

Chemistry, 2016 EC, natural science, entrance exam, round 1

Grade 12 · Chemistry · 2016 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 72

Total marks: 72

1. What are the molecular formulae of an alkene and alkyne containing seven carbon atoms, respectively? (1)
- A. ✓ **C 7 H 14 and C 7 H 12** B. C 7 H 16 and C 7 H 14
C. C 7 H 14 and C 7 H 16 D. C 7 H 12 and C 7 H 14

Answer: AAlkenes follow the general formula C_nH_{2n} (so for $n=7$, C_7H_{14}) and alkynes follow C_nH_{2n-2} (so for $n=7$, C_7H_{12}).

2. Which of the following is the CORRECT method of preparation of alkenes in the laboratory? (1)
- A. Alkylation of sodium acetylide with a primary alkyl halide.
B. Heating of sodium salt of an organic acid with soda lime.
C. Reaction of halogenated alkane with sodium.
D. ✓ **Dehydration of alcohols with concentrated sulfuric acid.**

Answer: D

Dehydration of alcohols using a strong acid catalyst like concentrated sulfuric acid is a standard laboratory method to prepare alkenes.

3. Which of the following is the product of fractional distillation of crude oil? (1)
- A. Producer gas B. Naphthalene
C. Water gas D. ✓ **Kerosene**

Answer: D

Kerosene is a major fraction obtained directly from the fractional distillation of crude oil, whereas producer gas and water gas are manufactured from coal or coke.

4. What is the molecular formula and IUPAC name of a saturated monocarboxylic acid having six carbon atoms? (1)
- A. C 5 H 11 COOH, heptanoic acid B. C 6 H 13 COOH, heptanoic acid
C. ✓ **C 5 H 11 COOH, hexanoic acid** D. C 6 H 13 COOH, hexanoic acid

Answer: CA saturated monocarboxylic acid with six carbon atoms has the IUPAC name hexanoic acid, and its molecular formula is $C_5H_{11}COOH$ (since one of the six carbons is in the carboxyl group).

5. During summer, the average value for the temperature measured in a certain chemistry laboratory is 298.15 K. (1)
How many decimal places are there in the measured value?
- A. 5 B. 3
C. ✓ **2** D. 1

Answer: C

The measured value 298.15 K has two digits after the decimal point, meaning there are 2 decimal places.

Having a pungent smell is a physical property because it can be observed without changing the chemical identity of the substance, unlike corrosiveness or decomposition upon light exposure, which are chemical properties.

11. Which of the following is the CORRECT explanation about herbicides? (1)
- A. ✓ **Selective herbicides control specific weed species, leaving the desired crop unharmed.**
 - B. Organochlorine compounds are the most common herbicide substances.
 - C. Herbicides are substances that are used to control unwanted insects.
 - D. Herbicides are substances that are used to enhance the growth of important plants.

Answer: A

Selective herbicides are specifically designed to control certain types of unwanted weeds while leaving the desired crop plants unharmed.

12. A student collected the following information from the community on the preparation of the local alcoholic drink "ARAKI": Step 1 : Distillation of the liquid mixture in traditional ways Step 2 : Adding a proportional amount of water to liquidity the tick dough - like mixture and leaving for 1-2 days for further fermentation Step 3 : "Bikel" preparation from barely, the starter ("Tinsess") preparation by mixing the Bikel with Gesho (Rhamunspronoides) powder and fermentation of the starter for few days Step 4 : Baking of bread from different ingredients and breaking down the bread and mixing with the fermented starter and leaving for fermentation for couple of days Which of the following is the correct procedure for the preparation of Araki? (1)
- A. Step 2 → Step 4 → Step 3 → Step - 1
 - B. Step 2 → Step 3 → Step 4 → Step - 1
 - C. ✓ **Step 3 → Step 4 → Step 2 → Step - 1**
 - D. Step 4 → Step 3 → Step 2 → Step - 1

Answer: C

Traditional preparation of Araki begins with making the starter 'Tinsess' from malted barley (Step 3), mixing it with baked bread for initial fermentation (Step 4), diluting the mixture with water for further fermentation (Step 2), and finally distilling it (Step 1).

13. Which one of the following synthetic polymers is used to make squeeze bottles, plastic wrapping and electrical insulation? (1)
- A. Polypropylene
 - B. Polymethyl methacrylate
 - C. Polyvinylchloride
 - D. ✓ **Polyethylene**

Answer: D

Polyethylene, especially low-density polyethylene (LDPE), is highly flexible and chemically inert, making it ideal for squeeze bottles, plastic wraps, and electrical wire insulation.

14. Which of the following descriptions of the property of a covalent compound is CORRECT? (1)
- A. ✓ **Covalent compounds have low melting and boiling points.**
 - B. Most covalent compounds are solids at room temperature.
 - C. Most covalent compounds are soluble in water.
 - D. Covalent compounds are non-volatile.

Answer: A

Covalent compounds generally have low melting and boiling points because the intermolecular forces holding the molecules together are relatively weak compared to ionic or metallic bonds.

15. The attractive force between molecules is known as _____. (1)
- A. nuclear force
 - B. ✓ **intermolecular force**
 - C. lattice force
 - D. intramolecular forces

Answer: B

Intermolecular forces are the attractive forces that exist between individual molecules, whereas intramolecular forces hold the atoms together within a single molecule.

16. The hybridization of the central atom xenon (Xe) in xenon tetrafluoride, XeF_4 , is sp^3d^2 . Which of the following is the shape of XeF_4 ? (1)
- A. Octahedral
B. ✓ **Square planar**
C. Tetrahedral
D. Seesaw shape

Answer: B

With sp^3d^2 hybridization, XeF_4 has 4 bonding pairs and 2 lone pairs on the central Xe atom, resulting in a square planar molecular geometry to minimize electron-pair repulsion.

17. Consider the following reaction between nitrogen (N_2) and oxygen (O_2): $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$. If the rate of disappearance of N_2 is $2.5 \times 10^{-6} \text{ M/s}$, what is the rate of reaction for the formation of NO? (1)
- A. ✓ **$5.0 \times 10^{-6} \text{ M/s}$**
B. $1.25 \times 10^{-3} \text{ M/s}$
C. $2.50 \times 10^{-3} \text{ M/s}$
D. $2.50 \times 10^{-6} \text{ M/s}$

Answer: A

According to the stoichiometry of the reaction, 2 moles of NO are formed for every 1 mole of N_2 consumed; therefore, the rate of formation of NO is twice the rate of disappearance of N_2 , which is $2 \times (2.5 \times 10^{-6} \text{ M/s}) = 5.0 \times 10^{-6} \text{ M/s}$.

18. Which of the following is a Lewis acid? (1)
- A. SO_4^{2-}
B. SO_3^{2-}
C. ✓ **BF_3**
D. NH_3

Answer: C

BF_3 is a Lewis acid because the central boron atom has only six valence electrons (an incomplete octet) and can accept an electron pair from a Lewis base.

19. The pH of a 0.10 M solution of an aqueous solution of a certain acid is 3. What is the value of acid ionization constant (K_a) of this acid? (1)
- A. 1.0×10^{-7}
B. ✓ **1.0×10^{-5}**
C. 1.0×10^{-3}
D. 1.0×10^{-1}

Answer: B

A pH of 3 means $[\text{H}^+] = 10^{-3} \text{ M}$. For a weak acid, $K_a \approx [\text{H}^+]^2 / [\text{HA}] = (10^{-3})^2 / 0.10 = 1.0 \times 10^{-5}$.

20. The shift in the position of equilibrium caused by the addition of an ion already involved in the reaction is known as _____. (1)
- A. ✓ **common-ion effect**
B. buffer-ion effect
C. hydrolysis-effect
D. titration-effect

Answer: A

The common-ion effect is the reduction in solubility or shift in equilibrium when an ionic compound containing an ion already present in the solution is added.

21. Which of the following is CORRECT about equivalents of acids and bases? (1)
- A. The volume of an acid or base required to reach equivalence point during acid-base titration reaction.
B. The number of moles of an acid or base required to form a one molar aqueous acidic or basic solution.
C. It is the amount of a substance that is required to react with one mole of hydroxide ions in redox reactions.
D. ✓ **It is the amount of a substance that is required to react with one mole of hydrogen ions in acid-base reactions.**

Answer: D

In acid-base chemistry, an equivalent of a substance is defined as the amount that either supplies or reacts with one mole of hydrogen ions (H^+).

22. A 250 mL solution is formed from 24.5 g of sulfuric acid (H_2SO_4). What is the normality of this solution? (Mol. wt. $\text{H}_2\text{SO}_4 = 98 \text{ g/mol}$) (1)
- A. 4.00 N
B. ✓ 2.00 N
C. 0.250 N
D. 0.125 N

Answer: B

Sulfuric acid (H_2SO_4) has a molar mass of 98 g/mol, so 24.5 g is 0.25 mol. In 250 mL (0.25 L), its molarity is 1.0 M, and since it is diprotic, its normality is $1.0 \text{ M} \times 2 = 2.00 \text{ N}$.

23. Which of the following reaction is used for the preparation of bases? (1)
- A. Reaction of metal hydroxides with dilute acids.
B. ✓ **Reaction of active metal oxides with water**
C. Heating of a salt with a non-volatile acid.
D. Heating of carbonates with dilute acids.

Answer: B

Active metal oxides, such as calcium oxide or sodium oxide, react directly with water to produce metal hydroxides, which are bases.

24. Which of the following salts is used in the treatment of waste water? (1)
- A. CaCO_3
B. BaSO_4
C. ✓ **FeCl_3**
D. KNO_3

Answer: C

Iron(III) chloride (FeCl_3) is widely used in wastewater treatment as a coagulant and flocculant to remove suspended solids and impurities.

25. A student prepared two beakers, each containing 100 mL of water. The student dissolved 10 mL of concentrated HCl in the first beaker and 10 mL of concentrated CH_3COOH in the second beaker, which of the following would occur in the solution? (1)
- A. **In the first beaker, a large fraction of HCl dissociates into ions and in the second beaker, a small fraction of CH_3COOH dissociates into ions.** ✓
B. In the first beaker, a small fraction of HCl dissociates into ions and in the second beaker, a large fraction of CH_3COOH dissociates into ions.
C. There is no dissociation or ionization of the HCl and CH_3COOH in both the first and second beakers.
D. The amount of HCl dissociated in the first beaker and the amount of CH_3COOH dissociated in the second beaker are identical.

Answer: A

Hydrochloric acid (HCl) is a strong acid that dissociates completely in water, whereas acetic acid (CH_3COOH) is a weak acid that only partially dissociates into ions.

26. Consider the following five-steps during the extraction of aluminum from its bauxite ore by the Hall process: I. Treating the mixture of an aqueous solution of sodium silicate and aluminate with an acid II. Heating aluminum oxide strongly in a furnace III. Heating the ore with sodium hydroxide solution IV Conversion of aluminum oxide to soluble sodium aluminate V. Electrolysis of molten mixture of cryolite and aluminum oxide Which of the following is the CORRECT sequence of production? (1)

- A. ✓ III, IV, I, II and V
B. IV, II, I, III and V
C. V, I, II, IV and III
D. II, I, III, IV and V

Answer: A

The correct sequence for the extraction of aluminum is: digesting the ore with NaOH (III), converting it to soluble sodium aluminate (IV), precipitating aluminum hydroxide with an acid/CO₂ (I), heating the hydroxide to form aluminum oxide (II), and finally undergoing electrolysis (V).

27. Which of the following food preservation methods leaves a product without loss of aroma or flavor? (1)

- A. Vacuum-packing
B. ✓ Freeze-drying
C. Freezing
D. Melting

Answer: B

Freeze-drying (lyophilization) dehydration occurs at very low temperatures under a vacuum, which preserves the original structure, aroma, and flavor of the food product better than other drying or preservation methods.

28. The electronic configuration of an element in the periodic table is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$. In which block does this element belong? (1)

- A. f-block
B. d-block
C. ✓ p-block
D. s-block

Answer: C

The electronic configuration ends in $4p^5$. Since the outermost electrons are filling the p-subshell, the element belongs to the p-block.

29. Which of the following is CORRECT about the formation of a covalent bond? A covalent bond is formed (1)

- A. between positively and negatively charged ions.
B. between mobile and stationary electrons.
C. ✓ by the sharing of valence electrons.
D. by the transfer of valence electrons.

Answer: C

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

30. The molecule of carbon tetrachloride (CCl₄) has four polar (C - Cl) bonds. However, CCl₄ is a non-polar molecule. Which of the following explains the reason for the observed property of CCl₄? (1)

- A. The molecule is non-polar because of the presence of four polar C-Cl bonds in the molecule.
B. The molecule is non-polar because of the difference in electronegativity between carbon and chlorine.
C. Even though the bond in CCl₄ is polar, the net dipole moment of the molecule is different from zero.
D. ✓ Even though the bond in CCl₄ is polar, the net dipole moment of the molecule is zero.

Answer: D

Carbon tetrachloride (CCl₄) has a highly symmetrical tetrahedral geometry, which causes the individual polar C-Cl bond dipoles to cancel each other out, resulting in a net dipole-moment of zero.

31. Which of the following is responsible for the unusual high boiling points of HF, H₂O and NH₃? (1)
- A. London dispersion forces
B. ✓ **Hydrogen bonding**
C. Covalent bonding
D. Ionic bonding

Answer: B

The unusually high boiling points of HF, H₂O, and NH₃ are due to strong intermolecular hydrogen bonding, which occurs when hydrogen is covalently bonded to highly electronegative atoms (F, O, N).

32. From the assumption of kinetic molecular theory of gases, which of the following is CORRECT? (1)
- A. The pressure of a gas is the effect of the negligible volume of the gas compared to the total volume of the gas.
B. The average kinetic energy of gas particles is inversely proportional to the absolute temperature of the gas.
C. There are some forces of attraction or repulsion between gas particles.
D. ✓ **Under ordinary conditions, the total volume of gas molecules is much smaller than the total volume of gas.**

Answer: D

According to the kinetic molecular theory, gas molecules are separated by distances much larger than their own dimensions, meaning the actual volume of the gas molecules is negligible compared to the volume of the container.

33. Which of the following is CORRECT about the phase change observed in water? (1)
- A. Water starts to evaporate at the boiling point and condenses at the melting point.
B. When a solid ice is heated, it is changed to liquid water without melting.
C. At the boiling point temperature, water exists in three different physical states.
D. ✓ **At the melting point of ice, the temperature remains constant.**

Answer: D

During a phase change, such as the melting of ice, the temperature remains constant because the added heat energy is used to overcome intermolecular forces rather than increase the average kinetic energy of the particles.

34. Given the symbols of the three subatomic particles; electrons (e⁻), protons (p⁺) and neutrons (n⁰), which of the following is the CORRECT comparison of the absolute masses of protons, electrons and neutrons? (1)
- A. Mass of e⁻ > mass of p⁺ = mass of n⁰
B. Mass of e⁻ = mass of p⁺ > mass of n⁰
C. ✓ **Mass of e⁻ < mass of p⁺ < mass of n⁰**
D. Mass of e⁻ > mass of p⁺ > mass of n⁰

Answer: C

The absolute mass of an electron (approx. 9.11×10^{-31} kg) is far less than that of a proton (approx. 1.673×10^{-27} kg), which in turn is slightly less than that of a neutron (approx. 1.675×10^{-27} kg), making the order mass of e⁻ < mass of p⁺ < mass of n⁰.

35. In the modern periodic table, what is the name of the group that contains the most electronegative elements? (1)
- A. Alkali
B. ✓ **Halogens**
C. Chalcogens
D. Noble gases

Answer: B

Group 17, the Halogens, contains the most electronegative elements in the periodic table, with fluorine being the most electronegative element of all.

36. A given element has atomic number of 55 and mass number of 133. Which of the following describes CORRECTLY the property of this element? (1)
- A. The non-metallic character of the element is high.
 - B. ✓ **The metallic character of the element is high.**
 - C. The element has high electron affinity.
 - D. The element has high electronegativity.

Answer: B

An element with atomic number 55 is Cesium (Cs), which is located at the bottom-left of the periodic table (Group 1, Period 6), exhibiting extremely high metallic character and reactivity.

37. Consider the mechanism for the decomposition of N_2O_5 to NO_2 : First step: $2\text{N}_2\text{O}_5(\text{g}) = 4\text{NO}_2(\text{g})$ Second step: $\text{N}_4\text{O}_{10}(\text{g}) \rightarrow \text{NO}_3(\text{g}) + 2\text{NO}_2(\text{g}) + \text{O}_3(\text{g})$ Third step: $\text{N}_2\text{O}_5(\text{g}) + \text{O}_3(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$ Overall: $2\text{N}_2\text{O}_5(\text{g}) \rightarrow 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$ Which step is the rate-determining step? (1)
- A. Third step
 - B. First step
 - C. The overall step
 - D. ✓ **Second step**

Answer: D

The second step is the slow step of the mechanism, which determines the overall rate of the chemical reaction and is known as the rate-determining step.

38. Consider the following reaction: $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) = 2\text{NO}(\text{g})$ The equilibrium concentrations of gaseous nitrogen, oxygen and nitrogen monoxide in a sealed container are as follows: $[\text{N}_2] = 1 \times 10^{-3} \text{ M}$, $[\text{O}_2] = 2 \times 10^{-5} \text{ M}$ and $[\text{NO}] = 4 \times 10^{-5} \text{ M}$. What is the value of the equilibrium constant for the reaction? (1)
- A. ✓ **8**
 - B. 2
 - C. 16
 - D. 4

Answer: A

The equilibrium constant is calculated as $K_c = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]} = \frac{(4 \times 10^{-5})^2}{(1 \times 10^{-3})(2 \times 10^{-5})} = 1.6 \times 10^{-9} / 2 \times 10^{-8} = 0.08$. Assuming the exponents in the question contained a minor typo, the numerical coefficient corresponds to 8.

39. At a certain temperature the following reaction has an equilibrium constant $K_c = 12.4$. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$ (1)
(g) If $[\text{N}_2] = 2.0 \text{ M}$, $[\text{H}_2] = 2.0 \text{ M}$ and $[\text{NH}_3] = 10.0 \text{ M}$, to which direction will the reaction proceed to reach equilibrium?
- A. The reaction will proceed to the reverse direction.
 - B. The reaction is at a chemical equilibrium.
 - C. The equilibrium is independent of the concentration.
 - D. ✓ **The reaction will proceed to the forward direction.**

Answer: D

The reaction quotient is calculated as $Q_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{10^2}{(2)(2^3)} = 6.25$. Since Q_c (6.25) is less than K_c (12.4), the reaction must proceed in the forward direction to reach equilibrium.

40. Upon standing long, "Tella" or "Tej" turns sour. Which of the following is the CORRECT explanation for the observed effect? (1)
- A. The reduction of alcohol to an acid.
 - B. ✓ **The oxidation of alcohol to an acid.**
 - C. Addition reaction of alcohol with an acid.
 - D. Decomposition reaction of alcohol.

Answer: B

When traditional fermented beverages like Tella or Tej stand for too long, ethanol (alcohol) is oxidized by bacteria in the presence of oxygen to form acetic acid, making the drink sour.

41. A student is interested in determining the content of a leaf from his/her environment and performed the following: Step: 1 He/she dried the leaves up in sun light Step: 2 Evaluated the work and draw conclusions Step: 3 Collected leaves from the tree around his village Step: 4 He/she boiled the leaves and collected the leaves extracted Step: 5 Analyze the content of the leaves extracted using an instrument Which of the following is the CORRECT procedure if a student developed an experimental skill? (1)
- A. Steps: 3 → 5 → 4 → 1 → 2
 - B. Steps: 3 → 4 → 1 → 5 → 2
 - C. ✓ **Steps: 3 → 1 → 4 → 5 → 2**
 - D. Steps: 3 → 1 → 5 → 4 → 2

Answer: C

The logical experimental procedure starts with collecting the leaves (Step 3), drying them (Step 1), boiling and extracting them (Step 4), analyzing the extract (Step 5), and finally drawing conclusions (Step 2).

42. "The hydrogen atom moves in a fixed circular orbit associated with allowable energy states" This is called _____. (1)
- A. Planck's theory
 - B. ✓ **Bohr's theory**
 - C. Pauli's principle
 - D. Aufbau's principle

Answer: B

Niels Bohr's model of the atom proposed that electrons orbit the nucleus in fixed circular paths corresponding to specific quantized energy levels.

43. Which of the following is the core electron configuration of the metal ion in ferric sulfate, $\text{Fe}_2(\text{SO}_4)_3$? (Atomic Number of Fe = 26) (1)
- A. $[\text{Ar}]4s^2 3d^6$
 - B. $[\text{Ar}]4s^1 3d^6$
 - C. $[\text{Ar}]3d^6$
 - D. ✓ **$[\text{Ar}]3d^5$**

Answer: D

Ferric sulfate contains iron in the Fe^{3+} state. Neutral Fe is $[\text{Ar}] 4s^2 3d^6$, so removing three electrons (two from 4s and one from 3d) yields the configuration $[\text{Ar}] 3d^5$.

44. A chemical bond that results from the attractive force between shared electrons and nonmetal nucleus is called _____. (1)
- A. ✓ **covalent bond**
 - B. ionic bond
 - C. hydrogen bond
 - D. metallic bond

Answer: A

A covalent bond is formed by the electrostatic attraction between the shared pair of electrons and the positively charged nuclei of the nonmetal atoms.

45. Which of the following is peroxide?

(1)

- A. ZnO
B. FeO
C. K₂O
D. ✓ **CaO₂**

Answer: D

CaO₂ (calcium peroxide) contains the peroxide ion (O₂²⁻), where each oxygen atom has an oxidation state of -1, unlike normal oxides where oxygen has an oxidation state of -2.

46. Among the following which one is a ternary acid?

(1)

- A. HBr
B. HCl
C. ✓ **H₂SO₄**
D. H₂S

Answer: C

A ternary acid is an acid composed of hydrogen, oxygen, and another nonmetal element. Sulfuric acid (H₂SO₄) contains three elements (H, S, and O), making it a ternary acid.

47. What is the pH of pure water at 37°C, where K_w equals 2.50×10^{-14} and its pH is 6.8? ($\log 10 0.4 = -0.4$)

(1)

- A. 8.8
B. 8.2
C. ✓ **6.8**
D. 7.5

Answer: C

For pure water, $[H^+] = [OH^-]$, so $[H^+] = \sqrt{K_w} = \sqrt{2.50 \times 10^{-14}} = 1.58 \times 10^{-7}$ M. Taking the negative logarithm gives $pH = -\log(1.58 \times 10^{-7}) = 7 - \log(1.58) \approx 6.8$.

48. The hydrogen ion concentration in a certain solution at 25 °C is 10×10^{-6} M. What is the pH of this solution?

(1)

- A. 8
B. 10
C. 2
D. ✓ **6**

Answer: D

Assuming the concentration is a typographical error for 1.0×10^{-6} M (often printed as 10^{-6} M), the pH is $-\log(10^{-6}) = 6$.

49. Given the following oxidation-reduction reaction: $H_2S + HNO_3 \rightarrow S + NO + H_2O$ Which of the following is CORRECT from the given equation?

(1)

- A. The oxidation number of N is increased.
B. The oxidation number of S is decreased.
C. S is a reducing substance.
D. ✓ **HNO₃ is an oxidizing agent.**

Answer: D

In this reaction, the oxidation state of nitrogen in HNO₃ decreases from +5 to +2 (it is reduced), which makes HNO₃ the oxidizing agent.

50. Consider the following diagram of an electrolytic cell: Which of the following is CORRECT from the given diagram

(1)

- A. Oxidation takes place at the cathode.
B. Reduction takes place at the anode.
C. ✓ **Magnesium ion is oxidizing agent in the electrode reaction.**
D. There is a decrease in oxidation number of chloride ion.

Answer: C

During the electrolysis of magnesium salts, magnesium ions (Mg²⁺) gain electrons (are reduced) at the cathode to form magnesium metal. Since Mg²⁺ is reduced, it acts as the oxidizing agent.

51. Which of the following is CORRECT about molten electrolytes and aqueous electrolytes? (1)
- A. The possible half reactions in molten electrolytes are more compared to aqueous electrolytes.
 - B. Both molten and aqueous electrolytes involve preferential discharge of ions at each electrode.
 - C. An electrolyte that conducts electricity when dissolved in a certain liquid is molten electrolyte.
 - D. ✓ **During the electrolysis of a molten electrolyte, the reduction of cations occurs at the cathode.**

Answer: D

In any electrolytic process, whether molten or aqueous, cations migrate to the cathode where they undergo reduction by gaining electrons.

52. Which of the following is NOT the industrial application of electrochemistry? (1)
- A. Electrolytic refining
 - B. Electroplating
 - C. ✓ **Electromagnetism**
 - D. Electro synthesis

Answer: C

Electromagnetism is a branch of physics concerning physical interactions of electric currents and magnetic fields, rather than a chemical process or industrial application of electrochemistry.

53. Which of the following chemical industries is INCORRECTLY matched with its products? (1)
- A. ✓ **Textile industry- glasses**
 - B. Beverage industry- alcohols
 - C. Food industry- Biscuits
 - D. Paper industry- cartons

Answer: A

The textile industry is involved in the design, production, and distribution of yarn, cloth, and clothing, whereas glass is produced by the glass/ceramic industry.

54. A student added 25 mL of AgNO_3 solution to a beaker and weighed the mass of the beaker and its content as m_1 . He/she added 50 mL of a saturated solution of NaCl into the second beaker and weighed the mass of the beaker and its content as m_2 . Finally, he/she mixed the two solutions and weighed the mass of the resulting solution with the two beakers and recorded as m_3 . If he/she found that $m_1 = m_2$, which one of the following laws is investigated by this trial? (1)
- A. Law of definite composition
 - B. Law of multiple proportions
 - C. Law of conservation of energy
 - D. ✓ **Law of conservation of mass**

Answer: D

Comparing the total mass of reactants before a reaction and the total mass of products after the reaction is the classic experimental method to demonstrate the Law of Conservation of Mass.

55. A chemical reaction that releases heat energy to the surrounding is known as _____. (1)
- A. ✓ **exothermic reaction**
 - B. endothermic reaction
 - C. decomposition reaction
 - D. combination reaction

Answer: A

An exothermic reaction is a chemical reaction that releases energy to its surroundings, usually in the form of heat.

56. A type of reaction in which two compounds react together to form two or more products by exchanging reactants ions is known as _____. (1)
- A. Decomposition reaction
 - B. Combination reaction
 - C. ✓ **Double Displacement reaction**
 - D. Single Displacement reaction

Answer: C

A double displacement (or metathesis) reaction is a type of reaction where two reactant ionic compounds exchange ions to form two new product compounds.

57. "At a given temperature and pressure, equal volumes of different gases contain equal number of molecules", this is known as _____ (1)
- A. Charle's law
B. Boyle's law
C. Gay Lussac's law
D. ✓ **Avogadro's law**

Answer: D

Avogadro's law states that equal volumes of all gases, at the same temperature and pressure, have the same number of molecules.

58. Which of the following includes the preconditions required for a chemical reaction to occur? (1)
- A. Temperature, activation energy, proper orientation
B. Temperature, pressure and proper orientation
C. ✓ **Activation energy, proper orientation and collision between reactants**
D. Activation energy, pressure and collision between reactants

Answer: C

According to collision theory, for a chemical reaction to occur, reactant particles must collide with each other, have sufficient kinetic energy (activation energy), and have the proper spatial orientation.

59. Consider the following reaction of zinc carbonate, ZnCO_3 : $\text{ZnCO}_3 (\text{s}) \rightarrow \text{ZnO}(\text{s}) + \text{CO}_2 (\text{g})$ The chemical reaction that takes place during the conversion of ZnCO_3 is classified as (1)
- A. ✓ **decomposition reaction**
B. combination reaction
C. double displacement reaction
D. single displacement reaction

Answer: A

The reaction shows a single reactant, zinc carbonate (ZnCO_3), breaking down into two simpler substances, zinc oxide (ZnO) and carbon dioxide (CO_2), which defines a decomposition reaction.

60. Given the following reaction: $\text{CaCO}_3 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$ (unbalanced) If 40 g of CaCO_3 reacts with 30 g of HCl , which substance is the limiting and which is the excess reagent? (Atomic Mass: $\text{Ca}=40 \text{ g/mol}$, $\text{C}=12 \text{ g/mol}$, $\text{O}=16 \text{ g/mol}$, $\text{H}=1 \text{ g/mol}$ and $\text{Cl}=35.5 \text{ g/mol}$) (1)
- A. HCl is limiting and CaCl_2 is excess reagents.
B. HCl is limiting and CaCO_3 is excess reactants.
C. CaCO_3 is limiting and CaCl_2 is excess reagents.
D. ✓ **CaCO_3 is limiting and HCl is excess reactants.**

Answer: D

The balanced equation is $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$. Since 40 g of CaCO_3 (0.4 mol) requires 0.8 mol (29.2 g) of HCl , and we have 30 g (0.82 mol) of HCl , CaCO_3 is the limiting reactant and HCl is the excess reactant.

61. A sample of a certain gas has a volume of 100 L at 27°C and 750 torr. The gas is expanded to a volume of 250 L at 200 torr. What is the final temperature of the gas? (1)
- A. -83°C
B. ✓ **-73°C**
C. -17°C
D. -273°C

Answer: B

Using the combined gas law, $T_2 = T_1 * (P_2 * V_2) / (P_1 * V_1) = 300 \text{ K} * (200 * 250) / (750 * 100) = 200 \text{ K}$. Converting to Celsius: $200 - 273 = -73^\circ\text{C}$.

62. Which of the following is a CORRECT explanation of the given term? (1)

- A. **Boiling point is the temperature at which the vapor pressure of the liquid equals the atmospheric pressure.**
- B. Condensation is the process by which a liquid changes to a gas at the boiling point of the liquid.
- C. Normal boiling point is the temperature at which the liquid starts to be converted to the gaseous state.
- D. Heat of vaporization is the energy required to convert one gram of a solid to a gas at its boiling point.

Answer: A

The boiling point of a liquid is precisely defined as the temperature at which its equilibrium vapor pressure equals the surrounding atmospheric or external pressure.

63. Which of the following is the general formula of alkenes? (1)

- A. $C_n H_{2n-2}$
- B. $C_n H_{2n+2}$
- C. $C_n H_n$
- D. **$C_n H_{2n}$**

Answer: D

Alkenes are unsaturated hydrocarbons containing at least one carbon-carbon double bond, and their general homologous formula is $C_n H_{2n}$.

64. What are the two types of polymerizations? (1)

- A. Condensation and substitution polymerizations
- B. Addition and decomposition polymerizations
- C. Condensation and displacement polymerizations
- D. **Addition and condensation polymerizations**

Answer: D

Polymerization reactions are broadly classified into two main types based on their reaction mechanism: addition (chain-growth) polymerization and condensation (step-growth) polymerization.

65. Which of the following is a monomer of natural rubber? (1)

- A. Ethylene terephthalate
- B. Styrene
- C. Hexamethylene diamine
- D. **Isoprene**

Answer: D

Natural rubber is a polymer of the organic compound isoprene (2-methyl-1,3-butadiene), which is its repeating monomer unit.

66. The component of the environment consisting earth's upper outer most skin, and accessible to human beings is known as _____. (1)

- A. biosphere
- B. **lithosphere**
- C. hydrosphere
- D. atmosphere

Answer: B

The lithosphere is the rigid, outermost rocky shell of the Earth, which comprises the crust and the upper mantle, and is directly accessible to human activity.

67. Consider the following steps that occur during the nitrogen cycle: Step: 1 Reduction of nitrate by microbial action Step: 2 Fixation of nitrogen by bacteria and algae Step: 3 Nitrification by nitrososnas and nitrobactra Step: 4 Denitrification of nitrate with acid and formaldyde Which of the following is the CORRECT sequence in the nitrogen cycle? (1)
- A. Step 2 → Step 3 → Step 4 → Step 1
B. Step 1 → Step 2 → Step 3 → Step 4
C. ✓ **Step 2 → Step 3 → Step 1 → Step 4**
D. Step 1 → Step 3 → Step 4 → Step 2

Answer: C

The nitrogen cycle begins with nitrogen fixation (Step 2), followed by nitrification (Step 3), microbial assimilation/reduction (Step 1), and ends with denitrification (Step 4) which returns nitrogen gas to the atmosphere.

68. Some hazardous substances damage and create unwanted changes in air, water, soil or any other natural resource. The resulting change created is known as: (1)
- A. afforestation
B. ✓ **pollution**
C. greenhouse effect
D. global warming

Answer: B

Pollution is defined as the introduction of contaminants into the natural environment that cause adverse, harmful, or unwanted changes to resources like air, water, and soil.

69. Given the following heterogeneous reaction: $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ What is the equilibrium constant expression for the above reaction? (1)
- A. $K_c = [\text{CaO}][\text{CO}_2]$
B. $K_c = [\text{CaO}][\text{CO}_2]/[\text{CaCO}_3]$
C. ✓ **$K_c = [\text{CO}_2]$**
D. $K_c = [\text{CaO}]/[\text{CaCO}_3]$

Answer: C

In a heterogeneous equilibrium, the concentration of pure solids (such as CaCO_3 and CaO) is constant and is omitted from the equilibrium expression, leaving only the gaseous species: $K_c = [\text{CO}_2]$.

70. Which of the following statements is CORRECT regarding the properties of monocarboxylic acids? (1)
- A. ✓ **Carboxylic acids react with active metals to form salt and hydrogen gas.**
B. The hydrolysis of carboxylic acids in water produces an ester and water.
C. Carboxylic acids react with strong bases to form esters and water.
D. Heating of carboxylic acid with alcohol produces salt and water.

Answer: A

Like mineral acids, monocarboxylic acids are acidic enough to react with active metals (such as sodium or magnesium) to liberate hydrogen gas and produce a metal carboxylate salt.

71. A water molecule has two bond pairs and two lone pairs of electrons. Which of the following is CORRECT about these pairs of electrons? (1)
- A. The repulsion between the two bonding pairs is greater than the repulsion between the two lone pairs.
B. ✓ **The repulsion between the two lone pairs is greater than the repulsion between the two bonding pairs.**
C. Bonding pair - lone pair repulsion is greater than lone pair - lone pair repulsion.
D. Lone pair - lone pair repulsion is exactly identical with bonding pair - bonding pair repulsion.

Answer: B

According to the Valence Shell Electron Pair Repulsion (VSEPR) theory, the order of repulsive forces is lone pair-lone pair > lone pair-bond pair > bond pair-bond pair. Therefore, the repulsion between the two lone pairs in a water molecule is greater than the repulsion between its two bonding pairs.

72. Which of the following CORRECTLY describes conjugate acids and conjugate bases?

(1)

- A. Conjugate acid is a species formed after a removal of a proton from a base whereas conjugate base is formed after addition of proton to an acid.
- B. **Conjugate base is a species formed after removal of a proton from an acid whereas conjugate acid is ✓ formed after addition of a proton to a base.**
- C. Conjugate acid has one fewer hydrogen and one more minus charge than the corresponding acid.
- D. Conjugate base has one more hydrogen and one fewer minus charge than the corresponding base.

Answer: B

According to the Brønsted-Lowry acid-base theory, a conjugate base is formed when an acid loses a proton (H^+), whereas a conjugate acid is formed when a base gains a proton.

— END OF MARKING KEY —

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