

Chemistry, 2006 EC, entrance exam

Grade 12 · Chemistry · 2006 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes

Questions: 73

Total marks: 73

1. Which of the following is NOT a conjugate acid-base pair? (1)
- A. $\text{HNO}_3/\text{NO}_3^-$ B. $\text{H}_2\text{SO}_4/\text{HSO}_4^-$
C. $\text{NH}_3/\text{NH}_2^-$ D. ✓ $\text{H}_3\text{O}^+/\text{OH}^-$

Answer: D

A conjugate acid-base pair must differ by exactly one proton (H^+). H_3O^+ and OH^- differ by two protons, as the conjugate base of H_3O^+ is H_2O , and the conjugate base of H_2O is OH^- .

2. Which of the following is correct? (1)
- A. ✓ $1\text{L} = 1\text{dm}^3$ B. $1\text{L} = 10\text{dm}^3$
C. $10\text{L} = 1\text{dm}^3$ D. $1\text{L} = 1\text{m}^3$

Answer: A

By definition of metric units of volume, 1 liter (L) is exactly equal to 1 cubic decimeter (dm^3).

3. Commercially, liquid vegetable oils are converted to solid fats such as margarine by: (1)
- A. ✓ **Hydrogenation** B. Hydration
C. Saponification D. Oxidation

Answer: A

Catalytic hydrogenation adds hydrogen across carbon-carbon double bonds in unsaturated liquid vegetable oils, raising their melting point to produce semi-solid or solid fats like margarine.

4. What is the chemical name for Aspirin? (1)
- A. ✓ **Acetyl salicylic acid** B. Salicylic acid
C. Methyl salicylate D. Sodium salicylate

Answer: A

Aspirin is the common trade name for acetylsalicylic acid, which is synthesized by the acetylation of salicylic acid.

5. Which of the following statement(s) is (are) true of an ideal liquid-liquid solution? I. It obeys $PV = nRT$ II. It obeys Raoult's law III. Solute-solute, solvent-solvent, and solute-solvent interactions are very similar. IV. Solute-solute, solvent-solvent, and solute-solvent interactions are quite different. (1)
- A. I, II and III B. I, II and IV
C. ✓ **II and III** D. II and IV

Answer: C

An ideal solution obeys Raoult's law over all concentrations because the intermolecular forces between unlike molecules (solute-solvent) are identical in strength to those between like molecules (solute-solute and solvent-solvent). $PV = nRT$ is the ideal gas law, not applicable to liquids.

6. In a reaction, $A + B \rightarrow \text{product}$, the rate is doubled when the concentration of B is doubled, and the rate increases by a factor of 8 when the concentrations of both the reactants (A and B) are doubled, the rate law for the reaction can be written as: (1)

A. $\text{Rate} = k[A][B]$

B. $\text{Rate} = k[A][B]^2$

C. ✓ $\text{Rate} = k[A]^2[B]$

D. $\text{Rate} = k[A]^2[B]^2$

Answer: C

Doubling [B] doubles the rate, meaning the reaction is first-order with respect to B. Doubling both [A] and [B] increases the rate by a factor of 8 ($2^x \times 2^1 = 8$), which gives $x = 2$, so the rate law is $\text{Rate} = k[A]^2[B]$.

7. Answer the following question using the phase diagram below. At which point can only the solid and liquid phases coexist? (1)

[Figure: A hand-drawn pressure-temperature phase diagram. The vertical axis is labelled 'Pressure' and the horizontal axis is labelled 'Temperature'. Three curves meet at a single point marked with a small open circle and labelled 3, sitting low and left of centre. From point 3 a straight steep line runs up and to the left, leaving the top of the drawing (the solid-liquid boundary); a filled square marked 4 sits on this line part-way up, and a filled dot sits higher on the same line. From point 3 an almost horizontal, slightly curving line runs left towards the pressure axis (the solid-gas boundary). From point 3 a curve rises gently to the right and then steepens, ending at a small circle labelled 8 at the upper right (the liquid-gas boundary); a small circle labelled 5 sits on this curve near its upper end. A dot labelled 1 lies in the region to the left of the steep line and above the almost-horizontal line. A dot labelled 2 lies in the open area above the rising right-hand curve and to the right of the steep line. A dot labelled 6 lies below the rising right-hand curve, beneath point 5.]

A. 1

B. 2

C. 3

D. ✓ 4

Answer: D

The boundary line running upwards from the triple point (3) represents the solid-liquid coexistence curve, on which point 4 is located.

8. Which electron transition in a hydrogen atom releases the largest energy? (1)

A. ✓ $n = 2 \rightarrow n = 1$

B. $n = 4 \rightarrow n = 2$

C. $n = 6 \rightarrow n = 3$

D. $n = 7 \rightarrow n = 6$

Answer: A

Transitions ending at the ground state ($n = 1$, the Lyman series) involve the greatest energy differences in the hydrogen atom; the transition $n = 2$ to $n = 1$ releases 10.2 eV, which is greater than any transition ending at higher levels.

9. The simplest formula for a compound containing Mn^{4+} and O^{2-} is (1)



Answer: B

To form an electrically neutral compound from Mn^{4+} and O^{2-} , two oxide ions are required for each manganese ion, giving the empirical formula MnO_2 .

10. What is the ratio of the energy of a photon of 300 nm wavelength radiation to that of 600 nm radiation? (1)

A. 1:2

B. 1:1

C. ✓ 2:1

D. 3:1

Answer: C

Photon energy is inversely proportional to wavelength ($E = hc/\lambda$), so the ratio of energy at 300 nm to 600 nm is $600/300$, which simplifies to 2:1.

11. Which one of the following chemicals is used to disinfect water? (1)
- A. Fluorine
B. Nitrogen
C. Oxygen
D. ✓ **Chlorine**

Answer: D

Chlorine is widely used as a disinfectant in water treatment to kill bacteria, viruses, and other harmful microorganisms.

12. During the titration of a known volume of a strong acid with a strong base, there is (1)
- A. A steady increase in PH
B. ✓ **A sharp increase in PH around the end point**
C. A steady decrease in PH
D. A sharp decrease in PH around the end point

Answer: B

In the titration of a strong acid with a strong base, the pH rises very slowly initially and then undergoes a steep, sharp increase around the equivalence point.

13. A solution with a PH of 7.5 would be described as: (1)
- A. Very basic
B. ✓ **Slightly base**
C. Slightly acidic
D. Very acidic

Answer: B

At 25 °C, a neutral solution has a pH of 7; a pH of 7.5 is just above 7, making it slightly basic.

14. The electrolysis of molten NaCl is an industrial process. What does the electrolysis produce? (1)
- A. ✓ **Na and Cl₂**
B. H₂ and O₂
C. Na⁺ and Cl⁻
D. NaOH and Cl₂

Answer: A

Electrolysis of molten sodium chloride in the Downs cell reduces sodium ions to liquid sodium metal at the cathode and oxidizes chloride ions to chlorine gas at the anode.

15. Butane burns in oxygen according to the equation below. $2\text{C}_4\text{H}_{10}(\text{g}) + 13\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{l})$. If 11.6g of butane is burned in 11.6 g of oxygen, which is the limiting reagent? (1)
- A. Butane
B. ✓ **Oxygen**
C. Neither
D. Both oxygen and butane

Answer: B

Burning 11.6 g of butane (0.20 mol) requires 1.30 mol (41.6 g) of O₂, but only 11.6 g (0.36 mol) of O₂ is available, making oxygen the limiting reactant.

16. A beaker filled to the 100mL mark with salt (the salt has a mass of 100g) and another beaker to the 100mL mark with water (the water has a mass of 100g) are mixed together in a bigger beaker until the salt is completely dissolved. What will be the mass of the solution? (1)
- A. It will be much more than 200g
B. It will be much smaller than 200g
C. ✓ **It will be exactly 200g**
D. It will be slightly more than 200g

Answer: C

According to the law of conservation of mass, the total mass of the resulting mixture equals the sum of the individual masses (100 g + 100 g = 200 g), even though the total volume may contract.

17. Which one of the following is NOT an intensive property?

(1)

- A. ✓ Mass
B. Temperature
C. Colour
D. Density

Answer: A

Mass is an extensive property because it depends on the amount of substance present, whereas temperature, color, and density are intensive properties.

18. Which of the following is natural polymer?

(1)

- A. Nylon
B. PVC
C. ✓ Cotton
D. Dacron

Answer: C

Cotton is composed almost entirely of cellulose, which is a naturally occurring biopolymer, while nylon, PVC, and Dacron are synthetic polymers.

19. Which of the following metals forms a volatile compound during the extraction process?

(1)

- A. Fe
B. Co
C. ✓ Ni
D. Cu

Answer: C

In the Mond process for nickel refining, nickel reacts with carbon monoxide to form the volatile complex nickel tetracarbonyl, $\text{Ni}(\text{CO})_4$, which boils at 43 °C.

20. Which one of the following atoms in its ground state has the greatest number of unpaired electrons?

(1)

- A. ${}_{13}\text{Al}$
C. ✓ ${}_{15}\text{P}$

Answer: C

Phosphorus ($Z = 15$) has the electron configuration $[\text{Ne}] 3s^2 3p^3$, which has 3 unpaired electrons in the 3p subshell according to Hund's rule, more than Al (1), Si (2), and S (2).

21. Which statement is true about chemical reactions at equilibrium?

(1)

- A. ✓ A forward and backward reactions proceed at equal rates**
B. The forward and backward reactions have stopped
C. The concentrations of the reactants and products are equal
D. The forward reaction is exothermic

Answer: A

Dynamic chemical equilibrium is reached when the rates of the forward and reverse reactions are equal, keeping the concentrations of reactants and products constant.

22. Which compound contains both covalent and ionic bonds?

(1)

- A. ✓ **Sodium carbonate**, Na_2CO_3 B. Magnesium bromide, MgBr_2
C. Dichloromethane, CH_2Cl_2 D. Ethanoic acid, CH_3COOH

Answer: A

Sodium carbonate (Na_2CO_3) has ionic bonds between the Na^+ cations and the CO_3^{2-} anions, and covalent bonds between the carbon and oxygen atoms within the carbonate polyatomic ion.

23. Which set of quantum numbers (n , l , m_l , m_s) is not possible? (1)
- A. 1, 0, 0, 1/2
B. ✓ 1, 1, 0, 1/2
C. 1, 0, 0, -1/2
D. 2, 1, -1, 1/2

Answer: B

For any principal quantum number n , the azimuthal quantum number l can only take integer values from 0 to $n - 1$; therefore, when $n = 1$, l must be 0 and cannot be 1.

24. Which of the following particles contains more electrons than neutrons? I. ${}^1_1\text{H}$ II. ${}^{35}_{17}\text{Cl}^-$ III. ${}^{39}_{19}\text{K}^+$ (1)
- A. ✓ I only
B. II only
C. I and II only
D. II and III only

Answer: A

A ${}^1_1\text{H}$ atom has 1 electron and 0 neutrons ($1 > 0$). ${}^{35}_{17}\text{Cl}^-$ has 18 electrons and 18 neutrons ($18 = 18$), and ${}^{39}_{19}\text{K}^+$ has 18 electrons and 20 neutrons ($18 < 20$).

25. Which molecule or ion does NOT have a tetrahedral shape? (1)
- A. ✓ XeF_4
B. SiCl_4
C. BF_4^-
D. NH_4^+

Answer: A

XeF_4 has 4 bonding pairs and 2 lone pairs on the central xenon atom (an AX_4E_2 system), giving it a square planar molecular geometry rather than tetrahedral.

26. Why are metals soft and malleable? (1)
- A. Because they are very shiny.
B. Because they experience electrostatic repulsion
C. Because of the presence of mobile electrons.
D. ✓ **Because the metal cations can slip over each other fairly easily.**

Answer: D

Metals are malleable because their positive metal ions are arranged in regular layers that can easily slide or slip over one another without disrupting the non-directional metallic bonding.

27. In which region of the Periodic Table would the element with the electronic structure below be located? (1)
- $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^6 5s^2$
- A. Group 6
B. Noble gases
C. S block
D. ✓ **D block**

Answer: D

The valence shell configuration ends in $4d^6 5s^2$, indicating that the differentiating electron enters the d subshell, placing this element (ruthenium) in the d-block.

28. Which factors will influence the rate of the reaction shown below? $\text{NO}_2(\text{g}) + \text{CO}(\text{g}) \rightleftharpoons \text{NO}(\text{g}) + \text{CO}_2(\text{g})$ I. The number of collisions per second II. The energy of the collisions III. The geometry with which the molecules collide (1)
- A. I only
B. II only
C. I and II only
D. ✓ **I, II and III**

Answer: D

According to collision theory, the rate of a chemical reaction depends on the frequency of collisions, the kinetic energy of the colliding particles, and their spatial orientation (geometry).

29. How many π bonds are present in CO_2 ? (1)
- A. One
B. ✓ two
C. three
D. four

Answer: B

Carbon dioxide has the Lewis structure $\text{O}=\text{C}=\text{O}$; each double bond consists of one σ (sigma) bond and one π (pi) bond, giving a total of two π bonds.

30. Which pair of monomers forms polyesters? (1)
- A. ✓ **Difunctional alcohol, difunctional organic acid**
B. Difunctional alcohol, difunctional amino acid
C. Ethylene, ethylene
D. Amino acid, amino acid

Answer: A

Polyesters are condensation polymers formed by the reaction between a diol (difunctional alcohol) and a dicarboxylic acid (difunctional organic acid), forming ester linkages with the loss of water.

31. Which changes will increase the amount of $\text{SO}_3(\text{g})$ at equilibrium? $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \Delta H^0 = -197\text{kJ}$ I. Increasing the temperature II. Decreasing the volume III. Adding a catalyst (1)
- A. I only
B. ✓ II only
C. I and II only
D. I, II and III

Answer: B

The reaction is exothermic with fewer moles of gas on the product side; decreasing the volume increases pressure, driving the equilibrium forward to produce more SO_3 . Increasing temperature shifts it in the reverse direction, while a catalyst does not change equilibrium amounts.

32. Which compound is a carboxylic acid? (1)
- A. ✓ CH_3COOH
B. $(\text{CH}_3\text{CO})_2\text{O}$
C. $(\text{CH}_3)_2\text{CHOOCH}_3$
D. $(\text{CH}_3)_2\text{O}$

Answer: A

CH_3COOH (acetic acid or ethanoic acid) contains the carboxyl group ($-\text{COOH}$), which characterizes carboxylic acids.

33. The mechanism of a reaction is shown below. $\text{HOOH} + \text{I}^- \rightarrow \text{HOI} + \text{OH}^-$ (slow) $\text{HOI} + \text{I}^- \rightarrow \text{I}_2 + \text{OH}^-$ (fast) $2\text{OH}^- + 2\text{H}_3\text{O}^+ \rightarrow 4\text{H}_2\text{O}$ (fast) What is the rate law based on this mechanism? (1)
- A. ✓ **Rate = $k[\text{HOOH}][\text{I}^-]$**
B. Rate = $k[\text{HOOH}]^2[\text{I}^-]$
C. Rate = $k[\text{HOOH}][\text{I}^-]^2$
D. Rate = $k[\text{HOOH}]$

Answer: A

The rate of a multi-step reaction is governed by the rate-determining (slow) step, which involves one molecule of HOOH and one iodide ion, giving the rate law Rate = $k[\text{HOOH}][\text{I}^-]$.

34. What is the equilibrium constant expression for the following reaction? $2\text{Hg}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{HgO}(\text{s})$ (1)
- A. ✓ **$K = 1/([\text{Hg}]^2/[\text{O}_2])$**
B. $K = [\text{Hg}]^2[\text{O}_2]$
C. $K = [\text{HgO}]^2/([\text{Hg}]^2[\text{O}_2])$
D. $K = [2\text{HgO}]/([2\text{Hg}][\text{O}_2])$

Answer: A

Pure solids like $\text{HgO}(\text{s})$ have constant concentrations and are assigned an activity of 1 in the equilibrium constant expression, yielding $K = 1/([\text{Hg}]^2[\text{O}_2])$.

35. A triacylglycerol that is solid at room temperature is called: (1)
- A. Lecithin
B. ✓ **Fat**
C. Wax
D. Oil

Answer: B

Triacylglycerols (triglycerides) that are solid at room temperature are classified as fats (usually rich in saturated fatty acids), whereas those that are liquid are called oils.

36. Which compound is an ester? (1)
- A. CH_3COOH
B. $\text{CH}_3\text{OC}_2\text{H}_5$
C. $\text{C}_2\text{H}_5\text{CHO}$
D. ✓ **HCOOCH_3**

Answer: D

HCOOCH_3 (methyl formate or methyl methanoate) contains the ester functional group ($-\text{COO}-$).

37. How many moles of sodium hydroxide are present in 2.5L of 0.5M aqueous solution? (1)
- A. 0.2
B. 0.5
C. ✓ **1.25**
D. 12.5

Answer: C

Moles = Molarity * Volume = $0.5 \text{ mol/L} * 2.5 \text{ L} = 1.25$ moles of NaOH.

38. Which species CANNOT act as a Lewis acid? (1)
- A. ✓ **NH_3**
B. BF_3
C. Fe^{2+}
D. AlCl_3

Answer: A

A Lewis acid is an electron-pair acceptor; NH_3 has a lone pair of electrons and no vacant low-energy orbital, making it a Lewis base rather than a Lewis acid.

39. Which of the following statements is true? (1)
- A. ✓ **A universal indicator is a mixture of indicators that will give a different colour for a different PH.**
B. Phenolphthalein is a universal indicator.
C. A universal indicator can only be used in either strongly acidic or basic solution.
D. The colour of a universal indicator is red in a weak acid.

Answer: A

A universal indicator is prepared by mixing several indicators together so that it displays distinct color changes across a wide continuous pH spectrum.

40. Three acids, HA, HB, HC have the following K_a values. $K_a(\text{HA}) = 1 \times 10^{-5}$ $K_a(\text{HB}) = 2 \times 10^{-5}$ $K_a(\text{HC}) = 1 \times 10^{-6}$ What is the correct order of increasing acid strength (weakest first)? (1)
- A. HA, HB, HC
B. HC, HB, HA
C. ✓ **HC, HA, HB**
D. HB, HA, HC

Answer: C

Acid strength increases with increasing K_a value. Since $K_a(\text{HC}) = 1 \times 10^{-6} < K_a(\text{HA}) = 1 \times 10^{-5} < K_a(\text{HB}) = 2 \times 10^{-5}$, the correct order from weakest to strongest is HC, HA, HB.

41. If the solute-solvent interactions are greater than the solute-solute and solvent-solvent interactions, what will be the total vapour pressure of the solution? (1)
- A. Greater than that calculated from Raoult's law
B. ✓ **Less than that calculated from Raoult's law**
C. The same as calculated from Raoult's law
D. Raoult's law cannot be applied for such interactions.

Answer: B

When solute-solvent attractive forces are stronger than solute-solute and solvent-solvent forces, the solution exhibits negative deviation from Raoult's law, resulting in a lower vapor pressure than predicted.

42. For which conversion is an oxidizing agent required? (1)
- A. $2\text{H}^+ (\text{aq}) \rightarrow \text{H}_2 (\text{g})$
B. ✓ $2\text{Br}^- (\text{aq}) \rightarrow \text{Br}_2 (\text{aq})$
C. $\text{SO}_3 (\text{g}) \rightarrow \text{SO}_4^{2-} (\text{aq})$
D. $\text{MnO}_2 (\text{s}) \rightarrow \text{Mn}^{2+} (\text{aq})$

Answer: B

An oxidizing agent causes oxidation. In the conversion $2\text{Br}^- \rightarrow \text{Br}_2$, the oxidation state of bromine increases from -1 to 0 (oxidation), which requires an oxidizing agent.

43. What volume of 0.500M NaOH is required to neutralize 25.0 mL of 1.2 M H_2SO_4 ? (Assume complete ionization of the acid). (1)
- A. 60mL
B. 90mL
C. 100mL
D. ✓ **120mL**

Answer: D

Neutralization requires $n(\text{OH}^-) = n(\text{H}^+)$. For H_2SO_4 , $n(\text{H}^+) = 2 \times (0.025 \text{ L} \times 1.2 \text{ M}) = 0.060 \text{ mol}$, requiring $V(\text{NaOH}) = 0.060 \text{ mol} / 0.500 \text{ M} = 0.120 \text{ L}$, or 120 mL.

44. A gas is confined to a cylinder under constant atmospheric pressure. When the gas undergoes a particular chemical reaction, it releases 135kJ of heat to its surroundings and does 63kJ of P-V work on its surroundings. What are the values of ΔH and ΔE for the process? (1)
- A. $\Delta H = 135\text{kJ}, \Delta E = 63\text{kJ}$
B. $\Delta H = -135\text{kJ}, \Delta E = -63\text{kJ}$
C. $\Delta H = 135\text{kJ}, \Delta E = 198\text{kJ}$
D. ✓ $\Delta H = -135\text{kJ}, \Delta E = -198\text{kJ}$

Answer: D

At constant pressure, $\Delta H = q = -135 \text{ kJ}$ because heat is released. Since the system does work on the surroundings ($w = -63 \text{ kJ}$), the change in internal energy is $\Delta E = q + w = -135 \text{ kJ} + (-63 \text{ kJ}) = -198 \text{ kJ}$.

45. The oxidation numbers of nitrogen in NH_3 , HNO_3 and NO_2 are respectively. (1)
- A. -3, -5, +4
B. +3, +5, +4
C. -3, +5, -4
D. ✓ **-3, +5, +4**

Answer: D

In NH_3 , H is +1 so N is -3; in HNO_3 , H is +1 and O is -2, giving N = +5; in NO_2 , each O is -2, giving N = +4.

46. Which statement about the following reaction is correct? $2\text{FeS (s)} + 3\text{CO}_2\text{ (g)} \rightarrow \text{Fe}_2\text{O}_3\text{ (s)} + 3\text{CO (g)}$ $\Delta H^0 = +26.6\text{kJ}$ (1)
- A. 26.6kJ of energy are released for every mole of Fe reacted.
B. 26.6kJ of energy are absorbed for every mole of Fe reacted.
C. 53.2kJ of energy are released for every mole of Fe reacted.
D. ✓ **13.3kJ of energy are absorbed for every mole of Fe reacted.**

Answer: D

The stoichiometric equation shows that 2 moles of FeS (containing 2 moles of Fe) absorb 26.6 kJ (positive ΔH implies endothermic). Therefore, $26.6\text{ kJ} / 2 = 13.3\text{ kJ}$ is absorbed per mole of Fe reacted.

47. The two standard electrode potentials involved in the nickel cadmium rechargeable cell are given below. (1)
- Calculate the ΔG^0 in kJ of the cells. $\text{NiO}_2\text{ (s)} + 2\text{H}_2\text{S (l)} + 2\text{e}^- \rightarrow \text{Ni(OH)}_2\text{ (s)} + 2\text{OH}^-$ $E^0 = +0.49\text{V}$
 $\text{Cd(OH)}_2\text{ (s)} + 2\text{e}^- \rightarrow \text{Cd(s)} + 2\text{OH (aq)}$ $E^0 = -0.76\text{V}$
- A. -184
B. -153
C. ✓ **-241**
D. -206

Answer: C

The standard cell potential is $E^0 = E^0(\text{cathode}) - E^0(\text{anode}) = +0.49\text{ V} - (-0.76\text{ V}) = +1.25\text{ V}$. Using $\Delta G^0 = -nFE^0$, $\Delta G^0 = -(2)(96,485\text{ C/mol})(1.25\text{ V}) \approx -241\text{ kJ}$.

48. Which of the following is a synthetic rubber produced from caprolactam (CPL)? (1)
- A. Nylon 6, 10
B. Terylene
C. Teflon
D. ✓ **Nylon6**

Answer: D

Nylon 6 is synthesized by the ring-opening polymerization of caprolactam (CPL) (though technically a synthetic polymer/polyamide fiber rather than a rubber, the question refers to this preparation).

49. Which of the following reaction is NOT a redox reaction? (1)
- A. ✓ $\text{Ag}^+\text{ (aq)} + \text{Cl}^-\text{ (aq)} \rightarrow \text{AgCl (s)}$
B. $2\text{Na (s)} + \text{Cl}_2\text{ (g)} \rightarrow 2\text{NaCl (s)}$
C. $\text{Mg (s)} + 2\text{HCl (aq)} \rightarrow \text{MgCl}_2\text{ (aq)} + \text{H}_2\text{ (g)}$
D. $\text{Cu}^{2+}\text{ (aq)} + \text{Zn (s)} \rightarrow \text{Cu (s)} + \text{Zn}^{2+}\text{ (aq)}$

Answer: A

The reaction of silver ions with chloride ions to form silver chloride is a double displacement/precipitation reaction with no change in oxidation states, so it is not a redox reaction.

50. The half-reaction for formation of magnesium metal upon electrolysis of molten MgCl_2 is: $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$ (1)
- What is the mass of magnesium formed upon passage of a current of 60.0A for a period of $2.00 \times 10^3\text{S}$?
- A. 5.0g
B. 10.0g
C. ✓ **15.1g**
D. 30.2g

Answer: C

Charge $Q = I \times t = 60.0\text{ A} \times 2.00 \times 10^3\text{ s} = 1.20 \times 10^5\text{ C}$. Moles of $\text{Mg} = Q / (2F) = 1.20 \times 10^5 / (2 \times 96,500) \approx 0.622\text{ mol}$, giving a mass of $0.622\text{ mol} \times 24.31\text{ g/mol} \approx 15.1\text{ g}$.

51. An aqueous solution is 70% nitric acid (HNO_3) by mass. What is the concentration of HNO_3 expressed in molality? (1)
- A. 0.559m
B. 8.62m
C. 11.1m
D. ✓ 37.0m

Answer: D

In 100 g of 70% HNO_3 solution, there are 70 g of HNO_3 (1.11 mol) and 30 g (0.030 kg) of water solvent. Molality = $1.11 \text{ mol} / 0.030 \text{ kg} = 37.0 \text{ m}$.

52. Which of the following is a natural polymer? (1)
- A. Polythene
B. ✓ Polysaccharides
C. Nylon
D. Terylene

Answer: B

Polysaccharides (such as starch, cellulose, and glycogen) are naturally occurring polymers, whereas polythene, nylon, and terylene are synthetic.

53. What is the ionization energy of an iron atom if it requires a radiation of 276nm to completely remove its outer most electron in the gaseous state? (Plank's constant, $h=6.626 \times 10^{-34} \text{ Js}$, speed of light, $c = 3 \times 10^8 \text{ ms}^{-1}$) (1)
- A. ✓ $7.21 \times 10^{-19} \text{ J}$
B. $7.21 \times 10^{-19} \text{ kJ}$
C. $7.21 \times 10^{19} \text{ J}$
D. $7.21 \times 10^{19} \text{ kJ}$

Answer: A

Ionization energy $E = hc / \lambda = (6.626 \times 10^{-34} \text{ J-s} \times 3.0 \times 10^8 \text{ m/s}) / (276 \times 10^{-9} \text{ m}) \approx 7.21 \times 10^{-19} \text{ J}$.

54. Which of the electron configurations describes the ground state electron configuration of Cl^- ? (1)
- A. ✓ $1s^2 2s^2 2p^6 3s^2 3p^6$
B. $1s^2 2s^2 2p^6 3s^1$
C. $1s^2 2s^2 2p^6 3p^1$
D. $1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1$

Answer: A

The chloride ion (Cl^-) has 18 electrons, possessing the stable noble gas configuration of argon: $1s^2 2s^2 2p^6 3s^2 3p^6$.

55. When 0.68 is divided by 14.364, the actual answer is 0.0473405. What will be the correct answer? (1)
- A. 0.05
B. ✓ 0.047
C. 0.0473
D. 0.04734

Answer: B

In division, the final answer must have the same number of significant figures as the measurement with the fewest significant figures; 0.68 has two significant figures, so the result rounds to 0.047.

56. What is the correct molecular electronic configuration for the molecular ion, B_2^+ ? (1)
- A. [option image did not render in the source capture]
B. [option image did not render in the source capture]
C. ✓ [option image did not render in the source capture]
D. [option image did not render in the source capture]

Answer: C

57. Which of the following molecules or ions will exhibit delocalized bonding? NO_2^- , NH_4^+ , N_3^- (1)
- A. ✓ NH_4^+ and N_3^- B. NH_4^+ and N_3^-
C. NO_2^- D. NO_2^- and NH_4^+

Answer: A

58. Based on molecular orbital theory, the bond orders of H_2 , H_2^+ and H_2^- are, respectively. (1)
- A. 1, 0, and 0 B. 1, 1/2, and 0
C. 1, 0, and 1/2 D. ✓ 1, 1/2, and 1/2

Answer: D

According to molecular orbital theory, H_2 has 2 bonding electrons (bond order = 1), H_2^+ has 1 bonding electron (bond order = 1/2), and H_2^- has 2 bonding and 1 antibonding electron (bond order = (2-1)/2 = 1/2).

59. How many 3d electrons are present in the ground state of chromium atom? (1)
- A. 4 B. ✓ 5
C. 6 D. 10

Answer: B

Chromium (Z = 24) has an anomalous ground-state electron configuration of $[\text{Ar}] 4s^1 3d^5$ due to the extra stability of a half-filled d-subshell, giving 5 electrons in the 3d subshell.

60. When the following substances are arranged in order of increasing melting point (lowest melting point first), the correct order is: (1)
- A. ✓ $\text{CH}_3\text{CH}_2\text{CH}_3$, CH_3COCH_3 , $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ B. $\text{CH}_3\text{CH}_2\text{CH}_3$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, CH_3COCH_3
C. CH_3COCH_3 , $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, $\text{CH}_3\text{CH}_2\text{CH}_3$ D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, $\text{CH}_3\text{CH}_2\text{CH}_3$, CH_3COCH_3

Answer: A

Intermolecular forces increase from nonpolar propane (dispersion forces only) to acetone (dipole-dipole forces) to 1-propanol (hydrogen bonding), giving the expected increasing order of phase-change temperatures.

61. The half-life for the first order decomposition of nitromethane, CH_3NO_2 , at 500K is 650 seconds. If the initial concentration of CH_3NO_2 is 0.500M, what will its concentration be (M) after 1300 seconds have elapsed? (1)
- A. ✓ 0.125 B. 0.140
C. 0.250 D. 0.425

Answer: A

The elapsed time of 1300 seconds represents exactly two half-lives (2×650 s). After two half-lives, the concentration decreases to $0.500 \text{ M}/4 = 0.125 \text{ M}$.

62. In a zero-order reaction for every 10° rise of temperature, the rate is doubled. If the temperature is increased from 10°C to 100°C , the rate of the reaction will become (1)
- A. 64 times B. 128 times
C. 256 times D. ✓ 512 times

Answer: D

An increase from 10°C to 100°C is a rise of 90°C , which corresponds to 9 ten-degree intervals. The rate therefore increases by a factor of $2^9 = 512$.

68. Which of these compounds is the ester formed from the reaction of acetic acid and 1-Propanol? (1)

[Figure: The four options are scanned images of condensed structural formulae rather than typed text; each is labelled with its letter to the left of the image. A: 'CH₃CO' written on the main line, with a double bond drawn vertically upward from the carbon of CO to an O, and a single bond drawn vertically downward from the same carbon to 'OCH₂CH₂' written on the line below. B: 'CH₃CH₂COH' on the main line, with a double bond drawn vertically upward to an O above the C, and a single bond drawn downward from beneath the CH₂ to 'OCH₂CH₂' on the line below. C: 'CH₃CH₂CH₂OCH₂' on the main line, with a double bond drawn vertically upward from the final CH₂ carbon to an O, and a single bond drawn downward from beneath the second CH₂ to 'OCH₂CH₂' on the line below. D: 'CH₃COCH₂CH₂CH₃' on a single line, with a double bond drawn vertically upward from the second carbon (the C of CO) to an O. This is the ticked option.]

- A. [structural formula image - see figure_description]
B. [structural formula image - see figure_description]
C. [structural formula image - see figure_description]
D. ✓ [structural formula image - see figure_description]

Answer: D

69. A lab instructor is preparing 5.0 liters of a 0.10M Pb(NO₃)₂ (molecular mass 331) solution. What is the mass required? (1)

- A. 165.5g of Pb(NO₃)₂ and add 5.0kg of H₂O
B. ✓ 165.5g of Pb(NO₃)₂ and add H₂O until the solution has a volume of 5.0 liters.
C. 33.1g of Pb(NO₃)₂ and add H₂O until the solution has a volume of 5.0 liters.
D. 33.1g of Pb(NO₃)₂ and add 5.0 liters of H₂O.

Answer: B

The mass of solute needed is 5.0 L × 0.10 mol/L × 331 g/mol = 165.5 g. To prepare a solution of a specified molarity, the solute is dissolved and water is added until the total volume reaches 5.0 L, rather than adding 5.0 L of solvent directly.

70. Which of the following is NOT a characteristic of the electrolytic cell containing aqueous solution of NaCl used in the manufacture of sodium hydroxide? (1)

- A. The sodium hydroxide solution is produced in the electrolytic cell.
B. ✓ The electrolyte must be a dilute solution of NaCl
C. Hydrogen is produced at the cathode.
D. The production of chlorine gas occurs at the anode

Answer: B

The industrial chlor-alkali process requires concentrated NaCl solution (brine); if a dilute solution were used, oxygen gas would be produced at the anode instead of chlorine.

71. The kinetic data are for the reaction: A + B → C From these data what are the orders of the reaction with respect to A and B? (1)

[Figure: A three-column data table sits between the stem and the options. Column headings: [A] | [B] | initial rate (mol dm⁻³ sec⁻¹). Rows: 0.1 / 0.1 / 1 × 10⁻⁵; 0.1 / 0.2 / 4 × 10⁻⁵; 0.2 / 0.1 / 1 × 10⁻⁵.]

- A. Order of A = 1 order of B = 0
B. ✓ Order of A = 0 order of B = 2
C. Order of A = 0 order of B = 4
D. Order of A = 1 order of B = 2

Answer: B

Doubling [B] while keeping [A] constant quadruples the rate (from 1 × 10⁻⁵ to 4 × 10⁻⁵), indicating second order with respect to B. Doubling [A] while keeping [B] constant has no effect on the rate, indicating zero order with respect to A.

72. Which of the following metals has the highest electrical and thermal conductivities of any metal? (1)

- A. ✓ Ag B. Cu
C. Ni D. Co

Answer: A

Silver (Ag) has the highest electrical conductivity and thermal conductivity of any known metal, slightly surpassing copper.

73. Which of the following is the most important source for the extraction of iron? (1)

- A. ✓ Hematite B. Bauxite
C. Chalcopyrite D. Sphalerite

Answer: A

Hematite (Fe_2O_3) is the most abundant and commercially important ore used for the industrial extraction of iron in blast furnaces.

— END OF MARKING KEY —

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