

Heisenberg's uncertainty principle states that it is fundamentally impossible to determine simultaneously both the exact position and momentum of a subatomic particle like an electron.

6. Which of the following is CORRECT according to Hund's rule? (1)
- A. **The lowest energy electron configuration for degenerate orbitals is the one with the maximum number of unpaired valence electrons**
 - B. No two electrons in a multi-electron atom have the same set of four quantum numbers; principal, secondary, magnetic and spin
 - C. The most stable atomic structures are those in which the electrons are in the lowest energy orbitals available
 - D. Electrons in an atom move in a circular orbits called stationary states and have a dual nature, particle and wave

Answer: A

According to Hund's rule, for degenerate orbitals, the lowest energy (most stable) electron configuration is the one with the maximum number of unpaired electrons with parallel spins.

7. Silver (Ag) has two stable isotopes; silver-107 (106.905 amu) that contributes 51.85% and silver-109 (108.905) contributes 48.15%. What is the relative atomic mass of silver? (1)
- A. 106.868
 - B. **✓ 107.868**
 - C. 108.868
 - D. 109.868

Answer: B

The relative atomic mass is calculated as the weighted average of the isotopic masses: $(106.905 \times 0.5185) + (108.905 \times 0.4815) = 55.430 + 52.438 = 107.868$ amu.

8. Which of the following is the class of an element with atomic number of 38? The element is: (1)
- A. a transition element
 - B. **✓ a representative element**
 - C. an inner transition element
 - D. post-translational element

Answer: B

The element with atomic number 38 is Strontium (Sr), which belongs to Group 2 (s-block). Representative elements include all s-block and p-block elements.

9. The average mass of the atoms in an element is known to be (1)
- A. isotopic mass
 - B. molar mass
 - C. equivalent mass
 - D. **✓ atomic mass**

Answer: D

The average mass of the atoms in a naturally occurring element, taking into account the abundance of its isotopes, is known as its atomic mass.

10. Which of the following statements is CORRECT about electromagnetic radiation? (1)
- A. **✓ The energy of an electromagnetic radiation increases with increase in its frequency**
 - B. The energy of an electromagnetic radiation increases with increase in its wavelength
 - C. The speed of an electromagnetic radiation is inversely proportional to its wavelength
 - D. The wavelength of an electromagnetic radiation is directly proportional to its frequency

Answer: A

According to the Planck relation ($E = h\nu$), the energy of electromagnetic radiation is directly proportional to its frequency (ν), so it increases as frequency increases.

11. Which of the following is the MOST STABLE ground state electronic configuration of Molybdenum? ($Z = 42$) (1)
- A. [Kr] 5s 2 4d 4
B. ✓ [Kr] 5s 1 4d 5
C. [Kr] 5s 2 4d 3
D. [Kr] 5s 1 4d 6

Answer: B

Molybdenum ($Z = 42$) has an anomalous electron configuration of [Kr] 5s¹ 4d⁵ instead of [Kr] 5s² 4d⁴, because a half-filled d-subshell offers extra stability.

12. Which of the following is NOT responsible for the shape of the modern periodic table? (1)
- A. valence electron
B. ✓ atomic mass
C. atomic number
D. the energy level

Answer: B

The modern periodic table is organized based on atomic number (electronic configuration), which determines groups (valence electrons) and periods (energy levels); atomic mass is not the organizing principle.

13. Which of the following is NOT included in the intermolecular forces found in covalent compounds? (1)
- A. Dipole-Dipole Forces
B. London Forces
C. Dispersion Forces
D. ✓ Electrostatic Forces

Answer: D

Electrostatic forces of attraction hold oppositely charged ions together in ionic compounds, whereas covalent compounds are held together by intermolecular forces such as dipole-dipole, dispersion, and London forces.

14. Among the following properties given below which one is CORRECT about crystalline solid? (1)
- A. Ionic crystals have weak inter-ionic forces, which makes them to have low melting points.
B. Molecular crystals are conductors of heat and electricity in molten state and usually have high melting points.
C. Covalent network crystals are conductors of heat and electricity and have low melting points.
D. ✓ Metallic crystals are ductile, malleable and they usually have high melting points.

Answer: D

Metallic crystals consist of metal cations surrounded by a sea of mobile valence electrons, making them ductile, malleable, and generally possessing high melting points.

15. Which of the following is observed in liquid water or solid ice due to hydrogen bonding? (1)
- A. Molecules of water are closer together in ice than in liquid water.
B. At the melting point of water, ice is denser than liquid water.
C. ✓ Molecules of water are closer together in liquid water than in ice.
D. When ice and water are mixed, the water floats on the surface of the ice.

Answer: C

Due to hydrogen bonding, ice forms an open, hexagonal cage-like structure, making it less dense than liquid water; thus, water molecules are packed more closely together in liquid water than in ice.

16. Among the following statements which explains the exception to the octet rule? When compound is formed, the central atom has: (1)
- A. eight electrons configuration.
B. ✓ more than eight electron configuration.
C. core element electron configuration.
D. noble gas electron configuration.

Answer: B

An exception to the octet rule occurs when the central atom in a molecule has an expanded valence shell, containing more than eight valence electrons (such as in SF₆ or PCl₅).

17. The properties of a covalent molecule depend on the intermolecular forces within the molecule. Which of the following is an example that can represent these phenomena? (1)
- A. ✓ **Polar cis -1, 2-dichloroethene has a higher boiling point than non-polar trans -1, 2-dichloroethene.**
 - B. Polar cis -1, 2-dichloroethene has a lower boiling point than non-polar trans -1, 2-dichloroethene.
 - C. Non-polar cis -1, 2-dichloroethene has a higher boiling point than polar trans -1, 2-dichloroethene.
 - D. Non-polar cis -1, 2-dichloroethene has a lower boiling point than polar trans -1, 2-dichloroethene.

Answer: A

cis-1,2-dichloroethene is polar because its dipoles reinforce each other, leading to strong dipole-dipole intermolecular attractions and a higher boiling point than the non-polar trans-isomer, where the dipoles cancel out.

18. Describe the hybridization scheme for the central atom of tetrachloroiodate, radical, ICl_4^- . (1)
- A. dsp^2
 - B. $\text{sp}^3 \text{d}$
 - C. ✓ **$\text{sp}^3 \text{d}^2$**
 - D. $\text{d}^3 \text{sp}^2$

Answer: C

The central iodine atom in ICl_4^- has 7 valence electrons, plus 4 from the chlorine atoms and 1 from the negative charge, giving 12 electrons (6 pairs). With 4 bonding pairs and 2 lone pairs, its steric number is 6, which corresponds to $\text{sp}^3 \text{d}^2$ hybridization.

19. "Reactant molecules are first transformed into an intermediate activated complex that is unstable and breaks into the products", this is called (1)
- A. reaction theory
 - B. collision theory
 - C. activation theory
 - D. ✓ **transition state theory**

Answer: D

According to transition state theory, reactants must pass through a high-energy, unstable intermediate state called the transition state or activated complex before forming products.

20. Which of the following differentiates between biological catalysts and non-biological catalysts? Biological catalysts (1)
- A. ✓ **are largely organic in nature while non-biological catalysts can be inorganic compounds.**
 - B. are largely inorganic in nature while non-biological catalysts can be organic compounds.
 - C. speed up chemical reactions while non-biological catalysts inhibit chemical reactions.
 - D. inhibit chemical reactions while non-biological catalysts speed up chemical reactions.

Answer: A

Biological catalysts (enzymes) are organic molecules (largely proteins), whereas non-biological catalysts can be inorganic substances such as metals, metal oxides, or acids.

21. What is the difference between homogenous and heterogeneous reactions? A reaction between substances in the same (1)
- A. state is called a homogenous reaction while between different states is heterogeneous reaction.
 - B. state is called heterogeneous reaction while between different states is homogenous reaction.
 - C. ✓ **phase is called a homogenous reaction while between different phases is heterogeneous reaction.**
 - D. phase is called heterogeneous reaction while between different phases is homogenous reaction.

Answer: C

A homogeneous reaction occurs within a single phase (e.g., entirely in gaseous or liquid solution), whereas a heterogeneous reaction occurs between reactants in different phases (e.g., solid and liquid).

22. Which of the following explains how transition state theory affects a reaction rate? (1)
- A. For reaction to occur, reactant molecules must collide with a certain minimum energy.
 - B. For reaction to take place, reactants must collide with the proper orientation.
 - C. The rate of reaction is directly proportional to the number of collisions per second.
 - D. **The rate of the reaction is dependent on the speed at which the reactants can clamp to the top of energy barrier.**

Answer: D

Transition state theory suggests that the rate of a reaction depends on the activation energy barrier, which represents the energy required for reactants to reach the transition state at the top of the barrier.

23. Rate constants of reactions are used when rates are determined experimentally. This is done by gathering data on the variation of (1)
- A. **concentration over time.**
 - B. time over concentration.
 - C. speed with time.
 - D. time with speed.

Answer: A

The rate of a chemical reaction is defined and experimentally determined by measuring the change in the concentration of reactants or products over a given period of time.

24. The decomposition of hydrogen iodide on gold surface is zero - order in HI. The rate constant for the reaction is 0.050 M/s. If the initial concentration of HI is 0.50 M, what is the half - life of this reaction? (1)
- A. 0.1 s
 - B. 1.0 s
 - C. 0.5 s
 - D. **5.0 s**

Answer: D

For a zero-order reaction, the half-life is calculated using the formula $t_{1/2} = [A]_0 / (2k)$. Substituting the given values yields $t_{1/2} = 0.50 \text{ M} / (2 * 0.050 \text{ M/s}) = 5.0 \text{ s}$.

25. An equation that defines the experimentally determined relation between the concentrations of reactants and rate of that reaction is known as _____. (1)
- A. **rate law**
 - B. rate constant
 - C. order of reaction
 - D. mechanism reaction

Answer: A

The rate law (or rate equation) is the experimentally determined expression that relates the rate of a chemical reaction to the concentrations of its reactants.

26. The ratio of the rate constant for the forward reaction over the reverse reaction is said to be _____. (1)
- A. gas constant
 - B. rate constant
 - C. reaction constant
 - D. **equilibrium constant**

Answer: D

The equilibrium constant (K_{eq}) is equal to the ratio of the rate constant of the forward reaction (k_f) to that of the reverse reaction (k_r).

27. Which of the following is CORRECT for a reaction at a chemical equilibrium? Given: Q_c is the reaction quotient and K_{eq} is the equilibrium constant (1)

- A. ✓ $Q_c = K_{eq}$ B. $Q_c > K_{eq}$
C. $Q_c \leq K_{eq}$ D. $Q_c \geq K_{eq}$

Answer: A

At chemical equilibrium, the rate of the forward reaction equals the rate of the reverse reaction, which means the reaction quotient (Q_c) is equal to the equilibrium constant (K_{eq}).

28. What is the value of equilibrium constant (K_p) for the following reaction? $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ Given: (1)
the equilibrium partial pressures of the three gases (SO_3 , O_2 and SO_2) are 0.10 atm, 0.25 atm and 0.50 atm, respectively.

- A. 0.625 atm B. ✓ 6.25 atm
C. 62.5 atm D. 625 atm

Answer: B

The equilibrium constant expression is $K_p = (P_{SO_2}^2 \cdot P_{O_2}) / P_{SO_3}^2$. Substituting the given partial pressures gives $K_p = (0.50^2 \cdot 0.25) / 0.10^2 = 0.0625 / 0.01 = 6.25$ atm.

29. The equilibrium constant K_c for the equilibrium reaction $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ is 6.1. In which direction will the reaction proceed to reach equilibrium? Given: $[CO] = 2.5$ M, $[Cl_2] = 1.0$ M and $[COCl_2] = 5.0$ M (1)

- A. ✓ Forward reaction B. Backward reaction
C. In the direction of the reactants D. Not possible to predict

Answer: A

The reaction quotient is $Q_c = [COCl_2] / ([CO][Cl_2]) = 5.0 / (2.5 \cdot 1.0) = 2.0$. Since Q_c (2.0) is less than K_c (6.1), the reaction will proceed in the forward direction to reach equilibrium.

30. Which of the following is the CORRECT order of carboxylic acid listed below based on the number of functional group that contains mono, di and tricarboxylic acids, respectively? (1)

- A. citric acid, acetic acid and oxalic acid B. oxalic acid, acetic acid and citric acid
C. acetic acid, citric acid and oxalic acid D. ✓ acetic acid, oxalic acid and citric acid

Answer: D

Acetic acid contains one carboxylic acid group (monocarboxylic), oxalic acid contains two (dicarboxylic), and citric acid contains three (tricarboxylic).

31. A triglyceride containing primarily unsaturated fatty acids is known as (1)

- A. ✓ oil B. ester
C. soap D. fat

Answer: A

Triglycerides containing primarily unsaturated fatty acids are liquid at room temperature and are referred to as oils, whereas those containing saturated fatty acids are solid and are called fats.

32. Which of the following methods is used for the preparation of saturated monocarboxylic acids? Oxidation of (1)

- A. ✓ primary alcohols B. secondary alcohols
C. tertiary alcohols D. quaternary alcohols

Answer: A

Saturated monocarboxylic acids are prepared by the complete oxidation of primary alcohols, typically using a strong oxidizing agent like acidified potassium dichromate.

33. Which of the following is the common use of esters? It is used for (1)
- A. making soaps, detergents and shampoos B. ✓ **making artificial flavors and perfumes**
C. preparation of carboxylic acids D. preparation of primary alcohols

Answer: B

Esters generally have pleasant, fruity odors and are widely used in the food and cosmetic industries for making artificial flavors and perfumes.

34. A student placed 50 mL of 1 M sulfuric acid into the 500 mL round - bottom flask. He/she added 5 g of sodium dichromate and a few pieces of broken porcelain. After mixing the resulting solution, he/she cooled the mixture under a running tap. He/she added 5 mL of ethanol drop-wise into the flask and boiled under reflux for 20 minutes. In this experiment ethanol (1)
- A. ✓ **is oxidized by sodium dichromate and produces acetic acid**
B. is reduced by sodium dichromate and produces acetic acid
C. reacts with sodium dichromate to produce ethane, carbon dioxide and water
D. reacts with sodium dichromate to produce an ester and water

Answer: A

Boiling ethanol under reflux with acidified sodium dichromate (a strong oxidizing agent) oxidizes the primary alcohol completely into acetic (ethanoic) acid.

35. "At a given temperature, the solubility of a sparingly soluble and chemical unreactive gas in a liquid is proportional to the partial pressure of the gas over the solution", this quantitative relationship is given by _____. (1)
- A. Raoult's law B. Hess's law
C. ✓ **Henry's law** D. Dalton's law

Answer: C

Henry's law states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the partial pressure of that gas above the liquid.

36. The ratio of the number of moles of a component in a mixture to the total number of moles in the mixture is known to be _____. (1)
- A. molarity B. molality
C. mole percent D. ✓ **mole fraction**

Answer: D

The mole fraction is defined as the ratio of the number of moles of a specific component to the total number of moles of all components in the mixture.

37. Which of the following distinguishes between homogenous and heterogeneous mixtures? In homogenous mixture (1)
- A. components are not distributed uniformly while in heterogeneous mixture the components are distributed uniformly
 - B. it contains distinct regions of different composition while in heterogeneous mixture the components do not have visible boundary
 - C. **components are distributed uniformly while in heterogeneous mixture the components are not distributed uniformly**
 - D. composition is not uniform while in heterogeneous mixture the components are mixed as individual atoms and molecules

Answer: C

In a homogeneous mixture (such as a solution), the components are distributed uniformly throughout, whereas in a heterogeneous mixture, the composition is non-uniform.

38. Which of the following explanations differentiates between suspensions and colloids? (1)
- A. **Suspensions are composed of particles that settle down in due course of time while colloidal particles do not settle down**
 - B. Suspensions are homogenous mixtures composed of particles visible to the naked eye while colloids are heterogeneous mixtures.
 - C. Colloids are composed of particles that settle down in due course of time while suspensions do not settle down.
 - D. Colloids are homogenous mixtures composed of particles visible to the naked eye while suspensions are heterogeneous mixtures.

Answer: A

Suspensions contain larger particles that settle out of the mixture over time due to gravity, whereas the smaller particles in colloids remain dispersed and do not settle.

39. How much water is added to 75 mL of 0.5 M HCl solution to prepare a 0.1 M HCl solution? (1)
- A. 75 mL
 - B. 150 mL
 - C. **300 mL**
 - D. 375 mL

Answer: C

Using $M_1 \cdot V_1 = M_2 \cdot V_2$, the final volume of the diluted solution is $V_2 = (0.5 \text{ M} \cdot 75 \text{ mL}) / 0.1 \text{ M} = 375 \text{ mL}$. Therefore, the volume of water added is $V_2 - V_1 = 375 \text{ mL} - 75 \text{ mL} = 300 \text{ mL}$.

40. Which of the following methods is used to prepare a supersaturated sodium thiosulfate solution? (1)
- A. **Slowly dropping the temperature of a saturated solution of sodium thiosulfate**
 - B. Increasing the volume of unsaturated solution through slow evaporation
 - C. Slowly increasing the temperature of unsaturated solution of sodium thiosulfate
 - D. Increasing the volume of a saturated solution through slow evaporation

Answer: A

A supersaturated solution is typically prepared by dissolving a large amount of solute in a solvent at an elevated temperature and then slowly cooling the saturated solution down without disturbance.

41. The maximum amount of a solute that dissolves in a given quantity of solvent at a given temperature is said to be _____. (1)
- A. molarity
B. molality
C. normality
D. ✓ **solubility**

Answer: D

Solubility is defined as the maximum concentration of a solute that can dissolve in a solvent at a given temperature and pressure to establish an equilibrium.

42. The ratio of the number of equivalents of the solute divided by the total volume of solution gives _____. (1)
- A. equivalent mass
B. molar mass
C. ✓ **normality**
D. molality

Answer: C

Normality (N) is defined as the number of gram-equivalent weights of solute per liter of solution.

43. Which of the following is CORRECT about the heat of solution? (1)
- A. If the solute-solvent attraction is stronger than both the solvent-solvent and solute-solute attraction, the solution process is endothermic.
- B. **If the solute-solvent attraction is stronger than both the solvent and solute-solute attraction, the solution process is exothermic.**
- C. If the solute-solvent attraction is stronger than both the solvent-solvent and solute-solute attraction, the solution process is neutral.
- D. The solution process is independent of solute-solvent, solvent-solvent or solute-solute attractions.

Answer: B

When solute-solvent interactions are stronger than the individual solute-solute and solvent-solvent attractions, the solution process releases energy and is exothermic.

44. Which of the following is the definition of an acid according to Lewis concept? An acid is a substance that: (1)
- A. increases $[H^+]$ when placed in water
B. decreases $[OH^-]$ when placed in water
C. ✓ **acts as an electron pair acceptor**
D. acts as a proton donor

Answer: C

According to the Lewis concept, an acid is defined as a chemical species that can accept a pair of electrons to form a covalent bond.

45. Which one of the following is a buffer solution? A mixture of (1)
- A. ethanoic acid and ethanol
B. ✓ **acetic acid and sodium acetate**
C. acetic anhydride and acetate ion
D. sodium ethanoate and ethyl alcohol

Answer: B

A buffer solution consists of a weak acid and its conjugate base. Acetic acid (a weak acid) mixed with sodium acetate (providing the conjugate acetate ion) forms a classic buffer system.

46. Which of the following determines the equivalent mass of acids and bases? (1)
- A. Total number of electrons transferred in a chemical reaction
 - B. ✓ **Number of hydrogen ions or hydroxide ions transferred in a chemical reaction**
 - C. Mole of reactants and products at the equilibrium point of the reactions
 - D. Mole of reactants and products at the start and at the end of a chemical reaction

Answer: B

The equivalent mass of an acid or a base is determined by dividing its molar mass by the number of moles of hydrogen ions (H^+) or hydroxide ions (OH^-) it transfers or neutralizes per mole of the substance.

47. What is the concentration of OH^- ions in a solution whose $pH = 6$? (1)
- A. $1.0 \times 10^{-6} M$
 - B. ✓ **$1.0 \times 10^{-8} M$**
 - C. $1.0 \times 10^{-6} M$
 - D. $1.0 \times 10^{-8} M$

Answer: B

Since $pH + pOH = 14$, a solution with $pH = 6$ has a $pOH = 8$. The concentration of hydroxide ions is therefore $[OH^-] = 10^{-pOH} = 1.0 \times 10^{-8} M$.

48. The pH of a $1.00 M$ solution of formic acid ($HCOOH$) is 1.88 . What is the percent ionization of formic acid? K_a of $HCOOH = 1.7 \times 10^{-4}$ (1)
- A. 0.013
 - B. ✓ **1.30**
 - C. 0.13
 - D. 13.0

Answer: B

A pH of 1.88 corresponds to a hydrogen ion concentration of $[H^+] = 10^{-1.88} \approx 0.0132 M$. The percent ionization of the $1.00 M$ formic acid is $\frac{0.0132}{1.00} \times 100\% \approx 1.30\%$.

49. What is the $[H^+]$ ion concentration in $1.0 \times 10^{-3} M$ solution of a weak acid (CH_3COOH), whose $K_a = 1.8 \times 10^{-5}$ (1)
- A. $4.13 \times 10^{-4} M$
 - B. ✓ **$1.34 \times 10^{-4} M$**
 - C. $4.13 \times 10^{-5} M$
 - D. $1.34 \times 10^{-5} M$

Answer: B

Using the simplified weak acid formula, the hydrogen ion concentration is $[H^+] \approx \sqrt{K_a \times C} = \sqrt{1.8 \times 10^{-5} \times 1.0 \times 10^{-3}} = \sqrt{1.8 \times 10^{-8}} \approx 1.34 \times 10^{-4} M$.

50. From the following alternatives, which one is a Brønsted-Lowry base? (1)
- A. ✓ **NH_3**
 - B. NH_4^+
 - C. H_2S
 - D. H_3O^+

Answer: A

According to the Brønsted-Lowry theory, a base is a proton acceptor. Ammonia (NH_3) can accept a proton to form the ammonium ion (NH_4^+), which makes it a Brønsted-Lowry base.

51. Which of the following is a CORRECT explanation for the existence of hydrogen ion (H^+) as hydronium ion (H_3O^+) in water? (1)

- A. ✓ **The small size and high charge of protons**
- B. The large size and small charge of protons
- C. The neutral pH of liquid water
- D. The small reactivity of water with protons

Answer: A

A bare proton (H^+) has an extremely small size and a high positive charge density, creating a strong electric field that causes it to immediately bind with a polar water molecule to form a hydronium ion (H_3O^+).

52. The difference between the reduction potentials of a voltaic cell's cathode and anode is known as _____. (1)

- A. electrode cell
- B. electrochemical cell
- C. electrochemical potential
- D. ✓ **cell potential**

Answer: D

The difference between the standard reduction potentials of the cathode and the anode in an electrochemical cell is known as the cell potential (E_{cell}°) or electromotive force (emf).

53. Which of the following is galvanic requires continuous supply of reactant and continuous removal of product to keep functioning? (1)

- A. Daniel cell
- B. Leclanché Cell
- C. ✓ **Fuel Cell**
- D. Mercury Cell

Answer: C

A fuel cell is a type of galvanic cell that does not store chemical energy; instead, it requires a continuous supply of reactants (like H_2 and O_2) and the continuous removal of products (like H_2O) to operate indefinitely.

54. Which of the following factors DOES NOT affect the preferential discharge of ions in the electrochemical series? (1)

- A. The nature of the electrodes
- B. ✓ **The nature of the ions in the electrolyte**
- C. The concentration of the ions in the electrolyte
- D. The position of the ions in the electrochemical series

Answer: B

The three standard factors affecting the preferential discharge of ions are their position in the electrochemical series, their concentration, and the nature of the electrodes. The "nature of the ions" is already accounted for by their position in the series.

55. During the electrolysis of dilute sulfuric acid solution, which of the following is discharged at the anode electrode? (1)
- A. OH⁻ ions are discharged in preference to SO₄²⁻ ions, because the concentration of OH⁻ ions is greater than SO₄²⁻ ions.
 - B. SO₄²⁻ ions are discharged in preference to OH⁻ ions, because the concentration of SO₄²⁻ ions is greater than OH⁻ ions.
 - C. **OH⁻ ions are discharged in preference to SO₄²⁻ ions, because the OH⁻ ion is below the SO₄²⁻ ion in the electrochemical series.** ✓
 - D. SO₄²⁻ ions are discharged in preference to OH⁻ ions, because SO₄²⁻ ions are stronger bases than OH⁻ ions.

Answer: C

During the electrolysis of dilute sulfuric acid, OH⁻ ions from water are discharged at the anode in preference to SO₄²⁻ because OH⁻ lies below SO₄²⁻ in the electrochemical series (it has a lower, less positive standard reduction potential and is easier to oxidize).

56. An electrolysis reaction of copper (II) sulfate deposited copper metal at the cathode and liberated oxygen gas at the anode. What are the electrodes used for this reaction? (1)
- A. Zinc electrodes
 - B. Magnesium electrodes
 - C. Copper electrodes
 - D. **✓ Platinum electrodes**

Answer: D

To deposit copper at the cathode and liberate oxygen gas at the anode during the electrolysis of CuSO₄, inert electrodes like platinum must be used. If copper electrodes were used, the copper anode itself would oxidize instead of water.

57. Which of the following is CORRECT about the environmental effects of corrosion? (1)
- A. is a non-redox reaction of metals
 - B. is the major factor to prevent rusting of iron
 - C. causes metals to be stronger in industry and construction
 - D. **✓ causes enormous damage to buildings, bridges, ships and cars**

Answer: D

Corrosion is a destructive electrochemical process where metals are oxidized by environmental agents, causing severe structural damage to buildings, bridges, ships, and vehicles.

58. Which of the following is the CORRECT half reactions at the electrodes and overall reaction observed during the electrolysis of CuSO₄ solution using inert electrodes? (1)
- A. Anode: 2Cu²⁺ (aq) + 4e⁻ → 2Cu (s) Cathode: 4OH⁻ (aq) → 2H₂O (l) + O₂ (g) + 4e⁻ Cell reaction: 2Cu²⁺ (aq) + 4OH⁻ (aq) → 2Cu (s) + 2H₂O (l) + O₂ (g)
 - B. **Anode: 4OH⁻ (aq) → 2H₂O (l) + O₂ (g) + 4e⁻ Cathode: 2Cu²⁺ (aq) + 4e⁻ → 2Cu (s) Cell reaction: 2Cu²⁺ (aq) + 4OH⁻ (aq) → 2Cu (s) + 2H₂O (l) + O₂ (g)** ✓
 - C. Anode: Cu (s) → Cu²⁺ (aq) + 2e⁻ Cathode: Cu²⁺ (aq) + 2e⁻ → Cu (s) Cell reaction: Cu (s) + Cu²⁺ (aq) → Cu²⁺ (aq) + Cu (s)
 - D. Anode: 2H₂O (l) + O₂ (g) + 4e⁻ → 4OH⁻ (aq) Cathode: 2Cu (s) → 2Cu²⁺ (aq) + 4e⁻ Cell reaction: 2Cu (s) + 2H₂O (l) + O₂ (g) → 2Cu²⁺ (aq) + 4OH⁻ (aq)

Answer: B

During the electrolysis of aqueous CuSO₄ with inert electrodes, oxidation of OH⁻ occurs at the anode (4OH⁻ → 2H₂O + O₂ + 4e⁻) and reduction of Cu²⁺ occurs at the cathode (2Cu²⁺ + 4e⁻ → 2Cu), yielding the correct overall cell reaction shown in option B.

64. Which of the following IS NOT made by an addition polymer?

(1)

- A. polyethylene
B. Teflon
C. Polystyrene
D. ✓ Polyester

Answer: D

Polyethylene, Teflon, and polystyrene are made via addition (chain-growth) polymerization of monomers containing double bonds, whereas polyester is a condensation (step-growth) polymer.

65. Which of the following polymers is a natural polymer?

(1)

- A. ☒ Glycogen
- B. Nylons
- C. Polystyrene
- D. Polyester

Answer: A

Glycogen is a highly branched polysaccharide of glucose that serves as energy storage in animals, making it a natural polymer. Nylons, polystyrene, and polyesters are synthetic polymers.

66. "Entropy of an isolated thermodynamic system always increases during a spontaneous process", this is called

(1)

- A.** Hess's law
- B. ✓ The second law of thermodynamics**
- C.** The first law of thermodynamics
- D.** The third law of thermodynamics

Answer: B

The Second Law of Thermodynamics states that the total entropy of an isolated system always increases over time for any spontaneous process.

67. What are the monomers of Bakelite, in a condensation polymer?

(1)

- A. Hexamethylene diamine and adipic acid
B. Terephthalic acid and ethylene glycol
C. Styrene and 1,3-butadiene
D. ✓ **Formaldehyde and phenol**

Answer: D

Bakelite is a thermosetting phenol-formaldehyde resin formed by the condensation polymerization of phenol and formaldehyde monomers.

68. Which of the following expression about entropy or entropy change is CORRECT?

(1)

- A. Entropy is the sum of internal energy and the pressure-volume product of a system.
- B. Entropy change for a chemical change is the product of the entropies of the products and the entropies of the reactants.
- C. ✓ **Entropy is the thermodynamic property of a system that is related to its degree of randomness.**
- D. Entropy change for a chemical change is the sum of the entropies of the reactants minus the sum of the entropies of the products.

Answer: C

Entropy is a thermodynamic quantity that represents the degree of disorder or randomness in a system, making option C correct. Option D incorrectly defines the sign of the entropy change.

69. What is the standard free energy change, ΔG° , for the complete combustion of methane? $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$ Given: The standard free energies of formation: - $\text{CH}_4(\text{g}) = -51 \text{ kJ/mol}$ - $\text{CO}_2(\text{g}) = -394 \text{ kJ/mol}$ - $\text{H}_2\text{O}(\text{l}) = -237 \text{ kJ/mol}$

(1)

- A. -631 kJ/mol
B. -632 kJ/mol
C. -838 kJ/mol
D. ✓ -817 kJ/mol

Answer: D

The free energy change is calculated as $\Delta G_{\text{rxn}}^{\circ} = [\Delta G_f^{\circ}(\text{CO}_2) + 2\Delta G_f^{\circ}(\text{H}_2\text{O})] - [\Delta G_f^{\circ}(\text{CH}_4) + 2\Delta G_f^{\circ}(\text{O}_2)] = [-394 + 2(-237)] - [-51 + 0] = -817 \text{ kJ/mol}$.

70. A process that occurs only as long as energy is continually applied to the system is said to be (1)
- A. thermodynamic process B. ✓ **nonspontaneous process**
C. spontaneous process D. equilibrium process

Answer: B

A nonspontaneous process is one that does not occur naturally on its own and requires a continuous external input of energy to drive the system.

71. What kind of system is formed by closing a flask containing water, so that NO water vapor can escape from or condense into the container? (1)
- A. An open system B. ✓ **A closed system**
C. An isolated system D. An adiabatic system

Answer: B

A closed system is one that prevents the transfer of matter (such as water vapor entering or escaping) but allows the transfer of energy (heat) across its boundary.

END OF THE MARKING KEY

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