energy storage? (CO1, K4)

Or

(b) Describe the chemical energy storage with examples. (CO1, K5)

12. (a) Explain the construction of a lead—acid battery? (CO2, K4)

Or

(b) Describe the charging and discharging characteristics of SLA batteries? (CO2, K5)

13. (a) Difference between a lithium battery and a lithum-ion battery. (CO3, K4)

Or

(b) Explain the principle and construction of a lithium-ion battery? (CO3, K4)

14. (a) What are the types of super capacitors. (CO4, K4)

Or

(b) Explain the basic components of a super capacitor. (CO4, K4)

15. (a) Evaluate the hybrid fuel cell—battery systems with applications. (CO5, K5)

Or

(b) Explain the concept of hybrid energy systems. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1000 words each.

16. (a) Explain different modes of energy storage? (CO1, K4)

Or

(b) Compare the different energy storage systems. (CO1, K5)

17. (a) Describe the principle of operation of a lead—acid battery with necessary reactions. (CO2, K5)

Or

(b) Analyze the types, design, and characteristics of lead—acid batteries used in automotive (SLI) applications? (CO2, K4)

18. (a) Explain the role of nanomaterials in anodes and cathodes of lithium-ion batteries? (CO3, K4)

Or

(b) Describe the working principle of Zinc-air batteries and draw the neat diagram. (CO3, K4)

19. (a) Evaluate the fabrication and components of a fuel cell system. (CO5, K5)

Or

(b) Analyze low-temperature and reversible fuel cell systems with applications. (CO4, K4)

20. (a) Compare battery-supercapacitor and fuel cell-battery hybrid systems. (CO5, K4)

Or

(b) Evaluate hybrid fuel cell-battery systems with respect to performance and applications. (CO5, K5)

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R4591

Sub. Code
25MES2C3

M.Sc. DEGREE EXAMINATION, APRIL – 2026

Second Semester

Energy Science

ADVANCED NANOMATERIALS AND THEIR APPLICATIONS

(CBCS – 2025 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective questions by choosing the correct option.

1. Which nanostructure exhibits quantum confinement in all three dimensions? (CO1, K1)

   (a) Thin film

   (b) Nanowire

   (c) Quantum dot

   (d) Nanocomposite

2. The tunnel effect in nanomaterials is mainly associated with (CO1, K2)

   (a) Surface roughness

   (b) Electron wave nature

   (c) Thermal vibration

   (d) Crystal defects

3. Arc discharge method for nanomaterial synthesis involves (CO2, K1)

(a) High-temperature electric arc

(b) Low-temperature chemical reaction

(c) Enzymatic reduction

(d) Mechanical milling

4. Spray pyrolysis method is based on the principle of (CO2, K2)

(a) Electrolysis

(b) Thermal decomposition of precursor droplets

(c) Mechanical attrition

(d) Photoactivation

5. The main reason for rapid research growth in nanocomposites. (CO3, K2)

(a) Low cost of all nanomaterials

(b) Ease of synthesis only

(c) Tailorable properties for advanced applications

(d) Availability of bulk raw materials

6. Recognise the primary advantage of CNT-metal oxide nanocomposites. (CO3, K2)

(a) Reduced electrical conductivity

(b) Improved mechanical strength and charge transport

(c) Increased brittleness

(d) Lower surface area

7. Identify the category to which biopolymers mainly belong. (CO4, K1)

(a) Bioinert ceramics

(b) Metallic biomaterials

(c) Naturally derived biomaterials

(d) Magnetic composites

8. Recognize the temperature at which ferromagnetic materials lose permanent magnetism. (CO4, K2)

(a) Néel temperature

(b) Curie temperature

(c) Blocking temperature

(d) Transition temperature

9. Recognize the role of nanostructured TiO_2 in dye-sensitized solar cells. (CO5, K2)

(a) Electron transport and charge collection

(b) Electrolyte regeneration

(c) Thermal insulation

(d) Light reflection

10. Select the characteristic that distinguishes perovskite solar cells from conventional solar cells. (CO5, K2)

(a) Low absorption coefficient

(b) Tunable band gap and high absorption

(c) Poor charge transport

(d) High operating temperature

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Explain the significance of nanoscale dimensions in determining material properties. (CO1, K4)

Or

(b) Describe how tunnelling effects influence electrical conduction in nanostructured materials. (CO1, K5)

12. (a) Illustrate the sol—gel method for nanomaterial synthesis. (CO2, K4)

Or

(b) Outline the electrochemical deposition technique for nanomaterials. (CO2, K4)

13. (a) Outline the different types of nanocompositer based on reinforcement and matrix combinations. (CO3, K4)

Or

(b) Discuss the key mechanical, electrical, and thermal properties exhibited by nanocomposites. (CO3, K5)

14. (a) Illustrate the design factors considered in selecting biomaterials for implant applications. (CO4, K4)

Or

(b) Outline the properties and applications of biopolymers and biodegradable polymers. (CO4, K4)

15. (a) Outline the application of nanomaterials in supercapacitors and hybrid capacitors. (CO5, K4)

Or

(b) Explain the role of nanomaterials in cancer detection and diagnosis. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) Explain nanoscale concepts to describe the physical and chemical property variations in nanomaterials. (CO1, K4)

Or

(b) Discuss the technological importance of dimensionality in nanostructured materials. (CO1, K4)

17. (a) Discuss chemical synthesis methods of nanomaterials with merits and demerits. (CO2, K5)

Or

(b) Differentiate between phytosynthesis and mycosynthesis methods. (CO2, K4)

18. (a) Evaluate the structure, property, and application relationship in metal oxide-polymer nanocomposites. (CO3, K5)

Or

(b) Examine the technological significance of nanocomposites in the context of recent research trends and industrial applications. (CO3, K5)

19. (a) Compare different implant materials used in biomedical applications based on their properties and performance. (CO4, K4)

Or

(b) Examine magnetic Curie temperature, and Neel temperature in relation to magnetic material behavior. (CO4, K5)

20. (a) Compare nanomaterial-based batteries and supercapacitors with conventional energy storage devices. (CO5, K4)

Or

(b) Analyze the impact of nanomaterials on biomedical and self-cleaning applications. (CO5, K4)

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R4592

Sub. Code
25MES2E1

M.Sc. DEGREE EXAMINATION, APRIL – 2026

Second Semester

Energy Science

Elective: WIND AND HYDRO ENERGY

(CBCS – 2025 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following questions by choosing the correct options.

1. The gearbox in wind turbine is mainly used to _____ (CO1, K1)

   (a) Increase torque

   (b) Decrease voltage

   (c) Increase rotational speed

   (d) Store energy

2. Wind shear refers to variation of wind speed with _____ (CO1, K2)

   (a) Time (b) Height

   (c) Pressure (d) Temperature

3. In grid –connected wind systems, frequency control is mainly maintained by _____ (CO2, K2)

   (a) Turbine (b) Gearbox

   (c) Tower (d) Utility grid

4. The spacing between turbines in a wind farm is designed to minimize _____ (CO2, K1)

(a) Noise (b) Wake losses

(c) Generator heating (d) Tower vibration

5. Hydrology deals with the study of _____ (CO3, K2)

(a) Water cycle (b) Wind flow

(c) Solar radiation (d) Biomass

6. Small hydropower plants in India are classified up to _____ (CO3, K1)

(a) 10 MW (b) 25 MW

(c) 50 MW (d) 100 MW

7. Tidal energy is produced due to gravitational forces of Moon and _____ (CO4, K1)

(a) Mars (b) Venus

(c) Jupiter (d) Sun

8. Wave energy is generated due to _____ (CO4, K1)

(a) Ocean temperature difference

(b) Wind over sea surface

(c) River discharge

(d) Earthquake

9. Environmental impact of large hydro projects mainly includes _____ (CO5, K1)

(a) Soil erosion and displacement

(b) Air pollution

(c) Nuclear waste

(d) Radiation

10. The primary factor in the site selection of a hydro plant is _____ (CO5, K2)

(a) Coal availability (b) Wind speed

(c) Water head (d) Temperature

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each

11. (a) Explain the basic concept of wind energy conversion. (CO1, K3)

Or

(b) Write a short note on electrical generators used in wind turbines. (CO1, K4)

12. (a) Describe grid-connected wind turbines. (CO2, K4)

Or

(b) Write short notes on offshore wind farms. (CO2, K4)

13. (a) Explain the classification of hydropower plants. (CO3, K3)

Or

(b) Discuss micro, mini and small hydropower systems. (CO3, K4)

14. (a) Compare run-of-river and storage power plants. (CO4, K4)

Or

(b) Explain the working principle of tidal power plants. (CO4, K4)

15. (a) Explain the cost structure of hydroelectric power plants. (CO5, K4)

Or

(b) Discuss environmental issues related to large hydro projects. (CO5, K5)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each

16. (a) Derive and explain the wind power equation and its parameters. (CO1, K5)

Or

(b) Describe wind turbine size classification with examples. (CO1, K4)

17. (a) Discuss installation and planning of wind farms. (CO2, K4)

Or

(b) Explain the ecological impacts of wind energy. (CO2, K4)

18. (a) Briefly explain the hydropower potential in India. (CO3, K5)

Or

(b) Discuss the global status and development potential of hydropower. (CO3, K4)

19. (a) Discuss pumped storage power plants and their advantages. (CO4, K4)

Or

(b) Compare wave and ocean current power plants. (CO4, K5)

20. (a) Explain essential elements of hydroelectric power plant with neat sketch. (CO5, K4)

Or

(b) Discuss the economics and hydropower potential in North East India. (CO5, K5)

R4593

Sub. Code
25MES2S1

M.Sc. DEGREE EXAMINATION, APRIL – 2026

Second Semester

Energy Science

FUTURE OF PHOTOVOLTAIC TECHNOLOGIES

(CBCS – 2025 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective type questions by choosing the correct option.

1. Which solar cell has the highest laboratory efficiency? (CO1, K1)

   (a) DSSC (b) Perovskite

   (c) Multi-junction (d) Organic

2. CdTe is classified as: (CO1, K2)

   (a) Silicon PV

   (b) Thin-film PV

   (c) Organic PV

   (d) Quantum PV

3. PERC technology improves: (CO2, K2)

(a) Cost (b) Weight

(c) Efficiency (d) Colour

4. Roll-to-roll manufacturing is mainly used for: (CO2, K2)

(a) Silicon wafers

(b) Flexible PV

(c) Concentrator PV

(d) Bifacial PV

5. BIPV integrates PV into: (CO3, K1)

(a) Batteries (b) Buildings

(c) Vehicles (d) Satellites

6. Floating PV systems are installed on: (CO3, K2)

(a) Land (b) Rooftops

(c) Water bodies (d) Deserts

7. LCA stands for (CO4, K1)

(a) Life Cycle Analysis

(b) Load Capacity Assessment

(c) Light Conversion Area

(d) Long-term Cost Analysis

8. PV policies mainly aim to promote: (CO4, K2)

(a) Fossil fuels

(b) Nuclear energy

(c) Renewable energy

(d) Thermal power

9. Proposal writing is essential for: (CO5, K1)

(a) Manufacturing (b) Funding

(c) Installation (d) Recycling

10. Industry incubation supports: (CO5, K2)

(a) Exams

(b) Research commercialization

(c) Teaching

(d) Marketing only

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Explain the limitations of conventional silicon PV cells. (CO1, K4)

Or

(b) Examined the advantages of perovskite solar cells over thin-film solar cells. (CO1, K4)

12. (a) Evaluate the performance advantages and limitations of multi-junction solar cells in achieving high efficiency compared to single-junction solar cells. (CO2, K4)

Or

(b) Investigates the impact of roll-to-roll manufacturing on flexible photovoltaic technologies (CO2, K5)

13. (a) Assess the effectiveness of agrivoltaic systems in achieving sustainable land utilization and enhanced energy—food co-production, by examples. (CO3, K4)

Or

(b) Analyze how AI improves performance monitoring in PV systems. (CO3, K5)

14. (a) Examine the key factors driving global photovoltaic market adoption, including regional growth trends, cost and policy support mechanisms. (CO4, K4)

Or

(b) Critically analyze the implications of photovoltaic cost-reduction strategies on future global energy markets. (C04, K4)

15. (a) Explain the importance of industry exposure in PV system design. (CO5, K4)

Or

(b) Evaluate the role of proposal writing in securing funding for PV startups. (CO5, K5)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) Explain thin-film solar cell technologies and their applications. (CO1, K4]

Or

(b) Analyze the future prospects of organic photovoltaic and dye-sensitized solarcell (DSSC) technologies in next-generation energy applications. (CO1, K4)

17. (a) Examine and analyze how bifacial and tandem solar module technologies enhance photovoltaic performance and power output. (CO2, K4)

Or

(b) Evaluate sustainability challenges in next-generation PV manufacturing. (CO2, K5)

18. (a) Review the impact of smart grid technologies and energy storage on managing intermittency and grid integration of photovoltaic systems. (CO3, K4)

Or

(b) Estimate the effectiveness of floating PV systems in energy generation. (CO3, K5)

19. (a) Investigate Photovoltaics (PV) market dynamics and policy frameworks shaping global deployment. (CO4, K4)

Or

(b) Assess the environmental implications of next-generation photovoltaic technologies with respect to material use, emissions, and sustainability. (CO4, K4)

20. (a) Explain the process of designing innovative small-scale PV systems. (CO5, K4)

Or

(b) Evaluate the importance of incubation support for PV startups. (CO5, K5)

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