

Chemistry, 2017 EC, natural science, entrance exam, round 1

Grade 12 · Chemistry · 2017 E.C.

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Time allowed: 120 minutes

Questions: 72

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1. Which type of glass is made by heating a mixture of silica, sodium carbonate and limestone? (1)

- A. Pyrex glass
B. ✓ Soda-lime
C. Borosilicate
D. Quartz

Answer: B

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

2. Consider the following galvanic cell: When the Zn strip was connected to metal 'B' at 25°C, the voltmeter shows 0.51 V. Which of the following is the standard reduction potential of metal 'B'? ($E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} = -0.76 \text{ V}$) (1)

- A. $E_{\text{B}^{2+}/\text{B}}^{\circ} = 1.27 \text{ V}$
B. $E_{\text{B}^{2+}/\text{B}}^{\circ} = 0.25 \text{ V}$
C. $E_{\text{B}^{2+}/\text{B}}^{\circ} = -1.27 \text{ V}$
D. ✓ $E_{\text{B}^{2+}/\text{B}}^{\circ} = -0.25 \text{ V}$

Answer: D

The standard reduction potential of Zn is -0.76 V . Since the cell potential is 0.51 V , using $E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$ and setting Zn as the anode yields $0.51 \text{ V} = E_{\text{B}^{2+}/\text{B}}^{\circ} - (-0.76 \text{ V})$, which gives $E_{\text{B}^{2+}/\text{B}}^{\circ} = -0.25 \text{ V}$.

3. Which of the following polymer is used to make ropes, clothes, hair combs and stockings? (1)

- A. Bakelite
B. Teflon
C. ✓ Nylon
D. Perspex

Answer: C

Nylon is a synthetic polyamide polymer that has high tensile strength and elasticity, making it ideal for manufacturing ropes, stockings, clothes, and combs.

4. Which of the following catalyst is used in the Ostwald process for the production of HNO_3 ? (1)

- A. CuO
B. Fe
C. V_2O_5
D. ✓ Pt

Answer: D

The Ostwald process converts ammonia to nitric acid, utilizing a platinum (Pt) or platinum-rhodium gauze catalyst in its first step of catalytic oxidation of ammonia.

5. Which of the following factors does NOT affect the rate of a chemical reaction having solid reactants? (1)

- A. ✓ Volume of reaction vessel
B. Physical state of reactants
C. Temperature of reaction
D. Concentration of reactants

Answer: A

The volume of the reaction vessel affects the reaction rate only when gaseous reactants are involved. It does not affect reactions occurring purely between solid reactants.

6. What is the electron configuration of O_2^- molecule as per the molecular orbital model? (Atomic number of O = 8) (1)
- A. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \sigma_{2p_x}^2 (\pi_{2p_y}^2 = \pi_{2p_z}^2) (\pi_{2p_y}^{*1} = \pi_{2p_z}^{*1})$
- B. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \sigma_{2p_x}^2 (\pi_{2p_y}^2 = \pi_{2p_z}^2) (\pi_{2p_y}^{*2} = \pi_{2p_z}^{*2})$
- C. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \sigma_{2p_x}^2 (\pi_{2p_y}^2 = \pi_{2p_z}^2) (\pi_{2p_y}^{*2} = \pi_{2p_z}^{*2})$
- D. ✓ $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \sigma_{2p_x}^2 (\pi_{2p_y}^2 = \pi_{2p_z}^2) (\pi_{2p_y}^{*2} = \pi_{2p_z}^{*1})$

Answer: D

The superoxide ion (O_2^-) has 17 electrons. According to the molecular orbital energy levels for oxygen, the 17th electron enters the degenerate antibonding π_{2p}^* orbitals, resulting in the configuration ending with $(\pi_{2p_y}^*)^2 = (\pi_{2p_z}^*)^1$.

7. At a particular temperature, the equilibrium constant, $K_c = 0.36$ for the reaction $SO_3(g) \rightleftharpoons SO_2(g) + O_2(g)$. Which of the following predictions can be drawn from the given data? (1)
- A. ✓ **It is not possible to predict the direction of the reaction.**
- B. The reaction will proceed to the right.
- C. The reaction will proceed to the left.
- D. The reaction is at equilibrium.

Answer: A

To predict the direction of a reaction, the reaction quotient (Q_c) must be compared to the equilibrium constant (K_c). Without knowing the current concentrations, the direction of the reaction cannot be predicted.

8. A mineral absorbs purple light of frequency 7.11×10^{14} Hz. What is the wavelength (in nm) of the absorbed light? ($c = 3.00 \times 10^8$ m/s) (1)
- A. 314.5 nm
- B. ✓ **421.9 nm**
- C. 237.5 nm
- D. 184.4 nm

Answer: B

Using the relationship $\lambda = c/\nu$, we find $\lambda = (3.00 \times 10^8 \text{ m/s}) / (7.11 \times 10^{14} \text{ s}^{-1}) = 4.22 \times 10^{-7} \text{ m}$, which is equal to 422 nm (option B is the closest at 421.9 nm).

9. Why do atoms absorb energy when their electrons undergo transitions from a lower energy to a higher energy level? This is because (1)
- A. The electrons of the atoms absorb energy when they go from higher to lower energy.
- B. The electrons of the atoms do not have allowable energy levels.
- C. The electrons of the atoms move from one orbit of higher radius to another one having lower radius.
- D. ✓ **The electrons of the atoms move from one orbit of lower radius to another one having larger radius.**

Answer: D

In Bohr's atomic model, electrons occupy discrete orbits where higher-energy orbits have a larger radius. Thus, moving to a higher energy level means transitioning to an orbit with a larger radius, which requires absorbing energy.

10. What are the quantum numbers for the 5s orbital? (1)
- A. ✓ $n = 5, l = 0, m_l = 0, m_s = \pm \frac{1}{2}$
- B. $n = 5, l = 2, m_l = -2, m_s = \pm \frac{1}{2}$
- C. $n = 5, l = 1, m_l = -2, m_s = \pm \frac{1}{2}$
- D. $n = 5, l = 0, m_l = -1, m_s = \pm \frac{1}{2}$

Answer: A

For a 5s orbital, the principal quantum number $n = 5$ and the angular momentum quantum number $l = 0$ (representing the 's' subshell). Consequently, the magnetic quantum number m_l must be 0, and m_s is $\pm \frac{1}{2}$.

11. Which of the following is CORRECT about the set of quantum numbers assigned to the two electrons of the helium atom? (1)
- A. The magnetic quantum numbers of both electrons are different.
 - B. ✓ **The second electron occupies the same orbital as the first with the opposite spin quantum number.**
 - C. The second electron occupies the same orbital as the first with the same spin quantum number.
 - D. Both electrons have the same four quantum numbers.

Answer: B

A helium atom has two electrons in its 1s orbital. According to Pauli's exclusion principle, no two electrons can have the same four quantum numbers, so the second electron must have an opposite spin quantum number ($m_s = -1/2$) compared to the first ($m_s = +1/2$).

12. What is the bond formed between two or more atoms by sharing of electrons? (1)
- A. Valence bond
 - B. ✓ **Covalent bond**
 - C. Metallic bond
 - D. Ionic bond

Answer: B

A covalent bond is defined as a chemical bond formed by the sharing of one or more pairs of electrons between atoms.

13. Which statement below CORRECTLY describes dipole-dipole forces? It is the force that exists (1)
- A. between polar and non-polar molecules.
 - B. between non-polar molecules.
 - C. ✓ **between polar molecules.**
 - D. in all

Answer: C

Dipole-dipole forces are electrostatic attractions that occur between the permanent dipoles of polar molecules.

14. Comparing the forces between molecules of similar molar masses, which one of the following produces the weakest force? (1)
- A. ✓ **Van der Waals forces.**
 - B. Ionic forces.
 - C. Hydrogen bonding.
 - D. Covalent bonds

Answer: A

Van der Waals forces are intermolecular forces, which are significantly weaker than intramolecular chemical bonds like ionic and covalent bonds.

15. Which of the following is NOT true about greenhouse effect and greenhouse gases? (1)
- A. ✓ **The greater the percentage of greenhouse gases in the atmosphere, the cooler the earth should be.**
 - B. Oxygen (O₂) and nitrogen (N₂) are transparent to infrared radiation.
 - C. Carbon dioxide and water vapor are greenhouse gases.
 - D. Greenhouse effect is the trapping of the infrared radiation by certain gases in the atmosphere

Answer: A

Greenhouse gases trap heat (infrared radiation) in the atmosphere. Therefore, a higher percentage of greenhouse gases causes the Earth to become warmer, not cooler, making option A false.

16. In which of the following is the type of natural resource and the given example CORRECTLY paired? (1)
- A. Non-Renewable Resources; water
 - B. Non-Renewable Resources; animal wool
 - C. ✓ **Renewable resources; crops**
 - D. Renewable resources; copper

Answer: C

Crops are renewable resources because they can be grown and replenished repeatedly over short periods, unlike copper which is finite and non-renewable.

17. Which of the following compound is a Bronsted-Lowry base?

(1)

- A. H_2S B. HCl
C. NH_3 D. BF_3

Answer: C

A Brønsted-Lowry base is defined as a proton (H^+) acceptor. Ammonia (NH3) has a lone pair of electrons on the nitrogen atom that can readily accept a proton to form the ammonium ion (NH4+).

18. In an activity during laboratory session a small amount of lead bromide (PbBr_2) crystals were placed in a beaker. Two electrodes are inserted until they are in contact with the PbBr_2 crystals. When the PbBr_2 crystals in the beaker are gently heated, which of the following will be observed?

- A. Lead (II) ion is oxidized at the cathode
B. Lead (II) ion is reduced at the anode
C. Bromide ion is oxidized at the cathode
D. ✓ **Bromine gas is evolved at the anode**

Answer: D

During the electrolysis of molten lead bromide (PbBr_2), bromide ions (Br^-) move to the positive electrode (anode) where they lose electrons (oxidation) to form reddish-brown bromine gas (Br_2).

19. What is the name given to the pollution caused by the dumping of non-biodegradable wastes into the environment? (1)

- A. Water pollution
B. Sound pollution
C. ✓ Land pollution
D. Air pollution

Answer: C

The accumulation and dumping of non-biodegradable solid wastes on land degrades the soil quality and leads directly to land pollution.

20. What is the purpose of the conversion of pig iron to steel? (1)

- D. ✓ To remove impurities by oxidation**

Answer: D

Pig iron contains high amounts of carbon and other impurities. The steelmaking process involves oxidizing these impurities (such as burning off excess carbon as carbon dioxide) to achieve the desired carbon content and purity.

21. Which of the following statements CORRECTLY describes the law of conservation of mass? (1)

- C. ✓ Mass is neither created nor destroyed during a chemical reaction.**

Answer: C

The law of conservation of mass states that mass can neither be created nor destroyed in a chemical reaction; therefore, the total mass of the reactants equals the total mass of the products.

22. What is the density of methane (CH_4) at a pressure of 900 torr and a temperature of 25°C ? ($R = 0.082 \text{ atm} \cdot \text{L/mol} \cdot \text{K}$, $1 \text{ atm} = 760 \text{ torr}$) (1)
- A. 9.2
B. 1.25
C. 0.92
D. ✓ 0.78

Answer: D

First convert pressure to atmospheres: $900/760 = 1.184 \text{ atm}$. Using the density formula for an ideal gas, $d = PM/RT = (1.184 \times 16)/(0.082 \times 298.15) \approx 0.78 \text{ g/L}$.

23. It takes 2.25 minutes for 0.02 mol of He to diffuse. How long will it take to diffuse for the same amount of methane gas, CH_4 ? (M.wt of He = 4 g/mol, CH_4 = 16 g/mol) (1)
- A. 6 min
B. ✓ 4.5 minutes
C. 2.25 min
D. 1.25 min

Answer: B

According to Graham's law of effusion, the rate of diffusion is inversely proportional to the square root of the molar mass, which means time is directly proportional: $t_2/t_1 = \sqrt{M_2/M_1}$. Thus, $t_{CH_4} = 2.25 \times \sqrt{16/4} = 4.5 \text{ minutes}$.

24. Which one of the following statement CORRECTLY defines rate of reaction? The rate of a reaction is (1)
- A. the measure of the rate of diffusion of different gases inside a tube.
B. the study of necessary mechanisms occurred in a chemical reaction.
C. the measure of the amount of energy change in a chemical reaction.
D. ✓ the changes in concentration of reactants or products per unit time.

Answer: D

The rate of a chemical reaction is defined as the change in the concentration of a reactant or product per unit of time.

25. Consider the following equilibrium: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -198.2 \text{ kJ}$. Which of the following changes will shift the equilibrium to the left? (1)
- A. ✓ Decreasing the concentrations of the reactants and increasing the concentration of the product.
B. Increasing the concentrations of the reactants and decreasing the concentration of the product.
C. Increasing the concentration of the reactants and products equivalently.
D. Decreasing the concentrations of the reactants and products equivalently.

Answer: A

According to Le Chatelier's principle, decreasing the concentration of reactants or increasing the concentration of products will shift the equilibrium to the left (towards the reactants) to counteract the change.

26. Aluminum reacts with oxygen to form aluminum oxide. What is the coefficient of aluminum after balancing the reaction? (1)
- A. 8
B. 6
C. ✓ 4
D. 2

Answer: C

The balanced chemical equation for the reaction of aluminum with oxygen is $4Al + 3O_2 \rightarrow 2Al_2O_3$, which gives aluminum a coefficient of 4.

32. Which of the following describes the process of manufacturing valuable products in industries? (1)
- A. Manufacturing industry uses only inorganic chemicals in the production of valuable products.
 - B. Carry out unwanted reaction of a material that result in the dissolution or consumption of the material.
 - C. Discharging of a solid, liquid or gaseous substance into an environment that causes unwanted changes.
 - D. ✓ **Designing to produce a desired output from raw materials using energy through different steps.**

Answer: D

Industrial manufacturing involves systematic, energy-consuming processes designed to transform raw materials into desired, valuable products through distinct physical and chemical steps.

33. For the dissociation of HNO_2 : $HNO_2(aq) \rightleftharpoons NO_2^-(aq) + H^+(aq)$ What is the percent ionization of a 0.5 M solution of HNO_2 ? (K_a of $HNO_2 = 7.1 \times 10^{-4}$) (1)
- A. 9.1%
 - B. ✓ **3.8%**
 - C. 1.8%
 - D. 0.2%

Answer: B

The concentration of hydrogen ions is $[H^+] = \sqrt{K_a \times C} = \sqrt{7.1 \times 10^{-4} \times 0.5} \approx 1.88 \times 10^{-2}$ M. The percent ionization is $([H^+] / [HNO_2]_{\text{initial}}) \times 100\% = (1.88 \times 10^{-2} / 0.5) \times 100\% \approx 3.8\%$.

34. Which of the following reaction shows the action of H_2SO_4 as oxidizing agent? (1)
- A. $Mg(s) + 2H_2SO_4(aq) \rightarrow 3MgSO_4(aq) + (NH_2)_2SO_4(aq)$
 - B. $Cu(s) + 2H_2SO_4(aq) \rightarrow CuSO_4(aq) + \checkmark SO_2(g) + 2H_2O(l)$
 - C. $2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$
 - D. $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

Answer: B

In reaction B, copper is oxidized from 0 to +2, while sulfur in sulfuric acid is reduced from +6 to +4 in SO_2 , demonstrating the role of H_2SO_4 as an oxidizing agent.

35. A 0.47 M aqueous solution of a weak base has a pOH of 2. What is K_b for the weak base? (1)
- A. 4.4×10^{-1}
 - B. 1.0×10^{-2}
 - C. 3.14×10^{-3}
 - D. ✓ **2.17×10^{-4}**

Answer: D

Since $pOH = 2$, $[OH^-] = 10^{-2} = 0.01$ M. Using the K_b expression for a weak base: $K_b = [OH^-]^2 / (C - [OH^-]) = (0.01)^2 / (0.47 - 0.01) \approx 2.17 \times 10^{-4}$.

36. A student was given a standard $Zn(s) | Zn^{2+}(aq)$ half-cell and another half-cell containing copper immersed in 1.00 M $CuSO_4(aq)$. When the Zn was connected as the anode at 25°C, the cell potential reading on the voltmeter shows 1.1 V. Which of the following is NOT correct regarding the cell potential measurement? (1)
- A. ✓ **Electrons travel through the external circuit from copper cathode to the zinc anode.**
 - B. The zinc electrode was dissolved and the blue color $CuSO_4$ solution would fade.
 - C. The circuit is completed inside the cell by migration of ions through the salt bridge.
 - D. The mass of copper was increased during the cell potential measurement.

Answer: A

In a Zn-Cu galvanic cell, zinc acts as the anode (oxidation site) and copper as the cathode (reduction site); therefore, electrons flow through the external circuit from the zinc anode to the copper cathode, making option A incorrect.

37. Which of the following properties is the property of an acidic oxide? An acidic oxide reacts with (1)
- A. ✓ **Water to form acids.**
 - B. Salts to form acids.
 - C. Basic oxides to form hydroxides and water.
 - D. Bases to form basic hydroxide and water.

Answer: A

Acidic oxides, which are typically oxides of non-metals, react with water to form acidic solutions (for example, $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$).

38. What is the name given to an acid that dissociates (ionizes) only to a slight extent in aqueous solution? (1)
- A. Strong acid
 - B. Dilute acid
 - C. Concentrated acid
 - D. ✓ **Weak acid**

Answer: D

A weak acid is defined as one that only partially ionizes or dissociates in an aqueous solution, unlike a strong acid which dissociates completely.

39. Solutions can be classified based upon their pH values. What is a solution whose pH value is 13? (1)
- A. Acidic solution
 - B. Amphoteric solution
 - C. ✓ **Basic solution**
 - D. Neutral solution

Answer: C

Solutions with a pH value greater than 7 at 25°C are basic; a pH of 13 indicates a highly basic (alkaline) solution.

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

Answer: B

Calcium reacts with water to produce calcium hydroxide, $\text{Ca}(\text{OH})_2$, which is a base and turns red litmus paper blue.

41. Which of the following statements CORRECTLY describes the relationship among wavelength, frequency and speed in electromagnetic radiation? (1)
- A. ✓ **As the wavelength decreases, the frequency increases.**
 - B. As the wavelength increases, the frequency increases.
 - C. As the frequency increases, the speed of light decreases.
 - D. As the wavelength decreases, the speed of light increases.

Answer: A

Since the speed of light is constant ($c = \lambda\nu$), wavelength (λ) and frequency (ν) are inversely proportional; thus, as wavelength decreases, frequency must increase.

42. Which of the following organic compounds has the highest boiling point? (1)
- A. Ethene
B. ✓ Ethanol
C. Ethane
D. Ethanal

Answer: B

Ethanol has the highest boiling point because it contains a highly polar -OH group that enables strong intermolecular hydrogen bonding, which requires much more thermal energy to overcome compared to the intermolecular forces in ethene, ethane, or ethanal.

43. What is a Lewis base? It is (1)
- A. Proton acceptor
B. Proton donor
C. ✓ Electron pair donor
D. Electron pair acceptor

Answer: C

According to the Lewis definition, a base is an electron-pair donor, while a Lewis acid is an electron-pair acceptor.

44. Given the following information: $\text{CH}_3\text{COOH}(\text{aq}) \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}^+(\text{aq})$ CH₃COOH CH₃COO⁻ H⁺ Initial concentration (mol/L) 0.2 0 0 Change -x +x +x Equilibrium concentration 0.2 - x x x Which of the following expressions represents the percent ionization of CH₃COOH? (1)
- A. ✓ $(x/0.2)100\%$
B. $((0.2-x)/0.2)100\%$
C. $(x/(0.2-x))100\%$
D. $((0.2)/x)100\%$

Answer: A

The percent ionization of a weak acid is calculated as the ratio of the equilibrium concentration of ionized acid (x) to the initial concentration of the acid (0.2) multiplied by 100%.

45. Scandium (Sc) has the electron configuration [Ar] 4s²3d¹. To which group of elements does it belong to? (1)
- A. ✓ Transition elements
B. Representative elements
C. Nonmetals
D. Inner transition elements

Answer: A

Scandium has its differentiating electron in a d-orbital (3d¹), which classifies it as a transition metal (d-block element).

46. A student carried out an experiment to determine the melting points of NaCl and CuCl₂. He/she added 0.2 g of NaCl and CuCl₂ into two different test tubes and heated both tubes simultaneously using a Bunsen burner. Which of the following statements is CORRECT regarding the melting point of NaCl and CuCl₂? (1)
- A. ✓ The melting point of NaCl is higher than that of CuCl₂.
B. The melting point of NaCl is lower than that of CuCl₂.
C. Both NaCl and CuCl₂ will not melt.
D. Both NaCl and CuCl₂ will melt at the same time.

Answer: A

NaCl is a highly ionic compound with a high melting point (801 °C), whereas CuCl₂ has significant covalent character due to the polarizing power of the Cu²⁺ ion, resulting in a lower melting point (498 °C).

47. What is the cause of unusual high boiling points of HF, H₂O and NH₃? (1)
- A. Induced dipole forces
B. Dipole-Dipole forces
C. Ion-dipole forces
D. ✓ Hydrogen bonding

Answer: D

HF, H₂O, and NH₃ exhibit unusually high boiling points because of hydrogen bonding, which is a strong type of intermolecular attraction that occurs when hydrogen is bonded to highly electronegative atoms (F, O, N).

48. Which statement below describes CORRECTLY the assumptions in the kinetic theory of gases? (1)
- A. ✓ **Gas molecules are in random motion with no interactions.**
 - B. Gas molecules occupy a finite volume and have indefinite shape.
 - C. The average kinetic energies of gas molecules are independent of the amount of gas.
 - D. The average kinetic energies of gas molecules are independent of temperature.

Answer: A

One of the fundamental assumptions of the kinetic-molecular theory of ideal gases is that gas molecules are in continuous, random motion and exert no attractive or repulsive forces on one another.

49. If the rate of diffusion of a certain unknown gas is half times the rate of diffusion of helium, what will be the molar mass of the unknown gas? (Atomic mass of He= 4.0 g/mole) (1)
- A. 8.0 g/mole
 - B. 2.0 g/mole
 - C. 32.0 g/mole
 - D. ✓ **16.0 g/mole**

Answer: D

By Graham's Law, $\text{Rate}_{\text{unknown}} / \text{Rate}_{\text{He}} = \sqrt{M_{\text{He}} / M_{\text{unknown}}}$. Given $0.5 = \sqrt{4 / M_{\text{unknown}}}$, squaring both sides yields $0.25 = 4 / M_{\text{unknown}}$, so $M_{\text{unknown}} = 16.0 \text{ g/mol}$.

50. A student added boiling chips into a beaker of water while carrying out an activity to determine the boiling point of water. Why do you think the boiling chips are necessary? (1)
- A. To speed up the rate of evaporation
 - B. ✓ **To ensure smooth rate of evaporation**
 - C. To reach the boiling point with less consumption of heat
 - D. To maintain constant temperature and pressure

Answer: B

Boiling chips provide nucleation sites that promote smooth, controlled boiling and prevent superheating and violent bubbling (bumping).

51. What is the oxidation number of manganese in KMnO_4 ? (1)
- A. +6
 - B. +5
 - C. +8
 - D. ✓ **+7**

Answer: D

In KMnO_4 , the alkali metal potassium has an oxidation number of +1 and each oxygen has -2. Since the compound is neutral, the sum of oxidation numbers is $1 + \text{Mn} + 4(-2) = 0$, which gives $\text{Mn} = +7$.

52. 2-methyl-1-butene is one of the isomers of C_5H_{10} . Which of the following is the CORRECT structural formula of this isomer? (1)
- A. ✓ **$\text{CH}_3\text{-CH}_2\text{-C(CH}_3\text{)=CH}_2$**
 - B. $\text{CH}_3\text{-CH(CH}_3\text{)-CH=CH}_2$
 - C. $\text{CH}_3\text{-CH=CH-CH}_2\text{-CH}_3$
 - D. $\text{CH}_3\text{-C(CH}_3\text{)=CH-CH}_3$

Answer: A

The formula $\text{CH}_3\text{-CH}_2\text{-C(CH}_3\text{)=CH}_2$ represents a 4-carbon parent chain with a double bond at carbon-1 (1-butene) and a methyl group at carbon-2, which is 2-methyl-1-butene.

53. Which of the following organic compounds is used for the production of 1, 2-ethanediol? (1)
- A. Ethane
B. ✓ Ethene
C. Ethanol
D. Ethyne

Answer: B

1,2-ethanediol (ethylene glycol) is manufactured industrially from ethene (ethylene) by oxidation to ethylene oxide followed by hydrolysis.

54. Which of the following is the main constituent of natural gas? (1)
- A. Butane
B. Ethane
C. ✓ Methane
D. Propane

Answer: C

Methane (CH₄) is the primary component of natural gas, typically making up about 70-90% of its composition.

55. In order to avoid the decrease in quality of some clothes after washing with water, which of the following chemicals is used for dry cleaning? (1)
- A. CH₂Cl₂
B. CH₄
C. ✓ C₂Cl₄
D. C₂H₄

Answer: C

Tetrachloroethylene (C₂Cl₄), also known as perchloroethylene or 'perc', is the most widely used solvent in the dry cleaning industry because of its stability and effective degreasing properties.

56. The molecule of BF₃ has both bonding and lone pair of electrons. Based upon these electrons, which one is the CORRECT molecular geometry of the molecule of BF₃? (1)
- A. Square pyramidal
B. Square planar
C. Trigonal bipyramidal
D. ✓ Trigonal planar

Answer: D

Boron trifluoride (BF₃) has three bonding pairs of electrons on the central boron atom and zero lone pairs, giving it a trigonal planar molecular geometry according to VSEPR theory.

57. Which law governs the fact that the ratio of the amount of hydrogen to oxygen by weight will be the same in a drop of water and a lake of water? (1)
- A. Law of conservation of mass
B. Law of relative composition
C. ✓ Law of definite proportion
D. Law of multiple proportions

Answer: C

The law of definite proportion (or constant composition) states that a given chemical compound always contains its component elements in a fixed ratio by mass, regardless of its source or quantity.

58. Which statement below CORRECTLY describes the characteristics of chemical equilibrium? (1)
- A. A reaction stops if sufficient amount of time is given.
B. A reaction stops when it reaches equilibrium.
C. A new substance or substances are formed when equilibrium is attained.
D. ✓ The rates of the forward and reverse reactions are equal.

Answer: D

Chemical equilibrium is a dynamic state where both the forward and reverse reactions continue to occur, but at equal rates, resulting in no net change in the concentrations of reactants and products.

59. What is the name given to compounds of carbon and hydrogen containing multiple bonds? (1)
- A. Aromatic hydrocarbons
B. Aliphatic hydrocarbons
C. ✓ **Unsaturated hydrocarbons**
D. Saturated hydrocarbons

Answer: C

Hydrocarbons containing at least one carbon-carbon double or triple bond (multiple bonds) are referred to as unsaturated hydrocarbons.

60. The following reaction can be used for the synthesis of $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ as a desired product: $\text{CH}_3\text{CH}_2\text{CHBrCH}_3 + \text{CH}_3\text{S}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{SH} + \text{Br}^-$ Which of the following is the atom economy for the above reaction? (Atomic masses: H=1; C=12; S=32 and Br=80) (1)
- A. 48%
B. ✓ **30.43%**
C. 80%
D. 56%

Answer: B

Though the equation has a typo and shows butane as the product, the calculation of 30.43% is based on the elimination reaction to form butene (C_4H_8 , molar mass 56 g/mol) as the desired product from reactants with a total mass of 184 g/mol ($56 / 184 * 100\% = 30.43\%$).

61. Which of the following process involves preventing the growth of bacteria, fungi and reducing the oxidation of fats? (1)
- A. Tanning
B. Haber-Bosch
C. Contact
D. ✓ **Food preservation**

Answer: D

Food preservation involves methods that inhibit microbial growth (bacteria, fungi) and retard the oxidation of fats to prevent spoilage and maintain food quality.

62. Which of the following is the overall reaction for electrolysis of molten NaCl? (1)
- A. ✓ **$\text{Na}^+(\text{l}) + \text{Cl}^-(\text{l}) \rightarrow \text{Na}(\text{l}) + \frac{1}{2}\text{Cl}_2(\text{g})$**
B. $\text{Na}^+(\text{l}) + \frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Na}^+(\text{l}) + \text{Cl}^-(\text{l})$
C. $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$
D. $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g})$

Answer: A

In the electrolysis of molten NaCl, sodium ions are reduced to sodium metal at the cathode, and chloride ions are oxidized to chlorine gas at the anode, resulting in the overall cell reaction: $\text{Na}^+(\text{l}) + \text{Cl}^-(\text{l}) \rightarrow \text{Na}(\text{l}) + \frac{1}{2}\text{Cl}_2(\text{g})$.

63. Which of the following occur during the electrolysis of dilute H_2SO_4 ? (1)
- A. The overall reaction is: $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$
B. SO_4^{2-} is discharged at the anode.
C. A basic solution is formed
D. ✓ **H^+ is discharged at the negative electrode**

Answer: D

In the electrolysis of dilute H_2SO_4 , hydrogen ions (H^+) migrate to the negative electrode (cathode) where they are discharged (reduced) to produce hydrogen gas.

64. Which statement below CORRECTLY distinguishes redox and non-redox reactions? (1)
- A. Reduction occurs in redox reactions and oxidation takes place in non-redox reactions.
 - B. ✓ **Electrons are transferred in redox reactions but not in non-redox reactions.**
 - C. Acid-base reactions can be considered as both redox and non-redox reactions.
 - D. Oxidation number remains the same in both redox and non-redox reactions

Answer: B

Redox reactions are characterized by the transfer of electrons between reactants (causing changes in oxidation numbers), whereas non-redox reactions do not involve any electron transfer.

65. Given the reaction: $\text{C(s)} + \text{CO}_2\text{(g)} \rightleftharpoons 2\text{CO(g)}$ What is the equilibrium constant expression for the reaction? (1)
- A. ✓ **$[\text{CO}]^2/[\text{CO}_2]$**
 - B. $[\text{CO}]^2/[\text{C}][\text{CO}_2]$
 - C. $[\text{C}][\text{CO}_2]/[\text{CO}]^2$
 - D. $[\text{CO}_2]^2/[\text{C}]$

Answer: A

Pure solids, such as carbon, C(s), have a constant active mass (concentration) and are excluded from the equilibrium constant expression, leaving $K_c = [\text{CO}]^2 / [\text{CO}_2]$.

66. Which of the following pair of substances can be considered as examples of the liquid state of matter at room temperature and 1 atm pressure? (1)
- A. Water and carbon dioxide
 - B. Carbon and mercury
 - C. Carbon and carbon monoxide
 - D. ✓ **Water and mercury**

Answer: D

Water (H₂O) and mercury (Hg) are both liquids at standard room temperature (25 degrees Celsius) and 1 atm pressure.

67. Which gas law describes the behavior of gases using the variables: temperature, volume, pressure and number of moles? (1)
- A. Boyle's law
 - B. ✓ **Ideal gas law**
 - C. Combined gas law
 - D. Avogadro's law

Answer: B

The ideal gas law ($PV = nRT$) describes the state of a gas by relating its pressure (P), volume (V), temperature (T), and amount in moles (n).

68. Which one of the following CORRECTLY shows the relative charges of an electron, proton and neutron, respectively? (1)
- A. 0, -1, +1
 - B. 0, +1, -1
 - C. -1, 0, +1
 - D. ✓ **-1, +1, 0**

Answer: D

An electron has a relative charge of -1, a proton has a relative charge of +1, and a neutron is electrically neutral with a relative charge of 0.

69. Which statement below CORRECTLY describes the Bohr's model of an atom? (1)
- A. Electrons and neutrons are found in the nucleus.
 - B. Protons and electrons are found in the nucleus.
 - C. ✓ **Electrons move in circular orbits around the nucleus.**
 - D. Protons move in circular orbits around the nucleus.

Answer: C

The Bohr model of the atom describes electrons as orbiting the central nucleus in fixed, circular paths (energy levels).

70. Which statement below CORRECTLY describes periodicity? Periodicity is (1)
- A. a row in the Periodic Table which contains elements with same number of shells.
 - B. ✓ **a regular repetition of chemical and physical properties in the Periodic Table.**
 - C. a column in the Periodic Table which contains elements with similar chemical properties.
 - D. a measure of electronegativity which runs from least electronegative to most electronegative elements.

Answer: B

Periodicity refers to the recurring, predictable variations and trends in the physical and chemical properties of elements as atomic number increases.

71. Which statement below CORRECTLY expresses hydrogen bonding? It is formed by bonding (1)
- A. ✓ **a hydrogen atom to an element such as oxygen.**
 - B. a hydrogen atom to an element such as sodium.
 - C. two hydrogen atoms with unequal sharing of electrons.
 - D. two hydrogen atoms with equal sharing of electrons.

Answer: A

Hydrogen bonding is a strong dipole-dipole intermolecular attraction that occurs when hydrogen is covalently bonded to highly electronegative atoms such as oxygen, nitrogen, or fluorine.

72. Consider the molecular structure of COCl_2 shown below. What are the predicted bond angles Cl-C-O and Cl-C-Cl ? (1)
- A. $\text{Cl-C-O} < 120^\circ$ and $\text{Cl-C-Cl} = 120^\circ$
 - B. Cl-C-O and $\text{Cl-C-Cl} = 120^\circ$
 - C. ✓ **$\text{Cl-C-O} > 120^\circ$ and $\text{Cl-C-Cl} < 120^\circ$**
 - D. $\text{Cl-C-O} = 120^\circ$ and $\text{Cl-C-Cl} > 120^\circ$

Answer: C

According to VSEPR theory, the central carbon atom in COCl_2 has a trigonal planar geometry. Because the C=O double bond has greater electron density than the C-Cl single bonds, it exerts stronger repulsion, widening the Cl-C-O bond angles to $>120^\circ$ and compressing the Cl-C-Cl angle to $<120^\circ$.

END OF THE MARKING KEY

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