English

1.

Two identical vessels, each containing hydrogen and oxygen are considered that have different chemical energies. In the first vessel, the gases are contained in the elemental form, pure hydrogen and pure oxygen, in a ratio of 2:1. The second vessel contains the same number of atoms of hydrogen and oxygen as in the first vessel, but in the form of water. Consider the following statements for these vessels.

1. The internal energies of these vessels differ.

2. The internal energies of these vessels are the same.

3. A spark may set off a violent release of energy in the first vessel, but not in the second.

4. A spark may set off a violent release of energy in both vessels.

Which of the above statements is/are correct?

(A) Only 1
(B) Only 4
(C) Both 1 and 3
(D) Both 2 and 4

Correct Option(s): C

English

2.

Exergy is a useful quantity that stems from the second law of thermodynamics and helps in the analysis of energy and other systems and processes. Consider the following statements for exergy.

1. Exergy of a system is defined as the maximum shaft work that can be done by the composite of the system and a specified reference environment.

2. Exergy of the system can be increased when work is done on the system.

3. Exergy of the system is equivalent to the utilizable energy of the system.

4. Unlike energy, exergy cannot be transferred or transported across the boundary of a system.

Which of the above statements on exergy is/are wrong?

(A) Only 2
(B) Only 3
(C) Only 4
(D) Both 3 and 4

Correct Option(s): C

English

3.

Which one of the following gases accounts for more than 50 % of the anthropogenic greenhouse effect?

(A) CH_4
(B) CO_2
(C) N_2O
(D) CFC_s

Correct Option(s): B

English

4. Which statement among the following accurately describes the usefulness of exergy analysis in the context of sustainability?

(A) Exergy in any process can never be lost as it is conserved like energy.

(B) Exergy losses should be maximized to obtain sustainable development.

(C) Exergy can be lost due to internal irreversibility suggesting that exergy losses should be minimized to obtain sustainable development.

(D) Sustainability is not dependent on energy/exergy analysis of the process.

Correct Option(s): C

English

5.

An energy system is normally designed to work under various conditions. Which among the following can be used to assess the environmental burden of the energy system?

(A) Life cycle assessment

(B) Environmental impact assessment

(C) Efficiency of the energy system

(D) Both Life cycle assessment and Environmental impact assessment

Correct Option(s): D

English

6. What is the function of a heat transfer fluid in a solar thermal system?

(A) To convert sunlight into electricity

(B) To absorb and transport heat from the collector to a storage or application system

(C) To increase the surface area of the solar collector

(D) To reflect sunlight onto the collector

Correct Option(s): B

English

7.

Energy content of a biofuel is expressed in terms of Lower Heating Value (LHV) or Higher Heating Value (HHV). Consider the following statements on LHV and HHV of biofuels.

(A) Water vapor formed during the combustion may condense to form liquid water, releasing energy into the surrounding medium. If one measures the thermal energy before the vapor-to-liquid phase change, one gets the LHV.

(B) Water vapor formed during the combustion may condense to form liquid water, releasing energy into the surrounding medium. If one measures the thermal energy before the vapor-to-liquid phase change, one gets the HHV.

(C) Water vapor formed during the combustion may condense to form liquid water, releasing energy into the surrounding medium. If one measures the thermal energy after the vapor-to-liquid phase change, one gets the LHV.

(D) Water vapor formed during the combustion may condense to form liquid water, releasing energy into the surrounding medium. If one measures the thermal energy after the vapor-to-liquid phase change, one gets the HHV.

Which of the above statements is/are incorrect?

(A) Both A and B

(B) Both A and D

(C) Both B and C

(D) Both A and C

Correct Option(s): C

English

8. Large amounts of CO_2 cycle into and out of the atmosphere. Carbon dioxide emitters are called carbon sources, and those objects that absorb CO_2 are called carbon sinks. Which among the following is incorrect when fossil fuels and biofuels are compared?

(A) Like fossil fuels, biofuels too emit CO_2 into the atmosphere.

(B) As biomass accumulates, it functions as a sink but fossil fuels do not form fast enough to be considered sinks.

(C) Growing biofuel feedstock helps to reduce atmospheric CO_2 levels by acting as a carbon sink. When biofuels are burned, CO_2 is emitted back into the atmosphere acting as a carbon source. Hence, biofuels have no net impact on atmospheric CO_2 levels.

(D) The production of biomass partially offsets the CO_2 emitted during their combustion.

Correct Option(s): C

English

9. Which of the following enzymes help in starch liquefaction?

(A) α-amylase

(B) Glucoamylase

(C) Protease

(D) Transferase

Correct Option(s): A

English

10. Which among the following is not a hexose sugar?

(A) Glucans

(B) Xylans

(C) Galactans

(D) Mannans

Correct Option(s): B

English

11. The amount of sunlight striking the Earth

(A) varies by region, season and climate

(B) increases due to atmospheric absorption

(C) is constant throughout the solar insolation hours

(D) cannot be measured

Correct Option(s): A

English

12. Pick the correct statement among the following.

(A) Doping a Silicon crystal with Phosphorous adds extra unbonded electron to the crystal producing n-type material

(B) Doping a Silicon crystal with Phosphorous adds extra unbonded electron to the crystal producing p-type material

(C) In a p-type material, positrons are the majority charge carriers

(D) In a p-type material, electrons are the majority charge carriers

Correct Option(s): A

English

13. Which among the following is a zero band-gap semiconductor?

(A) N-type crystalline Si

(B) P-type crystalline Si

(C) Graphene

(D) GaAs

Correct Option(s): C

English

14. The surface of the crystalline- Si solar cell can act as a mirror reflecting the sunlight falling on it. Which among the following is the best method to overcome this reflection?

(A) Treating the top surface with a thin layer of SiO

(B) Texture the top surface

(C) Double antireflection coating

(D) A combination of texturing and double antireflection coating

Correct Option(s): D

English

15. Which among the following statements is incorrect?

(A) Amorphous Si is an insulator and cannot be used to make PV cells

(B) Amorphous Si can be used to make PV devices by controlled deposition and modifications

(C) Amorphous Si is used to make PV devices with low power requirements

(D) Amorphous Si absorbs solar radiation 40 times more efficiently than does single-crystal Si

Correct Option(s): A

English

16. When individual PV cells are joined to form a module, which of the following is incorrect?

(A) Joining cells in series builds voltage

(B) Joining cells in parallel increases amperage

(C) Joining cells in series builds voltage and increases amperage

(D) Both voltage and amperage are increased by arranging cells in both series and parallel.

Correct Option(s): C

English

17. Which of the following is correct about PV modules?

(A) Module efficiency decreases as spaces between cells decrease

(B) To increase efficiency, most modules are packed with circular cells

(C) To decrease efficiency, most modules are packed with square cells

(D) Module efficiency decreases as spaces between cells increase

Correct Option(s): D

English

18. In stand-alone PV systems

(A) Utility grid is desirable for the storage of excess energy

(B) Batteries are better suited for the storage of excess energy compared to a utility grid

(C) Batteries increase the efficiency when used as a storage device

(D) Batteries are desirable storage devices as they are directly compatible with AC loads

Correct Option(s): B

English

19.

The solar insolation in a sub-tropical area is found to be 750 W/m2. If a single solar cell of dimensions 10 cm × 10 cm produces a voltage of 0.5 V and a current of 2 A, the efficiency of the solar cell is

(A) 12.5%

(B) 15%

(C) 13.5%

(D) 20%

Correct Option(s): A

English

20. At the maximum power point in the I-V curve of a solar module, the value of dP/dV is

(A) 0

(B) Negative

(C) Positive

(D) -1

Correct Option(s): A

English

21.

The overall reaction for the discharge of a lead-acid battery is:

$PbO_2 + Pb + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

(A) The reaction at the negative electrode is:
$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

(B) The reaction at the positive electrode is:
$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

(C) The reaction at the negative electrode is:
$Pb + SO_4^{2-} \rightarrow Pb_2SO_4 + 4e^-$

(D) $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
and
$H_2 \rightarrow 2H^+ + 2e^-$

Correct Option(s): B

English

22.

A fuel cell used for an automotive application operates at a current of 350 A. If the electrode area of each cell is 0.04 m^2 which among the following is correct?

(A) The current density is 8750 A/m^2

(B) The drop in potential across electrolyte is 61 mV if the electrodes are 0.07 mm apart and the conductivity of the electrolyte is 10 S/m

(C) Both (a) and (b)

(D) Ohm's law cannot be used to calculate the drop in potential

Correct Option(s): C

English

23. Consider the design of an electrochemical cell. Which statement is incorrect among the following?

(A) The main components of a cell are the negative electrode, the positive electrode and the electrolyte

(B) The electrolyte is an ion insulator and an electronic conductor

(C) Electrons travel from the anode to the cathode through the external circuit during discharge.

(D) A separator can also act as an electrolyte

Correct Option(s): B

English

24. Consider a Li-ion battery for an electric vehicle application. This battery requires a discharge time of 2 h, 24 kWh of energy, and a targeted battery voltage of 360 V. The nominal single-cell voltage has a value of 3.75 V. Consider the following statements for this given battery. Consider the following statements. (A) Number of cells in series = 96 (B) The energy of an individual cell is the product of its capacity and voltage (C) The total energy of the battery is the sum of the energy from each individual cell (D) The energy content of a battery is independent of its size and battery chemistry

(A) Only A and B

(B) Only A and C

(C) Only A, B and C

(D) A, B, C and D

Correct Option(s): C

English

25. Which among the following is correct for fuel cells?

(A) Fuel cells are not thermal devices and are not limited by the Carnot efficiency of heat engines

(B) Fuel cells are thermal devices and are limited by the Carnot efficiency of heat engines

(C) Fuel cells are electrochemical devices and are limited by the Carnot efficiency of heat engines

(D) Fuel cells are electrochemical energy storage devices

Correct Option(s): A

English

26.

A solid oxide fuel cell operates on hydrogen and oxygen. The correct anode half-cell reaction for a solid oxide fuel cell is

(A) $H_2 + O^{2-} \rightarrow H_2O + 2e^-$

(B) $O_2 + 4e^- \rightarrow 2O^{2-}$

(C) $H_2 \rightarrow 2H^+ + 2e^-$

(D) $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

Correct Option(s): A

English

27. A 1600 kg passenger hybrid-electric vehicle is moving at 60 km/h. The battery has a nominal voltage of 300 V and a capacity of 8 kWh. Assume that the power is constant and neglect rolling resistance and aerodynamic drag during braking. To stop the vehicle in 3 seconds, the power available in principle from regenerative braking is

(A) 100 kW

(B) 50 kW

(C) 74 kW

(D) 148 kW

Correct Option(s): C

English

28.

Silicon is doped with 1 ppb (by weight) of Indium. What is the dopant concentration (cm^3) at room temperature? The density of silicon is 2.33 g/cm^{-3}; the molecular weight of indium is 114.82 g/mol.

(A) The dopant concentration is $1.22 \times 10^{13}/cm^3$

(B) The dopant concentration is $1.22 \times 10^{26}/cm^3$

(C) The dopant concentration is $1.22 \times 10^{-13}/cm^3$

(D) The dopant concentration is $1.22 \times 10^{-26}/cm^3$

Correct Option(s): A

English

29. An electrolyzer is used to produce hydrogen gas by splitting water. If an electrolyzer operates at an efficiency of 80 %, consuming 15 kWh of electrical energy to produce hydrogen, how much hydrogen (in kilograms) is produced? The energy requirement for hydrogen production by electrolysis is approximately 39.4 kWh/kg.

(A) 0.2 kg

(B) 0.3 kg

(C) 0.4 kg

(D) 0.6 kg

Correct Option(s): B

English

30. Which of the following statements correctly describes the main difference between a battery, an electrolyser, and a fuel cell?

(A) A battery generates electricity through a continuous supply of fuel, while a fuel cell stores chemical energy internally, and an electrolyzer converts chemical energy to electrical energy.

(B) A battery stores and releases energy internally, while an electrolyzer uses electrical energy to drive a chemical reaction, and a fuel cell converts chemical energy to electrical energy through an external fuel supply.

(C) A battery converts electrical energy into hydrogen, an electrolyzer stores electrical energy, and a fuel cell uses stored hydrogen to produce electricity.

(D) A battery requires an external fuel source like a fuel cell, while an electrolyzer can both store and release energy without any external input.

Correct Option(s): B

English

31.

Which option regarding the solar radiation is correct?

(A) Diffuse radiation is referred to the solar radiation when its direction has been changed due to reflection and scattering in the atmosphere

(B) The maximum value of solar radiation intensity is 5000 W/m2 which occurs at 0.48 mm of wavelength

(C) Only direct radiation is incident on the earth's surface

(D) Both Diffuse radiation is referred to the solar radiation when its direction has been changed due to reflection and scattering in the atmosphere and The maximum value of solar radiation intensity is 5000 W/m2 which occurs at 0.48 mm of wavelength

Correct Option(s): A

English

32. Which of the following statements on latitude and longitude is incorrect?

(A) Latitude is the angle made by the radial line joining the centre of the earth to the location and its projection on the equatorial plane

(B) Latitude varies from 45° at the equator to 90° at the poles

(C) Latitude along with the longitude indicates the position of any point on the earth

(D) Latitude is the angular distance north or south of the equator measured from the center of the earth

Correct Option(s): B

English

33. Which among the following is the most widely used method for hydrogen production currently?

(A) Electrolysis of water

(B) Steam methane reforming

(C) Solar hydrogen production

(D) Biomass gasification

Correct Option(s): B

English

34. Which of the following statements is true about green hydrogen?

(A) It is produced by splitting water molecules using fossil fuels as the energy source.

(B) It is produced by electrolysis of water using renewable energy sources like solar and wind.

(C) It is a by-product of natural gas extraction and is often associated with carbon emissions.

(D) It is chemically different from other types of hydrogen, such as blue or grey hydrogen.

Correct Option(s): B

English

35. What is a major advantage of green hydrogen compared to grey or blue hydrogen?

(A) It is cheaper to produce than hydrogen from natural gas

(B) It uses carbon capture technology to reduce emissions

(C) It produces no greenhouse gas emissions during production

(D) It is produced from coal gasification

Correct Option(s): C

English

36.

Steam methane reforming does not include

(A) Use of natural gas

(B) Water gas shift reaction

(C) Thermochemical hydrogen generation

(D) Production of CO_2

Correct Option(s): C

English

37. Which of the following steps is common to both coal and biomass gasification?

(A) Combustion of carbon at high temperatures

(B) Partial oxidation to produce syngas

(C) Anaerobic digestion

(D) Fermentation to produce bioethanol

Correct Option(s): B

English

38. How geothermal energy is harnessed for electricity generation?

(A) By capturing heat from the sun stored in the Earth's surface.

(B) By extracting steam or hot water from underground to drive turbines.

(C) By using the kinetic energy of moving tectonic plates.

(D) By burning underground fossil fuels to produce heat.

Correct Option(s): B

English

39. Which of the following is incorrect about tidal energy?

(A) It is produced by natural rise and fall of tides

(B) As water is denser than air, tidal energy is more powerful than wind energy

(C) It is less predictable and inconsistent compared to wind and solar energy

(D) Tidal energy is best captured in areas with high tidal ranges and strong currents

Correct Option(s): C

English

40.

A wind turbine with a blade length of 50 m operates at a wind speed of 15 m/s Determine the wind power. Assume air density to be 1.2 kg/m^3

(A) 15.9 MW

(B) 25.2 MW

(C) 20.5 MW

(D) 10.8 MW

Correct Option(s): A

English

41. Which of the following statements on hydrogen production is incorrect?

(A) Steam methane reforming is an oxidative process

(B) Oxidative processes of hydrogen production involves bond reorganisation

(C) Partial oxidation of fossil fuels involves stoichiometric amount of oxidant

(D) Biomass typically undergoes fermentation and gasification for hydrogen production

Correct Option(s): C

English

42.

Which of the following gases acts as an oxidant in dry reforming to form hydrogen?

(A) CO_2

(B) H_2O

(C) O_2

(D) CO

Correct Option(s): A

English

43. Which among the following is the safest way to store hydrogen?

(A) Type III cylinders

(B) Type IV cylinders

(C) Liquefied storage at 20 K

(D) Metal hydrides

Correct Option(s): D

English

44.

Which among the following cannot be classified as metal hydride?

(A) NaH

(B) MgH_2

(C) AlH_3

(D) NH_3

Correct Option(s): D

English

45.

Which among the following has the highest theoretical hydrogen storage capacity?

(A) $LaNi_5H_6$

(B) MgH_2

(C) NaH

(D) AlH_3

Correct Option(s): D

English

46. Which statement among the following is incorrect?

(A) Lithium ion batteries have higher power density than lead acid battery

(B) Lithium ion batteries have lower energy density than supercapacitors

(C) Lithium ion batteries have higher energy density than supercapacitors

(D) Supercapacitors have lower energy density compared to lead acid battery

Correct Option(s): B

English

47. Which among the following can be used for morphological characterization of materials?

(A) Powder X-ray diffraction

(B) Raman spectroscopy

(C) Scanning Electron Microscope

(D) Infrared spectroscopy

Correct Option(s): C

English

48. Which of the following statements on the electronic structure of materials is incorrect?

(A) When a bulk metal particle is reduced in size to form clusters of a few hundred atoms, the density of states in conduction band changes

(B) New electronic properties emerge at the nanoscale

(C) Small nanoclusters are analogous to molecules having discrete energy levels

(D) When a bulk metal particle is reduced in size to form clusters of a few hundred atoms, the density of states in conduction band remains the same

Correct Option(s): D

English

49. Carbon nanotubes (CNTs) have applications in batteries and fuel cells. Pick the correct option.

(A) Li can be stored in the CNTs

(B) Hydrogen can be stored in the CNTs at higher temperatures (> 50 °C)

(C) Physisorbed hydrogen in CNTs are strongly bonded to carbon

(D) Hydrogen can be chemisorbed on the CNTs at lower temperatures (< 100 K)

Correct Option(s): A

English

50.

A solar thermal collector has an area of 5 m^2 and receives solar radiation at a rate of 800 W/m^2. The collector is used to heat water from 20°C to 70°C. The specific heat capacity of water is 4.18 kJ/kg°C, and the mass flow rate of the water through the collector is 0.02 kg/s. If 60% of the solar radiation is effectively converted into heat, what is the useful thermal energy absorbed by the collector per second?

(A) 4000 W

(B) 2400 W

(C) 3200 W

(D) 6000 W

Correct Option(s): B