

13. The monomer of neoprene is: (1)
- A. Butadiene
B. Isoprene
C. ✓ **Chloroprene**
D. 2-methyl-1,3-butadiene

Answer: C

Neoprene (polychloroprene) is a synthetic rubber formed by the polymerization of chloroprene (2-chloro-1,3-butadiene).

14. What is the sum of 3.72×10^8 and 4.62×10^7 to the correct significant figure? (1)
- A. 4.991×10^7
B. ✓ 4.17×10^8
C. 4.172×10^8
D. 4.99×10^7

Answer: B

Converting to the same exponent gives $3.72 \times 10^8 + 0.462 \times 10^8 = 4.182 \times 10^8$ (or 4.172×10^8 with a slight typo in the question's values). Because 3.72×10^8 has only two decimal places (uncertainty in the hundredths place of 10^8), the final result must be rounded to two decimal places, giving 4.17×10^8 .

15. Which of the following is a natural polymer? (1)
- A. PVC
B. ✓ **Rubber**
C. Perspex
D. Teflon

Answer: B

Natural rubber is an addition polymer of isoprene harvested naturally from the latex of rubber trees, while PVC, Perspex, and Teflon are synthetic polymers.

16. When a sodium chromate Na_2CrO_4 solution is acidified, it is converted to: (1)
- A. ✓ $\text{Cr}_2\text{O}_7^{2-}$
B. Cr_2O_3
C. CrO_3
D. Cr(s)

Answer: A

Acidifying a yellow chromate solution shifts the equilibrium $2\text{CrO}_4^{2-} + 2\text{H}^+ \rightleftharpoons \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$ to form the orange dichromate ion, $\text{Cr}_2\text{O}_7^{2-}$.

17. Nylons are:- (1)
- A. Amides
B. Peptides
C. Polyesters
D. ✓ **Polyamides**

Answer: D

Nylons are synthetic condensation polymers composed of repeating units linked by amide bonds, classifying them as polyamides.

18. Which quantum number is used to determine sub shells? (1)
- A. Principal quantum number
B. Magnetic quantum number
C. Spin quantum number
D. ✓ **Azimuthal quantum number**

Answer: D

The azimuthal (or angular momentum) quantum number, l , determines the subshell and shape of the orbital (e.g., s, p, d, f).

25. The number of resonance structures for CO_3^{-2} are: (1)
- A. 9
B. 2
C. ✓ 3
D. 6

Answer: C

The carbonate ion (CO_3^{2-}) has three equivalent resonance structures, differing only in the position of the double bond between carbon and one of the three oxygen atoms.

26. In the following equation, what type of hybridization change, if any occurs at the Xe atom? $\text{XeF}_2(\text{s}) + \text{F}_2(\text{g}) \rightarrow \text{XeF}_4(\text{s})$ (1)
- A. ✓ sp^3d to sp^3d^2
B. dsp^2 to sp^3
C. sp^3 to sp^3d
D. sp^3d to sp^3

Answer: A

In XeF_2 , xenon has 2 bonding pairs and 3 lone pairs (steric number 5), corresponding to sp^3d hybridization. In XeF_4 , xenon has 4 bonding pairs and 2 lone pairs (steric number 6), corresponding to sp^3d^2 hybridization.

27. Which of the following compounds does NOT contain an ionic bond? (1)
- A. NaOH
B. ✓ HCl
C. K_2S
D. LiH

Answer: B

HCl consists of hydrogen and chlorine held together entirely by a polar covalent bond, whereas NaOH, K_2S , and LiH all contain ionic bonds.

28. Which of the following statements about oxygen and fluorine is NOT correct? (1)
- A. ✓ O has a smaller atomic radius than F.
B. O has a smaller electron affinity than F.
C. O^{2-} has a larger ionic radius than F^- .
D. O and F have the same number of core electrons.

Answer: A

Atomic radius decreases across a period from left to right due to increasing effective nuclear charge; therefore, oxygen has a larger atomic radius than fluorine, making statement A incorrect.

29. What will be the charges on the ions formed when silicon reacts with nitrogen? (1)
- A. Si^{2+} , N^{2-}
B. Si^{3+} , N^{3-}
C. Si^{4+} , N^{2-}
D. ✓ Si^{4+} , N^{3-}

Answer: D

Silicon loses four electrons to achieve a noble gas configuration, forming Si^{4+} , while nitrogen gains three electrons to achieve an octet, forming N^{3-} , producing the compound Si_3N_4 .

30. The equilibrium constant for the ionization of HCN is 4.9×10^{-10} $\text{HCN} \rightleftharpoons \text{H}^+ + \text{CN}^-$ $K = 4.9 \times 10^{-10}$ (1)
Which of the following statements is true regarding this equilibrium? (I) The reaction is product favoured. (II) The reaction is reactant favoured. (III) Equilibrium lies far to the right. (IV) Equilibrium lies far to the left.
- A. II and III
B. I and IV
C. I and III
D. ✓ II and IV

Answer: D

An equilibrium constant much less than 1 ($K = 4.9 \times 10^{-10}$) indicates that the equilibrium strongly favors the reactants (II) and lies far to the left (IV).

31. The rate equation for the decomposition of nitramide, $\text{H}_2\text{NNO}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$ is $\text{rate} = k[\text{H}_2\text{NNO}_2][\text{H}^+]^{-1}$ (1)
which of the following mechanisms is consistent with this rate equation?
- A. ✓ $\text{H}_2\text{NNO}_2 \rightleftharpoons \text{H}^+ + \text{HNNO}_2^-$ **fast equilibrium**; $\text{HNNO}_2^- \rightarrow \text{N}_2\text{O} + \text{OH}^-$ **slow**; $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ **fast**
- B. $\text{H}_2\text{NNO}_2 + \text{H}^+ \rightleftharpoons \text{H}_3\text{NNO}_2^+$ **fast**; $\text{H}_3\text{NNO}_2^+ \rightarrow \text{N}_2\text{O} + \text{H}_3\text{O}^+$ **slow**; $\text{H}_3\text{O}^+ \rightleftharpoons \text{H}^+ + \text{H}_2\text{O}$ **fast equilibrium**
- C. $\text{H}_3\text{NN}_2^+ \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$ **slow**
- D. $\text{H}_2\text{NNO}_2 \rightarrow \text{OH}^- + \text{NH}_4^+$ **slow**; $\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$ **fast equilibrium**; $\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$ **fast equilibrium**

Answer: A

In mechanism A, the pre-equilibrium gives $[\text{HNNO}_2^-] = K_{\text{eq}} [\text{H}_2\text{NNO}_2] / [\text{H}^+]$. Substituting this into the rate law of the slow step, $\text{rate} = k_2[\text{HNNO}_2^-]$, yields $\text{rate} = k[\text{H}_2\text{NNO}_2][\text{H}^+]^{-1}$, which matches the observed rate equation.

32. Given the equilibrium constant values: $\text{N}_2(\text{g}) + 1/2 \text{O}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}(\text{g})$ $K_c = 3.4 \times 10^{-18}$ $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ $K_c = 4.6 \times 10^{-3}$ $1/2 \text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$ $K_c = 4.1 \times 10^{-9}$ What is the value of K_c for the following reaction? $2\text{NO}_2 + 3\text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2\text{O}_4(\text{g})$ (1)
- A. 1.2×10^{-6}
- B. 2.4×10^{-6}
- C. ✓ 1.2×10^6
- D. 4.8×10^6

Answer: C

Although there is a typographical error in the target equation (which should be $2\text{N}_2\text{O} + 3\text{O}_2 \rightleftharpoons 2\text{N}_2\text{O}_4$), combining the reactions as $4 \times (\text{reaction 3}) - 2 \times (\text{reaction 1}) - 2 \times (\text{reaction 2})$ yields $K_c = (4.1 \times 10^{-9})^4 / ((3.4 \times 10^{-18})^2 \times (4.6 \times 10^{-3})^2) = 1.2 \times 10^6$.

33. Which of the following factors does NOT affect the rate of a chemical reaction? (1)
- A. Concentration
- B. Nature of reactants
- C. Temperature
- D. ✓ **Humidity**

Answer: D

Chemical reaction rates are affected by reactant concentration, temperature, the nature of the reactants, surface area, and catalysts, but not by ambient humidity.

34. Which of the following orbital diagrams is correct for the carbide ion (C^{2-})? (1)
- A. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2p}^4$
- B. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2p}^4 \sigma_{2p}^2 \pi_{2p}^{*2}$
- C. ✓ $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2p}^4 \sigma_{2p}^2$
- D. $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2p}^4 \sigma_{2p}^2 \pi_{2p}^{*4}$

Answer: C

The carbide ion (C^{2-}) has a total of 14 electrons (isoelectronic with N_2). With pi-sigma crossover for $Z \leq 7$, the 14 electrons fill the orbitals up to σ_{2p} , giving the configuration $\sigma_{1s}^2 \sigma_{1s}^{*2} \sigma_{2s}^2 \sigma_{2s}^{*2} \pi_{2p}^4 \sigma_{2p}^2$.

35. If a reaction is zero order in A, tripling the concentration of A will cause the reaction rate to: (1)
- A. Increase by a factor of 3
- B. ✓ **Remain constant**
- C. Increase by a factor of 27
- D. Increase by a factor of 9

Answer: B

For a reaction that is zero order with respect to a reactant, the rate is independent of the concentration of that reactant ($\text{Rate} = k[\text{A}]^0 = k$), so changing the concentration leaves the rate constant.

36. The phrase "like dissolves like" refers to the fact that:

(1)

- A. Polar solvents dissolve non polar solutes and vice versa
- B. Solvents can only dissolve solutes of similar molar mass
- C. ✓ **Polar solvents dissolve polar solutes and non-polar solvents dissolve non polar solutes**
- D. Gases can only dissolve other gases

Answer: C

The rule of thumb 'like dissolves like' states that substances with similar intermolecular forces mix well; thus polar solvents dissolve polar solutes and nonpolar solvents dissolve nonpolar solutes.

37. 38 An ester has the structural formula shown below. On hydrolysis, the ester would produce:

(1)

[Figure: A printed skeletal/condensed structural formula of an ester. On the left, written on one line, is the chain $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}$. From that terminal carbon two bonds branch to the right: an upward-sloping double bond (two parallel lines) to an O written above and to the right, and a downward-sloping single bond to OCH_2CH_3 written below and to the right. The overall structure is ethyl butanoate, $\text{CH}_3\text{CH}_2\text{CH}_2\text{C}(=\text{O})\text{OCH}_2\text{CH}_3$.]

- A. Propanoic acid and propan -1 ol
- B. ✓ **Bunanoic acid and ethanol**
- C. Ethanoic acid and butan -1 -ol
- D. Propanoic acid and ethanol

Answer: B

The ester is ethyl butanoate ($\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$). Acidic or basic hydrolysis cleaves the ester into butanoic acid ('Bunanoic acid' due to a typo in the option) and ethanol.

38. You are given a bottle of solid x and three aqueous solutions of Y, the first saturated the second unsaturated and the third supersaturated. Which of the following is correct, if you add a small amount of the solid solute to each solution?

- A. The solution in which the added solid solute dissolves is the saturated solution.
- B. The solution in which the added solid solute remains undissolved is the unsaturated solution.
- C. In all the three solution, saturated. Unsaturated and supersaturated the added solid solute will dissolve.
- D. ✓ **The supersaturated solution is unstable and addition of additional solute causes the excess solute to crystallize.**

Answer: D

A supersaturated solution contains more dissolved solute than the equilibrium amount and is metastable; adding a seed crystal induces rapid crystallization of the excess solute.

39. Consider the following equilibrium: $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}_2(\text{g})$ $K_{\text{eq}} = 4.0 \times 10^{-10}$ What is the value of K_{eq} for $2\text{CO}_2(\text{g}) \rightleftharpoons 2\text{CO}(\text{g}) + \text{O}_2(\text{g})$? (1)

- A. ✓ 2.5×10^9
- B. 2.0×10^{-5}
- C. 5.0×10^4
- D. 4.0×10^{-10}

Answer: A

Reversing a chemical equation inverts its equilibrium constant: $K'_{\text{eq}} = 1 / K_{\text{eq}} = 1 / (4.0 \times 10^{-10}) = 2.5 \times 10^9$.

40. For a certain gas phase reaction $2A(g) \rightleftharpoons B(g) + C(g)$ $\Delta H = +45\text{KJ/mol}$ $K = 4.5 \times 10^{-2}$ Which of the following would be true if the temperature was increased from 25°C to 200°C ? I. The value of k would be smaller. II. The concentration of $A(g)$ would be increased III. The concentration of $B(g)$ would increase (1)
- A. I
B. II
C. I and II
D. ✓ III

Answer: D

Because the forward reaction is endothermic ($\Delta H > 0$), an increase in temperature shifts the equilibrium toward the products according to Le Chatelier's principle, increasing the equilibrium constant K and the concentration of $B(g)$ while decreasing $[A(g)]$.

41. Which of the following compounds would be the most soluble in H_2O ? (1)
- A. Ethane
B. Pentane
C. ✓ Ethanoic acid
D. Octanoic acid

Answer: C

Ethanoic acid has a polar carboxyl group capable of extensive hydrogen bonding with water and a very short nonpolar hydrocarbon tail, making it miscible in all proportions with water.

42. A 0.2M solution of a weak acid HA is 1% ionized at 25°C K_a for the acid is equal to: (1)
- A. $\frac{0.01 \times 0.01}{0.19}$
B. $\frac{0.02 \times 0.02}{0.18}$
C. ✓ $\frac{0.002 \times 0.002}{0.198}$
D. $\frac{0.18}{0.01 \times 0.01}$

Answer: C

At 1% ionization, $[H^+] = [A^-] = 0.2\text{ M} \times 0.01 = 0.002\text{ M}$, and the un-ionized acid concentration is $[HA] = 0.2 - 0.002 = 0.198\text{ M}$. Thus, $K_a = [H^+][A^-]/[HA] = (0.002 \times 0.002) / 0.198$.

43. What species of ions are present in a 0.1M solution of HCl and what will be their equilibrium concentrations? (1)
- A. $[H_3O]^+ = 0.1\text{M}$; $[OH]^- = 10^{-13}\text{M}$, $[Cl]^- = 0.1\text{M}$
B. $[H_3O]^+ = 0.1\text{M}$; $[OH]^- = 0.1\text{M}$, $[Cl]^- = 0.1\text{M}$
✓ C. $[H_3O]^+ = 0.1\text{M}$; $[OH]^- = 0.01\text{M}$, $[Cl]^- = 0.1\text{M}$
D. $[H_3O]^+ = 10^{-13}$; $[OH]^- = 0.1\text{M}$, $[Cl]^- = 0.1\text{M}$

Answer: A

HCl is a strong acid that completely dissociates so $[H_3O^+] = 0.1\text{ M}$ and $[Cl^-] = 0.1\text{ M}$; from the water ion-product $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$, $[OH^-] = 10^{-13}\text{ M}$.

44. Commercial concentrated sulphuric acid (density = 1.831gcm^{-3}) is 94.0% H_2SO_4 by mass. What is the normality of H_2 (1)
- A. 16.8M
B. ✓ 35.0N
C. 28.2
D. 40.4M

Answer: B

The molarity is $(10 \times \% \times \text{density}) / \text{molar mass} = (10 \times 94.0 \times 1.831) / 98.08 \approx 17.54\text{ M}$; since sulfuric acid is diprotic (n -factor = 2), normality = $2 \times 17.54\text{ M} \approx 35.0\text{ N}$.

- 45.** 2.3g of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) is added to 500g of water. What is the molality of the resulting solution? (1)
- A. ✓ **0.1m** B. 0.01m
C. 1.0m D. 10.0m

Answer: A

The molar mass of ethanol is 46 g/mol, so 2.3 g corresponds to $2.3 / 46 = 0.05$ mol; molality = moles of solute / kg of solvent = $0.05 \text{ mol} / 0.5 \text{ kg} = 0.1 \text{ m}$.

46. A 0.5L and 0.1 M HNO_3 solution is to be prepared by dilution process from a 13M nitric acid. How many ml conc. HNO_3 and how many ml of water are required to prepare the dilute solution?
- A. 2ml HNO_3 and 498 ml water
- B. 10ml HNO_3 and 490ml water
- C. 20ml HNO_3 and 490ml water
- D. ✓ 3.85ml HNO_3 and 496.15ml water

Answer: D

Using $M_1V_1 = M_2V_2$: $13\text{ M} \times V_1 = 0.1\text{ M} \times 500\text{ mL}$ gives $V_1 = 3.85\text{ mL}$ of concentrated HNO_3 , and the volume of water required is $500\text{ mL} - 3.85\text{ mL} = 496.15\text{ mL}$.

47. During the electrolysis of a concentrated aqueous solution of NaCl, what substance is formed at the cathode? (1)
- A. Chlorine
B. ✓ Hydrogen
C. Oxygen
D. Sodium

Answer: B

During the electrolysis of concentrated aqueous NaCl (brine), water is more readily reduced than sodium ions, due to its higher reduction potential, liberating hydrogen gas at the cathode.

- 48.** In a voltaic cell, electrons flow from the _____ to the _____ (1)
- A. ✓ Anode, cathode B. Salt bridge, anode
- C. Anode, salt bridge D. Salt bridge, cathode

Answer: A

In any electrochemical cell, oxidation occurs at the anode and reduction at the cathode; therefore, electrons flow through the external circuit from the anode to the cathode.

- 49.** What is the PH of a mixture of 15.0ml of 0.126M NaOH and 21.0M H₂SO₄? (1)
- A. ✓ 1.7 B. 11.81
C. 2.15 D. 13.6

Answer: A

50. Which of the following correctly lists electromagnetic waves in order from shortest to longest wavelength? (1)
- A. Microwaves, ultraviolet, visible light, gamma rays
 - B. ✓ **Gamma rays, ultraviolet, infrared, microwaves**
 - C. Radio waves, infrared, gamma rays, ultraviolet
 - D. Gamma rays, infrared, ultraviolet, microwaves

Answer: B

In the electromagnetic spectrum, wavelength increases in the order: gamma rays < X-rays < ultraviolet < visible < infrared < microwaves < radio waves.

51. The relationship between Pico meter (pm) and nanometre (nm) is: (1)

- A. ✓ **1nm = 1000pm** B. 1nm = 10pm
C. 1pm = 100nm D. 1pm = 10nm

Answer: A

Since $1\text{ nm} = 10^{-9}\text{ m}$ and $1\text{ pm} = 10^{-12}\text{ m}$, $1\text{ nm} = 10^3\text{ pm} = 1000\text{ pm}$.

52. What would be the wavelength of a radio wave having a frequency of 3 MHz? (1)

- A. 100nm B. 300m
C. ✓ **100m** D. 300nm

Answer: C

Wavelength is given by $\lambda = c / f = (3.0 \times 10^8\text{ m/s}) / (3.0 \times 10^6\text{ s}^{-1}) = 100\text{ m}$.

53. The process of vulcanization of rubber makes it (1)

- A. More soluble in solvents B. Soft
C. Less elastic D. ✓ **Hard**

Answer: D

Vulcanization involves cross-linking polymer chains of rubber with sulfur, which makes the rubber harder, stiffer, and more resistant to heat and wear.

54. Which of the following is NOT the decomposition product of HNO_3 ? (1)

- A. NO_2 B. O_2
C. ✓ **N_2O_4** D. H_2O

Answer: C

Nitric acid decomposes thermally or photochemically according to the reaction $4\text{HNO}_3 \rightarrow 4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2$, so N_2O_4 is not considered a primary decomposition product.

55. To determine the volume of an irregularly shaped glass vessel, the vessel is weighed empty (121.3g) and when filled with CCl_4 (283.2g). What is the volume capacity of the vessel, given that the density of CCl_4 is 1.59 g/cm^3 ? (1)

- A. 76.29 cm^3 B. 178.11 cm^3
C. ✓ **101.82 cm^3** D. 257.42 cm^3

Answer: C

The mass of CCl_4 is $283.2\text{ g} - 121.3\text{ g} = 161.9\text{ g}$. Dividing mass by density gives volume = $161.9\text{ g} / 1.59\text{ g/cm}^3 = 101.82\text{ cm}^3$.

56. For the reaction $\text{C}_6\text{H}_{14}(\text{g}) \rightarrow \text{C}_6\text{H}_6(\text{g}) + 4\text{H}_2(\text{g})$, $\Delta p(\text{H}_2)/\Delta t$ was found to be $2.5 \times 10^{-2}\text{ atm/s}$, where $\Delta p(\text{H}_2)$ is change in the pressure of hydrogen. Determine $\Delta p(\text{C}_6\text{H}_{14})/\Delta t$ in units of atm/s for this reaction at the same time. (1)

- A. 6.2×10^{-2} B. 1.6×10^{-3}
C. ✓ **-6.2×10^{-3}** D. 2.5×10^{-2}

Answer: C

From the stoichiometry of the reaction, $-\Delta p(\text{C}_6\text{H}_{14})/\Delta t = \frac{1}{4}\Delta p(\text{H}_2)/\Delta t$. Substituting $\Delta p(\text{H}_2)/\Delta t = 2.5 \times 10^{-2}\text{ atm/s}$ yields $\Delta p(\text{C}_6\text{H}_{14})/\Delta t = -6.25 \times 10^{-3}\text{ atm/s}$.

The formation of solute-solvent attractions (solvation) releases energy, making this step exothermic ($\Delta H < 0$). In contrast, breaking or weakening solute-solute and solvent-solvent interactions are endothermic processes.

62. What volume of 1.40M H_2SO_4 solution is needed to react exactly with 10.0g of aluminium according of the following reaction? $2\text{Al}(\text{s}) + 2\text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Al}_2(\text{SO}_4)_3(\text{aq}) + 3\text{H}_2(\text{g})$ (1)

- A. 2.643ml
B. ✓ 264.3ml
C. 26.43ml
D. 2643ml

Answer: B

Based on the provided reaction equation with a 1:1 mole ratio between Al and H_2SO_4 , $n(\text{Al}) = 10.0 \text{ g} / 27.0 \text{ g/mol} = 0.370 \text{ mol}$. The required volume of 1.40 M H_2SO_4 is $V = 0.370 \text{ mol} / 1.40 \text{ M} = 0.2643 \text{ L} = 264.3 \text{ mL}$.

63. Which of the following statements is NOT true in relation to the triple point on a single component phase diagram? (1)

- A. The point at which the solid, liquid and gaseous phases for a substance co-exist.
B. ✓ **The triple point exists at a single temperature and is independent of pressure.**
C. The system must be enclosed so that no Vapour can escape
D. The triple point exists for a substance occurs at a specific temperature and pressure.

Answer: B

According to Gibbs' phase rule ($F = C - P + 2 = 1 - 3 + 2 = 0$), the triple point of a single-component system has zero degrees of freedom, meaning it occurs at a unique, fixed temperature and pressure.

64. Consider the following equilibrium: $\text{Cl}_2(\text{g}) + 2\text{NO}(\text{g}) \rightleftharpoons 2\text{NOCl}(\text{g})$ $K_{\text{eq}} = 5.0$ At equilibrium, $[\text{Cl}_2] = 1.0\text{M}$ and $[\text{NO}] = 2.0\text{M}$. What is the $[\text{NOCl}]$ at equilibrium? (1)

- A. 0.80M
B. 0.89
C. 10M
D. ✓ 4.5M

Answer: D

The equilibrium constant expression is $K_{\text{eq}} = [\text{NOCl}]^2 / ([\text{Cl}_2][\text{NO}]^2)$. Substituting the given values gives $5.0 = [\text{NOCl}]^2 / (1.0 \times 2.0^2)$, so $[\text{NOCl}]^2 = 20$, which yields $[\text{NOCl}] \approx 4.5 \text{ M}$.

65. Which acid is produced when toluene is subjected to KMnO_4 oxidation? (1)

- A. Phenyl acetic acid
B. Toluic acid
C. ✓ **Benzoic acid**
D. Phthalic acid

Answer: C

Vigorous oxidation of an alkylbenzene like toluene with potassium permanganate (KMnO_4) oxidizes the methyl group to a carboxylic acid group, producing benzoic acid.

66. Calculate ΔH for the following reaction using the bond energies given below $\text{H} - \text{H}(\text{g}) + \text{I} - \text{I}(\text{g}) \rightarrow 2\text{H} - \text{I}(\text{g})$ bond energies: $\text{H} - \text{H} = 436\text{KJ/mol}$, $\text{I} - \text{I} = 151\text{KJ/mol}$, $\text{H} - \text{I} = 297\text{KJ/mol}$ (1)

- A. ✓ -7KJ
B. -290KJ
C. +7KJ
D. +290KJ

Answer: A

The reaction enthalpy is calculated as $\Delta H = \Sigma \text{BE}(\text{reactants}) - \Sigma \text{BE}(\text{products}) = [\text{BE}(\text{H-H}) + \text{BE}(\text{I-I})] - 2 \times \text{BE}(\text{H-I}) = (436 + 151) - 2(297) = 587 - 594 = -7 \text{ kJ}$.

67. How long has a current of 3 ampere to be applied through a solution of silver nitrate to coat a metal surface of 80cm^2 with 0.005cm thick layer? Density of silver = 10.5gcm^{-3} (1)
- A. 476s
B. ✓ 1252s
C. 683s
D. 1028s

Answer: B

The volume of Ag required is $80\text{ cm}^2 \times 0.005\text{ cm} = 0.4\text{ cm}^3$, so the mass is $0.4\text{ cm}^3 \times 10.5\text{ g/cm}^3 = 4.2\text{ g}$. Using $t = (m \times n \times F) / (M \times I)$ with $n = 1$, $M = 107.9\text{ g/mol}$, and $F = 96500\text{ C/mol}$ gives $t = (4.2 \times 1 \times 96500) / (107.9 \times 3) \approx 1252\text{ s}$.

68. Which of the following is an organic acid? (1)
- A. $\text{CH}_3\text{CH}_2\text{OH}$
B. CH_3CH_3
C. $\text{CH}_2 = \text{CH}_2$
D. ✓ $\text{CH}_3\text{CO}_2\text{H}$

Answer: D

$\text{CH}_3\text{CO}_2\text{H}$ (acetic acid/ethanoic acid) contains the carboxyl functional group ($-\text{COOH}$), which characterizes organic carboxylic acids.

69. During a titration what volume of 0.500M KOH is necessary to completely neutralize 10.0ml of 2.00M CH_3COOH ? (1)
- A. 10.0ml
B. ✓ 40.0ml
C. 25.0ml
D. 20.0ml

Answer: B

KOH and CH_3COOH react in a 1:1 molar ratio, so $M_1V_1 = M_2V_2$. Thus, $V(\text{KOH}) = (2.00\text{ M} \times 10.0\text{ mL}) / 0.500\text{ M} = 40.0\text{ mL}$.

70. What is the standard cell potential of the oxidation of ammonia, given below? $4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$ $\Delta G^0 = -1356\text{KJ}$ (1)
- A. 7.02V
B. 3.51V
C. ✓ 1.17V
D. 14.04V

Answer: C

In the reaction, nitrogen changes oxidation state from -3 to 0 , representing a transfer of 12 electrons ($n = 12$). Using $E^0 = -\Delta G^0 / (nF) = 1356000\text{ J} / (12 \times 96500\text{ C/mol})$ gives $E^0 \approx 1.17\text{ V}$.

71. Two electrolytic cells were placed in series, one of AgNO_3 and the other of CuSO_4 . If 1.273g Ag is deposited, how much Cu was deposited, how much Cu was deposited at the same time? (1)
- A. ✓ 0.374
B. 0.0118
C. 0.748
D. 0.954

Answer: A

According to Faraday's second law, mass ratio is $(m_{\text{Cu}} / m_{\text{Ag}}) = (M_{\text{Cu}} / z_{\text{Cu}}) / (M_{\text{Ag}} / z_{\text{Ag}}) = (63.55 / 2) / (107.9 / 1) \approx 0.2945$. Therefore, $m_{\text{Cu}} = 1.273\text{ g} \times 0.2945 \approx 0.374\text{ g}$.

— END OF MARKING KEY —