

Applied Chemistry 2024 Question Paper and Solution

By Poly Notes Hub | Author: Arun Paul



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103(N)

APPLIED CHEMISTRY

Time Allowed: 2.5 Hours

Full Marks: 60

Answer to Question No. 1 of Group A must be written in the main answer script. In Question No. 1, out of 2 marks for each MCQ, 1 mark is allotted for right answer and 1 mark is allotted for correct explanation of the answer.

Answer any Five (05) Questions from Group-B.

Group A

1. Choose the correct answer from the given alternatives and explain your answer (any ten) 2×10=20
 - i. The (v/v) % of a solution containing 5 mL of alcohol in 40 mL of water is (a) 14.29% (b) 12.5% (c) 11.11% (d) 10%
 - ii. Unit of electro chemical equivalent is (a) gm (b) Coulomb (c) gm/Coulomb (d) Coulomb/gm
 - iii. Cu is extracted from Copper Pyrites ore by (a) Electrolytic reduction method (b) Thermit process (c) Self reduction method (d) Carbon reduction method
 - iv. The salt which is not responsible for hardness, is (a) $MgSO_4$ (b) $CaCl_2$ (c) Na_2SO_4 (d) $Ca(HCO_3)_2$
 - v. Anti-knocking quality of diesel is indicated by (a) Heptane number (b) Octane number (c) Cetane number (d) none of them
 - vi. Hybridisation of C in CH_4 is (a) sp^2 (b) sp (c) sp^3d (d) sp^3
 - vii. The oxidation number of Cl in $KClO_3$ is (a) 7 (b) 5 (c) 3 (d) 1
 - viii. The monomers of Buna-S rubber are (a) styrene and butadiene (b) isoprene and butadiene (c) vinyl chloride and sulphur (d) butadiene
 - ix. The amount of electricity that is required to deposit 24 gm of Na from fused NaCl is (a) 0.5 F (b) 1F (c) 2F (d) 3F. (At. Wt. of Na is 24)
 - x. Natural rubber is the polymer of (a) Styrene (b) iso-Butylene (c) Isoprene (d) Propylene
 - xi. Maximum number of electrons that can be accommodated in d sub-shell is (a) 5 (b) 10 (c) 20 (d) 2.
 - xii. Which of the following pH represents acidic solution? (a) 7 (b) 9 (c) 3 (d) 14
 - xiii. Which one of the following is weak electrolyte? (a) NaCl (b) H_2SO_4 (c) KCl (d) HCOOH
 - xiv. Formula for gypsum is: (a) $CaSO_4 + CaCO_3$ (b) $CaSO_4 \cdot \frac{1}{2} H_2O$ (c) $CaSO_4 \cdot 2 H_2O$ (d) none of these
 - xv. For Copper plating on a Iron nail, cathode, anode and electrolyte will be (a) Cu, Fe, $FeSO_4$ (b) Fe, Cu, $CuSO_4$ (c) Fe, Cu, $FeSO_4$ (d) Cu, Fe, $CuSO_4$
 - xv. Hardness of distilled water is (a) 0 ppm (b) 1 ppm (c) 10 ppm (d) 100 ppm

GROUP-B

2.
 - a) State Pauli's Exclusion Principle. What are the values of four Quantum numbers of the two electrons, present in the valance shell of ${}_{20}Ca$?
 - b) Calculate the molarity of a solution, prepared by dissolving 0.4 gm of NaOH in 250 mL solution.
 - c) State the hybridisation of central atoms of following molecules: (1+3)+2+2
 BF_3 , NH_3 , $BeCl_2$, and CH_4 .
3.
 - a) 500 ml of water sample contains 2.4 mg of $MgSO_4$ and 11.1 mg of $CaCl_2$. Find out the total hardness of the water sample. (Mol. Wt. of $MgSO_4 = 120$, Mol. Wt. of $CaCl_2 = 120$)
 - b) What is Zeolite? How water is softened using Zeolite process? (Use chemical reactions) 3+(1+2)+2
 - c) How an exhausted Zeolite bed can be revived?
4.
 - a) Explain – H_2O is liquid but H_2S is gas.
 - b) State Aufbau Principle. Write down the electronic configuration of ${}_{26}Fe^{2+}$.
 - c) The hardness of a water sample is 450 ppm. Calculate the amount of 0.01 (M) EDTA solution required to neutralize 20 ml of such water sample. 2+(1+2)+3

5. a) Write the name and formula of one Al alloy. How Al is extracted from Alumina?
b) State the differences between thermoplastic plastic and thermosetting plastic. Write down the name(s) of monomer(s) and one use of bakelite and teflon. (1+3)+(2+2)
6. a) What is proximate analyses of coal?
b) Write down the composition of Portland cement. What are the composition of carborundum and bell metal?
c) Why graphite is used as lubricant? 2+(2+2)+2
7. a) A coal sample of HCV 4800 kCal/kg contains 5% H in it. Calculate LCV of the coal sample.
b) Write down the composition and two applications of LPG and producer gas.
c) Define oiliness of a lubricating oil. 3+(2+2)+1
8. a) Write down the electrodes, electrolytes and chemical reactions for Lead storage battery during discharging.
b) Calculate the pH of 0.01(M) HCl solution. Give one example of basic buffer.
c) Compare between electrochemical corrosion and chemical corrosion with examples. 3+(2+1)+2
9. a) How does the rusting of iron occur? <https://www.wbscteonline.com>
b) Explain oxidation and reduction electronically with suitable example.
c) 0.75 ampere of electricity is passed through an aqueous solution of a divalent metal salt for 45 minutes. As a result, the weight of cathode is increased by 0.6662 gm. Determine the equivalent weight and atomic weight of the metal. 3+2+3

Group A

1. Multiple-Choice Questions (MCQs)

Each correct explanation is worth 2 marks (1 mark for correct choice, 1 mark for explanation).

i. The (v/v)% of a solution containing 5 mL of alcohol in 40 mL of water is:

- Solution: $\text{(v/v)\%} = \frac{\text{Volume of solute}}{\text{Total volume}} \times 100$

$$\text{Total volume} = 5 + 40 = 45 \text{ mL}$$

$$\text{(v/v)\%} = \frac{5}{45} \times 100 = 11.11\%$$

Answer: (c) 11.11%

ii. Unit of electrochemical equivalent:

- Electrochemical equivalent is the mass of a substance deposited per unit charge and is measured in **gm/Coulomb**.

Answer: (d) gm/Coulomb

iii. Cu is extracted from copper pyrites by:

- Copper pyrites are processed using the **self-reduction method** in metallurgy.

Answer: (c) Self-reduction method

iv. The salt which is not responsible for hardness:

- $\text{Ca}(\text{HCO}_3)_2$ causes temporary hardness. Other salts contribute to hardness, but MgSO_4 does not.

Answer: (a) MgSO_4

v. Anti-knocking quality of diesel is indicated by:

- Diesel quality is measured by **cetane number**.

Answer: (c) Cetane number

vi. Hybridisation of C in CH_4 is:

- Methane (CH_4) has an sp^3 hybridization because carbon forms four sigma bonds.

Answer: (d) sp^3

vii. Oxidation number of Cl in KClO_3 :

- Oxidation number: K = +1, O = -2, Cl = x .

$$+1 + x + 3(-2) = 0$$

$$x = +5$$

Answer: (b) 5

viii. Monomers of Buna-S rubber:

- Buna-S is made from **styrene and butadiene**.

Answer: (a) Styrene and butadiene

Answers



ix. Electricity required to deposit 24 gm of Na from fused NaCl:

- Molecular weight of Na = 23, Faraday constant = 1 F for sodium.

For 24 gm:

$$\frac{\text{Mass of Na}}{\text{Atomic mass}} = \frac{24}{23} \approx 1 \text{ F}$$

Answer: (b) 1F

x. Natural rubber is the polymer of:

- Natural rubber is a polymer of **isoprene**.

Answer: (c) Isoprene

xi. Maximum electrons in d sub-shell:

- d sub-shell can hold **10 electrons**.

Answer: (c) 10

xii. Acidic solution pH:

- pH of acidic solutions is less than 7.

Answer: (b) 5

xiii. Weak electrolyte:

- Weak electrolytes partially dissociate; examples include H_2SO_3 .

Answer: (b) H_2SO_3

xiv. Formula for gypsum:

- Gypsum formula is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$.

Answer: (c) $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

xv. Copper plating electrolyte:

- Electrolyte used is CuSO_4 .

Answer: (d) CuSO_4

xvi. Hardness of distilled water:

- Distilled water has **0 ppm** hardness.

Answer: (a) 0 ppm

Answers



Group B

2a. Pauli's Exclusion Principle and Quantum Numbers

The atomic number of Ca is 20. The valence shell (4s) has 2 electrons. For each electron:

- First electron:
 - Principal quantum number (n): 4
 - Azimuthal quantum number (l): 0 (s orbital)
 - Magnetic quantum number (m): 0
 - Spin quantum number (s): +1/2
- Second electron:
 - Principal quantum number (n): 4
 - Azimuthal quantum number (l): 0
 - Magnetic quantum number (m): 0
 - Spin quantum number (s): -1/2

2b. Molarity Calculation

Given:

Mass of NaOH = 0.4 gm, volume of solution = 250 mL, molar mass of NaOH = 40 g/mol.

$$\text{Moles of NaOH} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{0.4}{40} = 0.01 \text{ mol}$$

$$\text{Molarity} = \frac{\text{Moles}}{\text{Volume in L}} = \frac{0.01}{0.25} = 0.04 \text{ M}$$

2c. Hybridisation of Molecules

- BF₃: sp²
- NH₃: sp³
- BeCl₂: sp
- CH₄: sp³

5.

a)

- Name and Formula of One Al Alloy: **Duralumin (Aluminum Alloy)**; Composition: Al (95%), Cu (4%), Mg (0.5%), Mn (0.5%).
- Extraction of Aluminum from Alumina: **Hall-Hérout Process** involves the electrolysis of alumina dissolved in molten cryolite.

b)

- Differences Between Thermoplastic and Thermosetting Plastic:
Thermoplastic: Soften upon heating, can be remolded. Example: Polyethylene.
Thermosetting Plastic: Harden permanently after molding, cannot be remolded. Example: Bakelite.
- One Use Each:
Bakelite: Electrical switches.
Teflon: Non-stick cookware.

6.

a)

- Proximate Analysis of Coal: Determines moisture, volatile matter, fixed carbon, and ash content.

b)

- Composition of Portland Cement: Lime (CaO: 60–67%), Silica (SiO₂: 17–25%), Alumina (Al₂O₃: 3–8%), Iron oxide (Fe₂O₃: 0.5–6%), Gypsum (CaSO₄·2H₂O).
- Composition of:
Carborundum: Silicon carbide (SiC).
Bell Metal: Copper (80%) and Tin (20%).

c)

- Graphite as a Lubricant: Its layered structure allows easy slippage between layers, reducing friction.

7.

a)

- LCV of Coal Sample:
Higher Calorific Value (HCV): **4800 kcal/kg**
% Hydrogen (H): **5%**
Latent heat of water vapor (LHV): **587 kcal/kg**
Formula:

$$LCV = HCV - 0.09 \times \%H \times LHV$$

$$LCV = 4800 - 0.09 \times 5 \times 587 = 4800 - 264.15 = 4535.85 \text{ kcal/kg}$$

b)

- Composition of LPG: Propane (C_3H_8) and Butane (C_4H_{10}).
- Applications:
 1. Cooking fuel.
 2. Automobile fuel.
Composition of Producer Gas: CO and N_2 .
Applications:
 3. Industrial fuel.
 4. Metal cutting and welding.

c)

- Oiliness of Lubricating Oil: The property that enables oil to maintain a thin film between surfaces under high pressure.

8.

a)

- **Electrodes:** Lead (Pb) and Lead dioxide (PbO_2).
- **Electrolyte:** Sulfuric acid (H_2SO_4).
- **Discharging Reaction:**
At anode: $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$
At cathode: $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$.

b)

- pH of 0.01 M HCl Solution:
 $pH = -\log[H^+] = -\log[0.01] = 2$.
- Example of Basic Buffer: Ammonium hydroxide (NH_4OH) and Ammonium chloride (NH_4Cl).

c)

- Comparison Between Corrosion Types:
Electrochemical Corrosion: Involves electrochemical reactions, e.g., rusting of iron.
Chemical Corrosion: Direct reaction of metals with gases, e.g., oxidation of copper.

9.

a)

- Rusting of Iron:
 1. Formation of Fe^{2+} due to oxidation in the presence of oxygen and moisture.
 2. Reaction: $4Fe + 3O_2 + 6H_2O \rightarrow 4Fe(OH)_3$, which dehydrates to form rust ($Fe_2O_3 \cdot xH_2O$).

b)

- Oxidation: Loss of electrons, e.g., $Zn \rightarrow Zn^{2+} + 2e^{-}$.
- Reduction: Gain of electrons, e.g., $Cu^{2+} + 2e^{-} \rightarrow Cu$.

c)

- Given:

Current $I = 0.75$ A, Time $t = 45$ min = 2700 s,

Weight Increase of Cathode = 0.6662 g.

Faraday's Law:

$$\text{Weight} = \frac{Z \cdot I \cdot t}{96500}$$

Where Z is the electrochemical equivalent.

Rearranging:

$$Z = \frac{\text{Weight} \cdot 96500}{I \cdot t} = \frac{0.6662 \cdot 96500}{0.75 \cdot 2700} = 31.8 \text{ g/mol.}$$

Equivalent weight of the metal = 31.8.

Atomic weight for divalent metal = $2 \cdot 31.8 = 63.6$ g/mol.

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