

Chemistry, 2018 EC, entrance exam, version 3

Grade 12 · Chemistry · 2018 E.C.

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Questions: 75

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1. Which of the following sub atomic particle is used to determine chemical properties of elements? (1)
- A. proton
B. ✓ electron
C. Nucleus
D. Neutron

Answer: B

Electrons, particularly valence electrons in the outermost shell, are involved in chemical bonding and reactions, and therefore determine the chemical properties of elements.

2. An element has two isotopes with masses of 62.93 amu (69.17%) and 64.93 amu (30.83%). What is the average atomic mass? (1)
- A. 64.54 amu
B. ✓ 63.54 amu
C. 63.93 amu
D. 64.93 amu

Answer: B

The average atomic mass is calculated as $(62.93 \text{ amu} \times 0.6917) + (64.93 \text{ amu} \times 0.3083) = 43.53 + 20.02 = 63.55 \text{ amu}$, which rounds closely to 63.54 amu.

3. What is the effect of increasing atomic size on electronegativity down a group of periodic table? (1)
- A. The electronegativity increases because the atomic energy level increases.
B. The electronegativity increases because the atomic number increases.
C. ✓ The electronegativity decreases because the atomic size increases.
D. The electronegativity decreases because the atomic size decreases.

Answer: C

As you go down a group, atomic size increases due to the addition of electron shells, which increases the distance between the nucleus and valence electrons, thereby decreasing the electronegativity.

4. The periodic table contains two separate rows of inner transition elements located below the main table. These rows contain 14 elements each and belong to the 6th and 7th periods. Based on their position and electron configurations, which pair of element series correctly corresponds to 6th and 7th periods? (1)
- A. Halogenes, Nobel gas
B. ✓ lanthanoids, actinoids
C. chalcogens, halogens
D. actinoids, halogens

Answer: B

The lanthanoids (atomic numbers 57 to 71) belong to the 6th period, while the actinoids (atomic numbers 89 to 103) belong to the 7th period, and both series are placed below the main periodic table.

5. Aluminum reacts with a certain nonmetallic element, X to form a compound with the general formula AlX. Element X is a diatomic gas at room temperature. Element X must be (1)
- A. sulfur
B. fluorine
C. Bromine
D. ✓ **Nitrogen**

Answer: D

Aluminum has a +3 oxidation state, so for the neutral 1:1 compound AlX, X must have a -3 oxidation state. Nitrogen (N) is a diatomic gas (N₂) at room temperature and typically forms a -3 nitride ion, yielding AlN.

6. Ammonium ion (NH₄⁺) is formed when ammonia (NH₃) reacts with a hydrogen ion (H⁺). Which statement correctly analyzes the bond formed in the ammonium ion (NH₄⁺)? (1)
- A. All N-H bonds are ionic because the ion carries an overall positive charge.
B. ✓ **N-H bond is formed when nitrogen donates a lone pair of electrons to a hydrogen ion.**
C. N-H bonds are formed by transfer of electrons from hydrogen to nitrogen atom
D. The positive charge causes all bonds in the ion to become nonpolar covalent bonds.

Answer: B

The ammonium ion (NH₄⁺) is formed via a coordinate covalent bond where the nitrogen atom of ammonia donates its lone pair of electrons to the empty orbital of a hydrogen ion (H⁺).

7. A student misunderstood that London dispersion forces are insignificant and can be ignored when predicting physical properties. Which of the following is the best to evaluate this claim? (1)
- A. London forces exist only in gaseous molecules and not in liquids or solids.
B. London forces are the strongest type of interaction found in all substances.
C. ✓ **London forces exist in all molecules and become significant in large atoms.**
D. London forces only occur in ionic compounds and have no effect on molecules.

Answer: C

London dispersion forces exist in all atoms and molecules, polar or non-polar, and their strength increases significantly with molecular size and polarizability, which directly influences boiling and melting points.

8. Someone conducts an experiment by using a test tube with unknown compounds. If he/she touches the outer surface of the test tube during the reaction progress, he/she feels hot. This indicates the reaction that takes place in the test tube is _____. (1)
- A. absorbed heat from the surroundings.
B. ✓ **released heat energy to the surroundings.**
C. the unknown compound evaporated to atmosphere
D. heat is neither absorbed nor released during the reaction.

Answer: B

When a chemical reaction releases heat energy to its surroundings (exothermic), the temperature of the reaction vessel increases, making it feel hot to the touch.

9. If a student uses 2 grams of copper (II) oxide and obtains 1.60 grams of copper after reduction, which of the following statements correctly describes its law of definite proportion? (1)
- A. ✓ **The ratio of copper to oxygen remains constant in the compound.**
 - B. The compound contains more amount of oxygen than before.
 - C. The mass of copper depends on the volume of hydrogen gas used.
 - D. The changes temperature changes the composition of the compound.

Answer: A

The law of definite proportions states that a given chemical compound always contains its component elements in a fixed ratio by mass, which means the ratio of copper to oxygen in copper (II) oxide is constant regardless of the sample size.

10. Why does the electron configuration of chromium (Cr) deviate from the expected $[\text{Ar}] 4s^2 3d^4$? (1)
- A. ✓ **Half-filled d-orbitals are more stable than incomplete filled.**
 - B. d-orbital of Chromium is more stable than s-orbital
 - C. 4s orbital is in the higher energy than 3d orbital.
 - D. Electron fills the lower energy before higher energy.

Answer: A

Chromium adopts a $[\text{Ar}] 4s^1 3d^5$ configuration rather than $[\text{Ar}] 4s^2 3d^4$ because half-filled s and d subshells provide greater stability due to the symmetrical distribution of electrons and increased exchange energy.

11. Many classic experiments have given indirect evidence about the nature of the atom. Which statement below is NOT correct about the results of these experiments? (1)
- A. ✓ **Rutherford Experiment confirmed that Plum Pudding Model of the atom was correct.**
 - B. Dalton's atomic model stated that atoms are not subdivided into subatomic particles.
 - C. Oil Droplet Experiment showed that electric charge occurs in multi-electron charge.
 - D. Cathode Ray Tube Experiment demonstrated that electrons carry a negative electric charge.

Answer: A

Rutherford's gold foil experiment actually disproved the Plum Pudding Model by showing that the atom's positive charge and mass are concentrated in a tiny central nucleus rather than spread evenly throughout.

12. On the gold foil experiment, most alpha particles passed straight through the foil while a few were strongly deflected. What conclusion can be drawn from this observation? (1)
- A. Atoms are completely solid spheres and destructible.
 - B. Most of the mass of an atom is evenly distributed.
 - C. Electrons are embedded in a positive sphere of an atom.
 - D. ✓ **Atoms contain a small, dense, positively charged nucleus.**

Answer: D

Because most alpha particles passed straight through while only a few were strongly deflected, Rutherford concluded that the atom is mostly empty space with a tiny, dense, positively charged nucleus at its center.

13. Which of the following statements correctly relates wavelength, frequency, and speed of EMR in vacuum? (1)
- A. Wavelength increases, frequency increases, speed decreases
 - B. ✓ **Wavelength decreases, frequency increases, speed constant**
 - C. Wavelength increases, frequency decreases, speed decreases
 - D. Wavelength decreases, frequency decreases, speed constant

Answer: B

In a vacuum, all electromagnetic radiation travels at the same constant speed (c), and since $c = \lambda\nu$, wavelength (λ) and frequency (ν) are inversely proportional; thus, as wavelength decreases, frequency must increase.

14. Which combination represents all possible sets of quantum numbers for the 3d electrons? (1)
- A. ✓ **$n=3, l=2, m_l=-2,-1,0,1,2, m_s=\pm 1/2$**
 - B. $n=3, l=1, m_l=-1,0,1, m_s=\pm 1/2$
 - C. $n=3, l=2, m_l=-3,-2,-1,0,1,2,3, m_s=\pm 1/2$
 - D. $n=3, l=1, m_l=-2,-1,0,1,2, m_s=\pm 1/2$

Answer: A

For a 3d electron, the principal quantum number n is 3, the angular momentum quantum number l is 2, the magnetic quantum number m_l ranges from $-l$ to $+l$ ($-2, -1, 0, 1, 2$), and the spin quantum number m_s is $\pm 1/2$.

15. Which of the following sets shows the correct first four members of the alkane series? (1)
- A. Methane, Ethene, Propane, Butane
 - B. Methane, Methanol, Ethanol, Butanol
 - C. Methane, Ethyne, Propane, Butene
 - D. ✓ **Methane, Ethane, Propane, Butane**

Answer: D

Alkanes follow the general formula C_nH_{2n+2} . The first four members of the series are methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}).

16. Given elements: O, Be, N, B, F: which is the correct increasing order of first ionization energy? (1)
- A. $Be < B < N < O < F$
 - B. $F < B < Be < O < N$
 - C. $N < B < O < Be < F$
 - D. ✓ **$B < Be < O < N < F$**

Answer: D

While first ionization energy generally increases across a period, boron has a lower first ionization energy than beryllium because removing a 2p electron is easier than removing a paired 2s electron, and oxygen is lower than nitrogen because electron-electron repulsion in the paired 2p orbital of oxygen makes electron removal easier.

17. Which of the following statements is CORRECT regarding the formation of ionic compounds? (1)
- A. Ionic compounds are formed when electrons are shared between atoms.
 - B. Ionic compounds are formed between atoms with similar electronegativity.
 - C. ✓ **Ionic compounds form when electrons transferred from one atom to another.**
 - D. Ionic compounds formed by delocalization of electrons in metal.

Answer: C

Ionic compounds are formed when valence electrons are transferred from a metal atom to a non-metal atom, resulting in the electrostatic attraction between oppositely charged ions.

18. Why is graphite a good conductor of electricity, while diamond (C) is not, even though both are forms of carbon allotropes? (1)

- A. ✓ **Graphite has delocalized electrons due to its hexagonal structure, while diamond does not**
- B. Graphite is a metal having delocalized electron while diamond is a non-metal doesn't.
- C. Diamond has metallic bonding; while graphite forms ionic bond with each other.
- D. Both graphite and diamond have identical structures and conductivity randomly.

Answer: A

In graphite, each carbon atom is sp^2 hybridized, leaving one unhybridized valence electron per carbon free to delocalize across the layers and conduct electricity, whereas in diamond, all valence electrons are locked in localized sp^3 tetrahedral single bonds.

19. Which of the following lists correctly shows the strength of the intermolecular attractive forces in decreasing order? (1)

- A. ✓ **Hydrogen bond $\rightarrow$ dipole-dipole force $\rightarrow$ London force**
- B. Dipole-dipole force $\rightarrow$ Hydrogen bond $\rightarrow$ London force
- C. London force $\rightarrow$ dipole-dipole force $\rightarrow$ Hydrogen bond
- D. London force $\rightarrow$ Hydrogen bond $\rightarrow$ dipole-dipole force

Answer: A

Hydrogen bonding is the strongest type of intermolecular force among those listed, followed by dipole-dipole interactions, while London dispersion forces are typically the weakest.

20. When two chlorine atoms combine to form a chlorine molecule (Cl_2), a covalent bond is formed due to the overlapping of atomic orbitals. Which orbital overlap is responsible for the formation of the bond in Cl_2 ? (1)

- A. Side-by-side overlaps of two p orbitals to forms a π bond.
- B. ✓ **End-to-end overlap of two p orbitals to forms a σ bond.**
- C. End-to-end overlaps of two s orbitals to forms a σ bond.
- D. Side-by-side overlap of s orbital and p orbital forms a π bond.

Answer: B

Each chlorine atom has a half-filled 3p orbital in its valence shell. These two 3p orbitals overlap end-to-end along the internuclear axis to form a single covalent sigma (σ) bond.

21. You want to design a set of molecules whose central atoms all exhibit sp^2 hybridization. Using the concept of molecular geometry and hybridization, which of the following groups of molecules could best satisfy this requirement? (1)

- A. SO_2 , SO_4^{2-} , C_6H_6
- B. $CHCl_3$, C_6H_6 , C_2H_4
- C. ✓ **SO_2 , C_6H_6 , C_2H_4**
- D. $CHCl_3$, SO_2 , C_6H_6

Answer: C

The central S in SO_2 has two sigma bonds and one lone pair (steric number 3, sp^2); each C in benzene (C_6H_6) is bonded to three other atoms (steric number 3, sp^2); and each C in ethene (C_2H_4) is bonded to three other atoms (steric number 3, sp^2).

22. The molecule BF_3 consists of a boron atom bonded to three fluorine atoms. Based on VSEPR theory what is the shape and bond angle of BF_3 ? (1)
- A. Tetrahedral 109.5° bond angles
B. ✓ **Trigonal planar with 120° bond angles**
C. Linear with 180° bond angles
D. Bent with bond angles less than 120°

Answer: B

Boron in BF_3 has three bonding pairs and no lone pairs in its valence shell, which according to VSEPR theory yields a trigonal planar geometry with bond angles of exactly 120° .

23. Which of the following statements correctly describes Boyle's law? (1)
- A. The volume of a gas is directly proportional to temperature at constant pressure.
B. ✓ **The pressure of a gas is inversely proportional to its volume at constant temperature.**
C. The pressure of a gas is directly proportional to the number of moles at constant temperature.
D. The volume of a gas is directly proportional to pressure at constant temperature.

Answer: B

Boyle's law states that the pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature ($P \propto 1/V$).

24. Which of the following is NOT a pre-condition for a chemical reaction to occur? (1)
- A. Effective collision
B. Sufficient energy
C. proper orientation
D. ✓ **high activation energy**

Answer: D

For a chemical reaction to occur, reactant particles must collide with proper orientation and sufficient energy. A high activation energy is a barrier to a reaction rather than a pre-condition for it to take place.

25. Two substances X and Y have melting points of 100°C and 50°C , respectively. Which substance is more thermally stable as a solid? (1)
- A. Y, because it melts at lower temperature.
B. Both are equally stable at the given temperature.
C. ✓ **X, because it requires more heat to melt**
D. Impossible to guess.

Answer: C

A higher melting point indicates stronger intermolecular forces holding the solid lattice together, meaning substance X requires more heat energy to melt and is thus more thermally stable as a solid.

26. Which of the following changes will generally increase the rate of a reaction? (1)
- A. Decreasing temperature of the reaction.
B. Decreasing concentration of reactants.
C. ✓ **Using powdered solids instead of large size.**
D. Removing a catalyst from the reaction.

Answer: C

Using powdered solids instead of large chunks increases the surface area of the reactant, allowing more collisions per unit time and thus increasing the rate of reaction.

27. If K_{c1} and K_{c2} are the equilibrium constants for the two reactions: $\text{XeF}_6(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{XeOF}_4(\text{g}) + 2\text{HF}(\text{g}) \dots K_{c1}$ (1) and $\text{XeF}_4(\text{g}) + \text{XeF}_6(\text{g}) \rightleftharpoons \text{XeOF}_4(\text{g}) + \text{XeO}_3\text{F}_2(\text{g}) \dots K_{c2}$. What is the equilibrium constant for the reaction: $\text{XeF}_4(\text{g}) + 2\text{HF}(\text{g}) \rightleftharpoons \text{XeO}_3\text{F}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$?
- A. $K_{c1} - K_{c2}$ B. $K_{c2} - K_{c1}$
C. ✓ K_{c2}/K_{c1} D. K_{c1}/K_{c2}

Answer: C

The target reaction is obtained by reversing the first reaction (which has an equilibrium constant of $1/K_{c1}$) and adding it to the second reaction (K_{c2}). Therefore, the equilibrium constant of the target reaction is K_{c2}/K_{c1} .

28. How is the reaction quotient (Q_c) related to equilibrium constant (K_{eq})? (1)
- A. $Q_c < K_c$ after equilibrium B. $Q_c = K_c$ before equilibrium
C. ✓ **$Q_c = K_c$ at equilibrium** D. Q_c and K_c are not related

Answer: C

At chemical equilibrium, the rate of the forward reaction equals the rate of the reverse reaction, and the reaction quotient (Q_c) is equal to the equilibrium constant (K_c).

29. Which statement best explains why alcohols generally have higher boiling points than alkanes with similar molecular mass? (1)
- A. ✓ **Alcohols contain hydroxyl groups that form intermolecular hydrogen bonds.**
B. Alcohols molecules contain carbon atoms that increase intermolecular attractions.
C. Alcohols molecules have shorter carbon chains than most similar alkane molecules.
D. Alcohols molecules are less polar than alkanes with similar molecular masses.

Answer: A

Alcohols contain polar hydroxyl ($-\text{OH}$) groups that are capable of forming strong intermolecular hydrogen bonds, which require significantly more energy to overcome than the weaker London dispersion forces in alkanes.

30. Given the following compounds, what would be the correct decreasing order of boiling point? I. $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$ II. $\text{CH}_3(\text{CH}_2)_4\text{COOH}$ III. $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{COOH}$ (1)
- A. $\text{I} > \text{III} > \text{II}$ B. $\text{II} > \text{III} > \text{I}$
C. $\text{III} > \text{I} > \text{II}$ D. ✓ **$\text{II} > \text{I} > \text{III}$**

Answer: D

These compounds are structural isomers of hexanoic acid. Increased branching decreases the surface area of the molecule, weakening intermolecular dispersion forces and lowering the boiling point, yielding the order II (unbranched) $>$ I (single branch) $>$ III (double branch).

31. Which of the following describes a general method for synthesizing esters from carboxylic acids and alcohols, emphasizing reaction conditions and equilibrium? (1)
- A. Mixing alcohol and carboxylic acid without catalyst.
B. Carboxylic acids and alcohols are reacted under basic condition
C. ✓ **Heating of carboxylic acid and alcohol with concentrated H_2SO_4**
D. Esters formed only by oxidation of alcohols in the presence of Cu.

Answer: C

Fischer esterification involves heating a carboxylic acid and an alcohol in the presence of an acid catalyst, such as concentrated H_2SO_4 , which also acts as a dehydrating agent to drive the equilibrium toward ester formation.

32. Which evaluation correctly describes physical and chemical properties of oils? (1)
- A. Oils are solids and remain unreactive under all conditions.
 - B. Oils are polar solid and can't decompose when exposed to air.
 - C. ✓ **Oils are generally liquid undergo hydrogenation reaction**
 - D. Oils are nonpolar liquids but cannot react with acids and bases

Answer: C

Oils are liquid triglycerides because they contain a high proportion of unsaturated fatty acids with double bonds, which can undergo hydrogenation to yield solid saturated fats.

33. Why do tricarboxylic acids have higher boiling points than monocarboxylic acids? (1)
- A. Monocarboxylic acids are branched, lowering the boiling point.
 - B. Tricarboxylic acids are lighter, which increases boiling points.
 - C. Monocarboxylic acids contain double bonds, reducing its boiling point
 - D. ✓ **The more –COOH in tricarboxylic acid, forming stronger hydrogen bonds**

Answer: D

Tricarboxylic acids possess three carboxylic acid groups (–COOH) per molecule, allowing them to form a much more extensive and stronger network of intermolecular hydrogen bonds compared to monocarboxylic acids.

34. In a redox reaction: $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$. Which of the following statements correctly identifies the roles of the reactants? (1)
- A. MnO_2 is the reducing agent because the oxidation state of Mn increases.
 - B. HCl is the oxidizing agent because the oxidation state of Cl increases.
 - C. ✓ **MnO_2 is the oxidizing agent because the oxidation state of Mn decreases**
 - D. HCl is the reducing agent because the oxidation state of H decreases.

Answer: C

In this reaction, the oxidation state of Mn in MnO_2 decreases from +4 to +2, meaning it is reduced and therefore acts as the oxidizing agent.

35. When 5.0 g of magnesium reacts with 20.0 g of oxygen gas according to the reaction: $\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow \text{MgO(s)}$, What is the mass of MgO that can be formed? (1)
- A. ✓ **8.3 g**
 - B. 10.0 g
 - C. 16.7 g
 - D. 20.0 g

Answer: A

The balanced equation is $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$. Magnesium is the limiting reactant ($5.0 \text{ g} / 24.3 \text{ g/mol} = 0.206 \text{ mol}$), which yields 0.206 mol of MgO ($0.206 \text{ mol} * 40.3 \text{ g/mol} = 8.3 \text{ g}$).

36. A student crushes a large crystal of sugar into many small pieces before dissolving it in water. The sugar dissolves faster than the large crystal. Which of the following correctly describes the observation? (1)
- A. Increase in intermolecular force
 - B. ✓ **Increase the surface area of the molecule**
 - C. Increase in pressure of the system
 - D. Decrease temperature

Answer: B

Crushing the sugar crystal increases the total surface area of the solid, allowing more solvent molecules to collide with and dissolve the solute particles simultaneously.

37. A technician prepares a solution by dissolving 40 g of NaOH in enough water to make 500 mL of solution. What is the molarity (M) of this solution? (1)
- A. 1.0 M
B. ✓ 2.0 M
C. 0.5 M
D. 4.0 M

Answer: B

Molarity is defined as moles of solute per liter of solution. Since 40 g of NaOH is equal to 1.0 mole, dissolving it in 500 mL (0.5 L) of solution yields a molarity of $1.0 \text{ mol} / 0.5 \text{ L} = 2.0 \text{ M}$.

38. Which of the following oxides is classified as an amphoteric oxide? (1)
- A. CaO
B. SO₂
C. ✓ Al₂O₃
D. CO₂

Answer: C

Al₂O₃ is an amphoteric oxide because it can react with both acids (to form aluminum salts) and strong bases (to form aluminates).

39. Which of the following statements correctly applies to the formation and nature of salts? I. NaHSO₄ is a normal salt because all ionizable H⁺ from the acid are replaced. II. NaHSO₄ is acidic salt formed when ionizable H⁺ of the acid is not completely replaced by metal ions. III. Zn(OH)Cl is a basic salt because it contains one ionizable OH⁻ group in its formula. IV. Na₂CO₃ is a basic salt due to the presence of CO₃²⁻ that can be hydrolysis. (1)
- A. Only IV
B. Only II
C. ✓ II, III & IV
D. I, II & IV

Answer: C

NaHSO₄ is an acidic salt because it contains an ionizable hydrogen atom, making statement I false and statement II true. Zn(OH)Cl is basic due to the ionizable hydroxide group (III), and Na₂CO₃ produces a basic solution via carbonate hydrolysis (IV).

40. In a Galvanic cell consisting of Zinc and Copper electrodes, which of the following process occurs at the anode electrode? (1)
- A. Reduction half-cell reaction takes place
B. Copper ions are reduced to Copper metal.
C. Electrons flow from Copper to Zinc.
D. ✓ Zinc metal is oxidized to Zinc ions.

Answer: D

In a Zn-Cu galvanic cell, zinc is more active than copper and undergoes oxidation at the anode, losing electrons to form Zn²⁺ ions.

41. In the extraction of Iron using a blast furnace, what is the primary purpose of adding Limestone (CaCO₃) to the furnace? (1)
- A. Act as a reducing agent for the iron ore.
B. Provide the heat necessary for the reaction.
C. ✓ Remove impurities like silica (SiO₂)
D. Prevent the iron from re-oxidizing.

Answer: C

Limestone (CaCO₃) decomposes to calcium oxide (CaO), which reacts with acidic impurities such as silica (SiO₂) to form a molten slag (CaSiO₃) that can be easily separated from the iron.

42. Non-metals usually have poor electrical conductivity and are often brittle. However, they are widely used in electrical insulation and chemical industries. Which evaluation best explains how these properties affect their real-world uses? (1)
- A. Non-metals are unsuitable for all industrial applications because they are brittle.
- B. ✓ **Non-metals are useful as electrical insulators but their brittleness limits their use**
- C. Non-metals are mainly used for construction because they are strong and malleable
- D. Non-metals are good electrical and heat conductors like metal

Answer: B

Because non-metals have tightly bound valence electrons, they are excellent electrical insulators; however, their lack of metallic bonding makes them brittle, which can restrict their structural applications.

43. Abel is a grade 10 student. He took three different test tubes and added 5.00 ml of toluene to each test tube. Then he added 2 drops of Br₂ water in the first test tube, equal drops of cold KMnO₄ in the second test tube and again equal drops of concentrated H₂SO₄ in the third test tube. In which test tube does a reaction occur? (1)
- A. The 1st and the 3rd test tube
- B. The 2nd test tube and the 3rd test tube
- C. ✓ **The 3rd test tube**
- D. The 1st, 2nd and 3rd test tube

Answer: C

Toluene does not react with bromine water or cold KMnO₄ under ordinary conditions, but it readily undergoes electrophilic aromatic substitution (sulfonation) when treated with concentrated H₂SO₄.

44. Which of the following is the major limitation of the Arrhenius concept of acids and bases? (1)
- A. ✓ **It is limited to aqueous solutions**
- B. It explains proton transfer
- C. It includes Lewis acid-base reactions
- D. It applies to non-aqueous solvents

Answer: A

The Arrhenius theory defines acids and bases strictly in terms of H⁺ and OH⁻ ions produced in water, which limits its applicability to aqueous solutions and fails to explain acid-base behavior in non-aqueous solvents.

45. A grade 12 student prepares 0.20 M aqueous solution of Acetic acid in the laboratory, according to the ionization equation given: CH₃COOH(aq) ⇌ H⁺(aq) + CH₃COO⁻(aq): K_a = 1.8 × 10⁻⁵. Which of the following is the closest approximation of the hydrogen ion concentration? (√3.6 = 1.9) (1)
- A. ✓ **1.9 × 10⁻³ M**
- B. 1.9 × 10⁻⁸ M
- C. 1.9 × 10⁻⁵ M
- D. 1.9 × 10⁻⁴ M

Answer: A

Using the weak acid approximation, [H⁺] = sqrt(K_a * C) = sqrt(1.8 * 10⁻⁵ * 0.20) = sqrt(3.6 * 10⁻⁶) = 1.9 * 10⁻³ M.

46. Consider a solution that is 0.10 M acetic acid (CH₃COOH) and 0.20 M sodium acetate (NaCH₃COO). Which of the following statements is correct? (1)
- A. Adding a small amount of NaOH causes the pH to decrease slightly.
- B. When NaOH is added, the OH⁻ ions react with CH₃COO⁻ ions.
- C. ✓ **Adding a small amount of HCl causes the pH to decrease slightly.**
- D. When HCl is added, the H⁺ ions react with CH₃COOH molecules.

Answer: C

Adding a strong acid like HCl to a buffer causes a minimal decrease in pH as the added protons react with the conjugate base, sodium acetate.

47. Which of the following procedures can NOT produce a buffer solution? (1)
- A. ✓ **Equal volume of 0.5M NaOH and 1M HCl solution are mixed.**
 - B. Equal volume of 0.5M NaOH and 1M CH₃COOH solution are mixed.
 - C. Equal volume of 1M CH₃COONa and 1M CH₃COOH solution are mixed.
 - D. Equal volume of 1M NH₃ and 0.5 M HCl solution are mixed.

Answer: A

Mixing equal volumes of 0.5 M NaOH and 1 M HCl results in a solution with excess strong acid, which does not contain a weak conjugate acid-base pair and thus cannot function as a buffer.

48. A buffer solution is prepared using Acetic acid (CH₃COOH) and its conjugate base Sodium acetate (CH₃COONa). (1)
Under which condition will this buffer solution have maximum buffering capacity?
- A. ✓ **pH = pKa**
 - B. [A⁻] = 10[HA]
 - C. [HA] = 10[A⁻]
 - D. pH = pOH

Answer: A

A buffer solution has its maximum buffering capacity when the concentration of the weak acid equals that of its conjugate base, which corresponds to the point where pH is equal to pKa.

49. Which of the following salts will produce an acidic solution when dissolved in water? (1)
- A. ✓ **NH₄Cl**
 - B. CH₃COONa
 - C. NaCl
 - D. KNO₃

Answer: A

Ammonium chloride (NH₄Cl) is a salt derived from a strong acid (HCl) and a weak base (NH₃); the ammonium ion (NH₄⁺) undergoes hydrolysis to produce hydronium ions, resulting in an acidic solution.

50. The dye bromothymol blue (HBb) is a weak acid whose ionization can be represented as follows: HBb(aq) ⇌ H⁺(aq) + Bb⁻(aq). Which way will the equilibrium shift when NaOH is added? (1)
- A. Initially to the left, finally to right
 - B. Initially to the right finally to left
 - C. To the left
 - D. ✓ **to the right**

Answer: D

Adding NaOH introduces hydroxide ions (OH⁻) which neutralize hydrogen ions (H⁺). According to Le Chatelier's principle, the equilibrium shifts to the right to replenish the consumed H⁺ ions.

51. During laboratory class, a student placed clean water in a beaker and added pieces of calcium metal using tongs. Which of the following is observed color after the reaction has completed? (1)
- A. ✓ **The litmus paper turns to blue.**
 - B. The litmus paper turns to red.
 - C. The litmus paper maintains its color.
 - D. The litmus paper turns to colorless

Answer: A

Calcium metal reacts with water to produce calcium hydroxide, Ca(OH)₂, which is a basic solution that turns red litmus paper blue.

52. Which of the following statements is NOT correctly describing oxidation and reduction? (1)
- A. Oxidizing agent is a species being reduced and causes oxidation
 - B. Reducing agent is a species being oxidized and causes reduction.
 - C. ✓ **Oxidation is gain of electron while reduction is loss of electrons**
 - D. Oxidation and reduction reactions occur simultaneously

Answer: C

Oxidation is defined as the loss of electrons (OIL) and reduction is the gain of electrons (RIG), making statement C incorrect.

53. A chemist compares electrolysis of dilute NaCl solution and concentrated NaCl solution using inert electrodes. (1)
The substance produced at anode electrode of dilute NaCl solution and concentrated NaCl solution are _____ and _____ respectively.
- A. ✓ **Oxygen and chlorine.**
 - B. chlorine and chlorine
 - C. hydrogen and chlorine
 - D. Hydrogen and sodium

Answer: A

In dilute NaCl solution, water is preferentially oxidized at the anode to produce oxygen gas (O₂), whereas in concentrated NaCl, chloride ions are oxidized to produce chlorine gas (Cl₂) due to high concentration and overpotential.

54. An aqueous solution contains Ag⁺(aq) and Cu²⁺(aq) ions. Electrolysis is carried out using inert platinum electrodes. A constant current of 9.65 A is passed through the solution for 1000 seconds. Which metal will be deposited at the cathode and what mass will be deposited? (1)
- A. Copper, 10.8 g
 - B. ✓ **Silver, 10.8 g**
 - C. Silver, 5.4 g
 - D. Copper, 21.6 g

Answer: B

Since silver (Ag⁺) has a much higher reduction potential than copper (Cu²⁺), Ag⁺ is preferentially reduced. Passing 9.65 A for 1000 s provides 0.10 moles of electrons, which deposits 0.10 moles (10.8 g) of silver metal.

55. A Galvanic cell constructed from a strip of magnesium metal dipped in a solution of magnesium sulfate and a strip of silver metal immersed in a solution of silver nitrate. Which of the following correctly represents the cell notation for this galvanic cell? (1)
- A. Ag / Ag⁺ // Mg²⁺ / Mg
 - B. ✓ **Mg / Mg²⁺ // Ag⁺ / Ag**
 - C. Mg / Mg²⁺ / Ag⁺ / Ag
 - D. Ag / Ag⁺ // Mg / Mg²⁺

Answer: B

Magnesium is more active than silver, meaning it serves as the anode (oxidation) and silver serves as the cathode (reduction). The cell notation starts with the anode on the left and the cathode on the right: Mg / Mg²⁺ // Ag⁺ / Ag.

56. Aluminum metal reacts spontaneously with iron (II) ions according to the reaction: Al(s) + Fe²⁺(aq) → Al³⁺(aq) + Fe(s). What is the value of ΔG° for the reaction? (1)
- A. -1216 kJ
 - B. -608 kJ
 - C. ✓ **-706 kJ**
 - D. -203 kJ

Answer: C

For the balanced reaction, 6 moles of electrons are transferred (n = 6) and the cell potential is +1.22 V. Using ΔG = -nFE, we get -(6)(96485 C/mol)(1.22 V) = -706 kJ.

57. A metal pipeline buried underground is protected from corrosion by attaching a more reactive metal such as magnesium. Why does magnesium protect the iron pipe? (1)
- A. Magnesium decreases oxygen concentration around iron.
 - B. ✓ **Magnesium acts as a sacrificial anode and oxidizes first.**
 - C. Magnesium increases the potential of iron.
 - D. Magnesium prevents electron movement.

Answer: B

Magnesium has a lower reduction potential (is more active) than iron, allowing it to act as a sacrificial anode that oxidizes first, thereby protecting the iron pipe from corrosion.

58. Which of the following is considered a renewable resource? (1)
- A. Petroleum
 - B. Natural gas
 - C. ✓ **Solar energy**
 - D. Coal

Answer: C

Solar energy is classified as a renewable resource because it is continuously replenished by the sun and cannot be depleted, unlike fossil fuels.

59. At which stage of industrial manufacturing process of sulphuric acid, vanadium (V) oxide specifically required to ensure efficient industrial production? (1)
- A. ✓ **During the oxidation of sulfur dioxide to sulfur trioxide**
 - B. During the combustion of sulfur to produce sulfur dioxide
 - C. During the dilution of oleum with water to form sulfuric acid
 - D. During the reaction of sulfur trioxide with sulfuric acid to form oleum

Answer: A

Vanadium(V) oxide (V_2O_5) is used as a catalyst in the Contact process specifically during the key step where sulfur dioxide (SO_2) is oxidized to sulfur trioxide (SO_3).

60. Which one of the following fertilizers supplies the highest percentage of nitrogen to plants? (1)
- A. ✓ **Urea ($CO(NH_2)_2$)**
 - B. Urea Ammonium Nitrate ($CO(NH_2)_2 + NH_4NO_3$)
 - C. Diammonium Phosphate ($(NH_4)_2HPO_4$)
 - D. Monoammonium Phosphate ($NH_4H_2PO_4$)

Answer: A

Urea, $CO(NH_2)_2$, has a molar mass of 60 g/mol and contains 28 g/mol of nitrogen, translating to approximately 46.7% nitrogen, which is the highest among the choices.

61. Which of the following describes the process of manufacturing valuable products in industries? (1)
- A. ✓ **Designing to produce a desired output from raw materials using energy**
 - B. Discharging of a solid, liquid or gaseous substance into an environment
 - C. Unwanted reaction of a material those results in the dissolution of material.
 - D. Uses of only inorganic chemicals in the production of valuable products.

Answer: A

Industrial manufacturing is characterized by the systematic design and transformation of raw materials into valuable products using chemical processes and energy inputs.

62. Which type of glass is made by heating a mixture of silica, sodium carbonate and limestone? (1)
- A. Quartz
B. Pyrex
C. Borosilicate
D. ✓ Soda-lime

Answer: D

Soda-lime glass, the most common type of glass, is manufactured by melting a mixture of silica (sand), sodium carbonate (soda), and calcium carbonate (limestone).

63. Which of the following chemicals is commonly known as washing soda? (1)
- A. NaHCO_3
B. ✓ $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
C. NaOH
D. Na_2SO_4

Answer: B

Washing soda is the common household name for sodium carbonate decahydrate ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$).

64. Which of the following chemicals is mainly used to kill unwanted plants in agricultural fields? (1)
- A. Pesticides
B. ✓ Herbicide
C. Insecticide
D. Fungicide

Answer: B

Herbicides are chemical substances specifically formulated and used to kill or inhibit the growth of unwanted plants and weeds.

65. Which of the following is NOT a method of reducing water pollution? (1)
- A. Treatment of water before discharge into rivers and lakes.
B. Recycling and replacing of industrial and agricultural wastes.
C. Industries shouldn't discharge heat-laden water into water body.
D. ✓ Using high amount of agricultural chemicals and organic fertilizers.

Answer: D

Using high amounts of agricultural chemicals and fertilizers leads to nutrient runoff, causing eutrophication and severe water pollution, and is therefore not a reduction method.

66. Consider the following steps involved in the preparation of local alcohol (Araki). I: Fermentation of the mixture which converts sugars into ethanol. II: Preparation of the raw materials by crushing cereals and mixing them with water. III: Distillation of the fermented mixture to separate ethanol from water. IV: Heating the fermented mixture to produce alcohol, later condenses to liquid alcohol. Which of the following shows the correct sequence of steps in the preparation of local alcohol (Araki)? (1)
- A. ✓ II → I → IV → III
B. I → II → III → IV
C. II → IV → I → III
D. I → III → II → IV

Answer: A

The traditional preparation of Araki begins with preparing raw materials (II), followed by fermentation (I). The fermented mixture is then heated (IV) to undergo distillation (III) to separate and collect the ethanol.

67. What is the molar mass of a polyethylene sample, $[-\text{CH}_2-\text{CH}_2-]_n$, when $n = 4600$? (1)
- A. $1.288 \times 10^3 \text{ g/mol}$
B. ✓ $1.288 \times 10^5 \text{ g/mol}$
C. $1.196 \times 10^3 \text{ g/mol}$
D. $1.196 \times 10^4 \text{ g/mol}$

Answer: B

The molar mass of the monomer unit ($-\text{CH}_2-\text{CH}_2-$) is 28 g/mol. Multiplying this by the degree of polymerization ($n = 4600$) yields 128,800 g/mol, or $1.288 \times 10^5 \text{ g/mol}$.

73. Which of the following sample routine correctly indicates the extraction of copper from its principal ore? (1)
- A. ✓ **Concentration of ores → Roasting → Reduction → Purification**
- B. Concentration of ores → Purification → Roasting → Reduction
- C. Purification → Roasting → Reduction → Concentration of ores
- D. Concentration of ores → Roasting → Purification → Reduction

Answer: A

The metallurgical extraction of copper from its sulfide ores follows the standard sequence: concentration of ores (by froth flotation), roasting, reduction to obtain blister copper, and finally purification by electrolysis.

74. Which of the following is TRUE about a homologous series? (1)
- A. A group of compounds with different functional groups
- B. A group of isomers with the same boiling point
- C. Compounds with different molecular masses but the same formula
- D. ✓ **Hydrocarbons where each member differs from the next by a repeating unit $-CH_2$**

Answer: D

A homologous series is a series of organic compounds with similar chemical properties and the same functional group where each consecutive member differs by a repeating methylene ($-CH_2-$) unit.

75. The following reaction can be used for the synthesis of $CH_3CH=CHCH_3$ as a desired product: $CH_3CH_2CHBrCH_3 + CH_3S^- \rightarrow CH_3CH=CHCH_3 + CH_3SH + Br^-$. What is the atom economy for the above reaction? (1)
- A. 80%
- B. 48%
- C. 56%
- D. ✓ **30.4%**

Answer: D

Atom economy is calculated as (molar mass of desired product / sum of molar masses of reactants) x 100%. For this reaction, it is (56 g/mol of C_4H_8 / 184 g/mol of reactants) x 100% = 30.4%.

END OF THE MARKING KEY

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