Engineering Chemistry (DI01000071) - Winter 2024 Solution

Date: 2025-01-09

Question 1 [14 marks]

Fill in the blanks using appropriate choice from the given options:

Answer:

(1)	$[Ar]_4 s^1\, 3\, d^{10}$	Cu has 29 electrons, exception to Aufbau rule
(2)	14	pH + pOH = 14 at 25°C
(3)	cathode	Pure copper deposits at negative electrode
(4)	Cu	Copper forms protective oxide layer
(5)	semi-solid	Peat is partially decomposed organic matter
(6)	Dulong	Dulong's formula calculates calorific value
(7)	Lignite	Lignite has highest moisture (35-75%)
(8)	Poise	SI unit of dynamic viscosity
(9)	High	High flash point prevents ignition
(10)	Emulsion	Oil-water mixture forms emulsion
(11)	Bakelite	Phenol formaldehyde = Bakelite
(12)	S	Sulfur used for vulcanization
(13)	PHBV	PHBV is biodegradable polymer
(14)	volt	EMF measured in volts

Mnemonic: "Chemical Copper Creates Beautiful Properties" (for remembering key concepts)

Question 2(A) [6 marks]

Question 2(A)(1) [3 marks]

List the three importance of pH in various fields.

Answer:

Field	Importance	Application
Medicine	Blood pH maintenance	Normal pH 7.35-7.45 for proper body function
Agriculture	Soil pH optimization	pH 6-7 ideal for crop growth and nutrient absorption
Industry	Quality control	pH affects product quality in food, textiles, pharmaceutica

Mnemonic: "Medical Agriculture Industry" (MAI)

Question 2(A)(2) [3 marks]

Define: Buffer solutions, Half-cell, Faraday's first law of electrolysis.

Answer:

- **Buffer solutions**: Solutions that resist changes in pH when small amounts of acid or base are added.
- **Half-cell**: Single electrode immersed in its ionic solution, represents oxidation or reduction reaction.
- **Faraday's first law**: Amount of substance deposited/liberated at electrode is directly proportional to quantity of electricity passed ($w \propto Q$).

Mnemonic: "Buffers Help Faraday" (BHF)

Question 2(A)(3) [3 marks]

State the factors affecting the rate of corrosion.

Answer:

Factor	Effect	Description
Metal purity	Higher purity = Less corrosion	Impurities create galvanic cells
Temperature	Higher temp = Faster corrosion	Increases reaction rate
Humidity	Higher humidity = More corrosion	Promotes electrochemical reactions

Mnemonic: "Pure Temperature Humidity" (PTH)

Question 2(B) [8 marks]

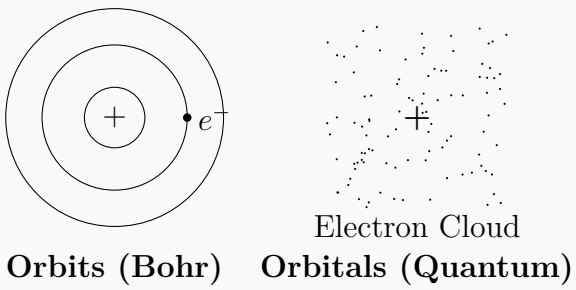
Question 2(B)(1) [4 marks]

Compare between orbits and orbitals (four points each).

Answer:

Aspect	Orbits	Orbitals
Definition	Fixed circular paths	3D probability regions
Shape	Circular/elliptical	s, p, d, f shapes
Energy	Definite energy levels	Energy ranges
Electron location	Exact position	Probability of finding

Diagram:



Orbits (Bohr) **Orbitals (Quantum)**

Mnemonic: "Definite Shape Energy Location" (DSEL)

Question 2(B)(2) [4 marks]

Classify fuels on the basis of its sources and physical states with one example of each.

Answer:

Classification	Type	Example	Description
Source-based	Natural	Coal	Formed naturally
	Artificial	Petrol	Man-made
Physical state	Solid	Wood	Solid at room temp
	Liquid	Diesel	Liquid at room temp
	Gaseous	LPG	Gas at room temp

Mnemonic: "Natural Artificial, Solid Liquid Gas" (NASLG)

Question 2(B)(3) [4 marks]

Explain bio-diesel with four important points.

Answer:

- **Source**: Made from vegetable oils, animal fats, or waste cooking oil.
- **Process**: Produced by transesterification reaction with methanol/ethanol.
- **Properties**: Biodegradable, non-toxic, renewable fuel source.
- **Applications**: Used in diesel engines, reduces emissions by 75%.

Chemical Reaction:

$$\text{Vegetable Oil} + \text{Methanol} \xrightarrow{\text{Catalyst}} \text{Bio-diesel} + \text{Glycerol}$$

Mnemonic: "Source Process Properties Applications" (SPPA)

Question 3(A) [6 marks]

Question 3(A)(1) [3 marks]

Explain solute, solvent and solution with the help of example.

Answer:

Component	Definition	Example
Solute	Substance being dissolved	Salt (NaCl)
Solvent	Substance doing the dissolving	Water (H_2O)
Solution	Homogeneous mixture	Salt water

Example: Sugar + Water = Sugar solution

- Sugar = Solute, Water = Solvent, Sugar water = Solution

Mnemonic: "Solute Solvent Solution" (SSS)

Question 3(A)(2) [3 marks]

Explain the formation of Electrovalent bond in NaCl.

Answer: **Process**:

1. **Step 1**: Na loses 1 electron → Na^+ (cation)
2. **Step 2**: Cl gains 1 electron → Cl^- (anion)
3. **Step 3**: Electrostatic attraction between Na^+ and Cl^- forms NaCl.

Reaction:

$$\begin{gathered} Na \longrightarrow Na^+ + e^- \\ Cl + e^- \longrightarrow Cl^- \\ Na^+ + Cl^- \longrightarrow NaCl \end{gathered}$$

Mnemonic: "Sodium Loses, Chlorine Gains, Attraction Forms" (SLCGAF)

Question 3(A)(3) [3 marks]

Explain Octane number for gasoline.

Answer:

Aspect	Description
Definition	Measure of fuel's resistance to knocking
Scale	0-100, higher = better anti-knock properties
Standard	n-heptane = 0, iso-octane = 100

Applications: High octane fuel prevents engine knocking, improves performance.
Mnemonic: "Octane Opposes Knocking" (OOK)

Question 3(B) [8 marks]

Question 3(B)(1) [4 marks]

Explain electrorefining of impure Cu with chemical equations and a labeled diagram.

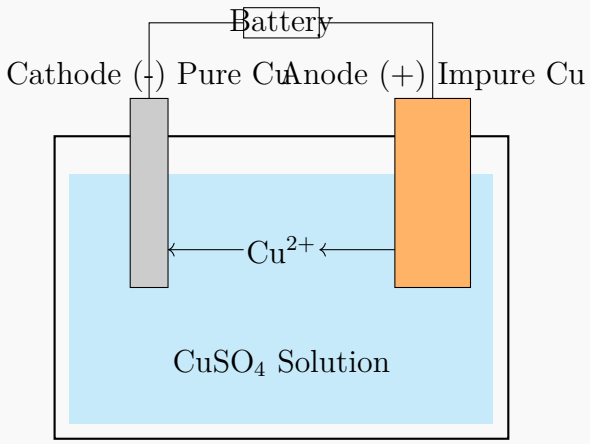
Answer: **Process**:

- **Anode**: Impure copper (Thick rod) - dissolves.
- **Cathode**: Pure copper (Thin strip) - deposits.
- **Electrolyte**: Acidified $CuSO_4$ solution.

Chemical Equations:

- At Anode: $Cu \longrightarrow Cu^{2+} + 2\,e^-$ (Oxidation)
- At Cathode: $Cu^{2+} + 2\,e^- \longrightarrow Cu$ (Reduction)

Diagram:



Mnemonic: "Anode Dissolves, Cathode Deposits" (ADCD)

Question 3(B)(2) [4 marks]

Explain preparation of ethene with chemical equation. Also write its two properties and two uses.

Answer: **Preparation**: Dehydration of ethanol with conc. H_2SO_4 at 170°C.

$$C_2H_5OH \xrightarrow[170\,^\circ C]{\text{Conc}\cdot H_2SO_4} C_2H_4 + H_2O$$

Properties:

- **Physical**: Colorless, sweet-smelling gas.
- **Chemical**: Unsaturated hydrocarbon, undergoes addition reactions.

Uses:

- Manufacturing polyethylene plastic.
- Artificial ripening of fruits.

Mnemonic: "Preparation Properties Uses" (PPU)

Question 3(B)(3) [4 marks]

Explain preparation of Buna-S rubber with chemical equation. Also write its two properties and two uses.

Answer: **Preparation**: Copolymerization of 1,3-Butadiene and Styrene in 3:1 ratio.

$$n\,CH_2{=}CH{-}CH{=}CH_2 + n\,C_6H_5{-}CH{=}CH_2 \longrightarrow -[CH_2{-}CH{=}CH{-}CH_2{-}CH(C_6H_5){-}CH_2]_n-$$

(Butadiene + Styrene → Buna-S)
Properties:

- High abrasion resistance.
- High load-bearing capacity.

Uses:

- Manufacturing automobile tires.
- Conveyor belts and hoses.

Mnemonic: "Butadiene Styrene Makes Strong Rubber" (BSMSR)

Question 4(A) [6 marks]

Question 4(A)(1) [3 marks]

Explain metal cladding for the prevention of corrosion of metals.

Answer:

- **Process**: Sandwiching the base metal between two layers of corrosion-resistant metal (like Al, Ni).
- **Method**: Sheets of coating metal are pressed on base metal through rollers under heat and pressure (Roll bonding).
- **Use**: Used in aircraft industry (Alclad - Duralumin sandwiched between pure Aluminum).
- **Mechanism**: Protective layer acts as a physical barrier against oxygen and moisture.

Mnemonic: "Coating Protects Metal" (CPM)

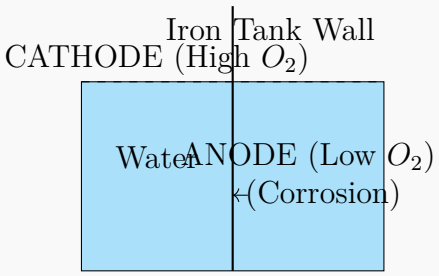
Question 4(A)(2) [3 marks]

Explain waterline corrosion with chemical equations and labeled diagram.

Answer: **Process**: Occurs due to differential aeration at the water-air interface. The part of metal below waterline (poor oxygen) becomes anodic, and part just below meniscus (rich oxygen) becomes cathodic.
Chemical Equations:

- Anode: $\mathrm{Fe} \longrightarrow \mathrm{Fe}^{2+} + 2\,\mathrm{e}^-$ (Corrosion occurs here)
- Cathode: $\mathrm{O_2} + 2\,\mathrm{H_2O} + 4\,\mathrm{e}^- \longrightarrow 4\,\mathrm{OH}^-$

Diagram:



Mnemonic: "Water Air Interface Corrodes" (WAIC)

Question 4(A)(3) [3 marks]

Explain the working principle of solar cells.

Answer:

Component	Function
Photovoltaic effect	Light energy converts to electrical energy
p-n junction	Creates electric field for charge separation
Electron-hole pairs	Generated when photons hit semiconductor

Process: Light hits surface → Electrons excited → Move across p-n junction → Current flow in external circuit.
Mnemonic: "Photo Voltaic Junction Creates Current" (PVJCC)

Question 4(B) [8 marks]

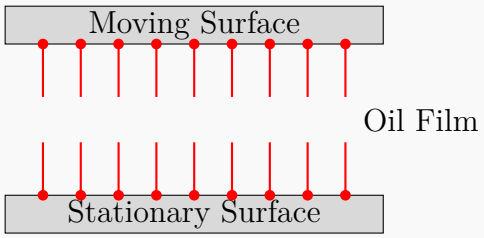
Question 4(B)(1) [4 marks]

Demonstrate the function of boundary lubrication with diagram.

Answer: **Function**: Used under high load and low speed. A thin molecular layer of lubricant gets adsorbed on metal surfaces, preventing direct metal-to-metal contact.
Mechanism:

- Polar ends of lubricant molecules attach to metal.
- Hydrocarbon chains stand perpendicular, creating a cushion.
- Prevents welding/seizure of surfaces.

Diagram:



Mnemonic: "Boundary Barriers Prevent Metal Contact" (BBPMC)

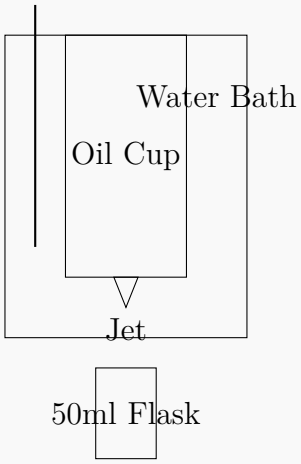
Question 4(B)(2) [4 marks]

Explain how viscosity is measured through redwood viscometer with labelled diagram.

Answer: **Principle**: Measures viscosity in "Redwood Seconds" - time taken for 50ml of oil to flow through a standard orifice under gravity.
Procedure:

1. Clean and level the instrument.
2. Fill oil in the cup to pointer level. Heat water bath to desired temp.
3. Remove ball valve, start stopwatch.
4. Collect 50ml oil in Kohlrausch flask. Stop watch.

Viscosity $= At - \frac{B}{t}$ (Kinematic viscosity)
Diagram:



Mnemonic: "Redwood Records Time" (RRT)

Question 4(B)(3) [4 marks]

Define: Semiconductor, Insulating material, Elastomer, Addition polymerization.

Answer:

Term	Definition
Semiconductor	Material with conductivity between conductor and insulator (e.g., Si, Ge).
Insulating material	Material that resists flow of electric current (e.g., Rubber, Glass).
Elastomer	Polymer with high elasticity, stretches and returns to shape (e.g., Natural Rubber).
Addition polymerization	Monomers join without elimination of by-products (e.g., PE, PVC).

Mnemonic: "Semi Insulating Elastic Addition" (SIEA)

Question 5(A) [6 marks]

Question 5(A)(1) [3 marks]

Solve: Calculate the pH and pOH of 0.004 M HCl aqueous solution. (log 4 = 0.6021)

Solution:

- HCl is a strong acid, completely ionizes: $HCl \longrightarrow H^+ + Cl^-$
- $[H^+] = [HCl] = 0.004\ M = 4 \times 10^{-3}\ M$
- $pH = -\log[H^+] = -\log(4 \times 10^{-3})$
- $pH = -(\log 4 + \log 10^{-3}) = -(0.6021 - 3) = 2.3979 \approx 2.40$
- $pOH = 14 - pH = 14 - 2.40 = 11.60$

Answer: pH = 2.40, pOH = 11.60

Question 5(A)(2) [3 marks]

Describe extrinsic semiconductors and it types with examples.

Answer: Extrinsic semiconductors are doped with impurities to increase conductivity.

Type	Dopant	Major Carrier	Example
n-type	Pentavalent (Gr V) (P, As)	Electrons	Si + P
p-type	Trivalent (Gr III) (B, Al)	Holes	Si + B

Mnemonic: "n-negative electrons, p-positive holes" (nnep)

Question 5(A)(3) [3 marks]

Distinguish between thermoplastic polymers and thermosetting polymer (Four points of each)

Answer:

Property	Thermoplastic	Thermosetting
Structure	Linear/branched chains	3D Cross-linked network
Heat effect	Softens on heating, hardens on cooling	Does not soften, chars on heating
Reversibility	Can be remolded (Reversible)	Cannot be remolded (Irreversible)
Solubility	Soluble in organic solvents	Insoluble
Example	PE, PVC, PS	Bakelite, Melamine

Mnemonic: "TP=Reversible, TS=Permanent"

Question 5(B) [8 marks]

Question 5(B)(1) [4 marks]

Describe hydrogen bond and its types with examples.

Answer: **Definition**: Weak electrostatic attraction between Hydrogen atom covalently bonded to a highly electronegative atom (F, O, N) and another electronegative atom.
Types:

1. **Intermolecular**: Between different molecules (e.g., H_2O, HF, Alcohol). raises BP.
2. **Intramolecular**: Within the same molecule (e.g., o-nitrophenol).

Diagram (Intermolecular in Water):

H–O–H - - H–O–H - - H–O–H
H-Bond

Mnemonic: "Hydrogen Needs FON friends"

Question 5(B)(2) [4 marks]

Differentiate between Primary cell and Secondary cell. (Four points)

Answer:

Aspect	Primary Cell	Secondary Cell
Rechargeability	Not rechargeable	Rechargeable
Reaction	Irreversible	Reversible
Life	Short life	Long life
Example	Dry cell, Daniel cell	Lead-acid, Ni-Cd, Li-ion

Mnemonic: "Primary = Permanent, Secondary = Reversible"

Question 5(B)(3) [4 marks]

Describe construction, working and chemical equations of lead-acid storage cell with a labelled diagram.

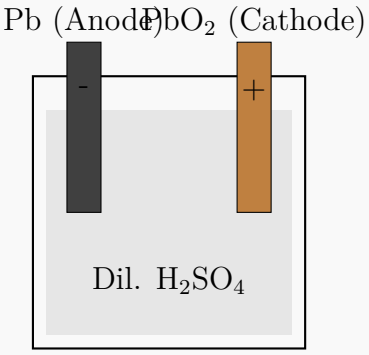
Answer: **Construction**:

- **Anode**: Spongy Lead (Pb).
- **Cathode**: Lead Dioxide (PbO_2).
- **Electrolyte**: Dilute H_2SO_4 (density 1.25-1.30 g/cc).

Working (Discharge):

- Anode: $Pb + {SO_4}^{2-} \longrightarrow PbSO_4 + 2\,e^-$
- Cathode: $PbO_2 + 4\,H^+ + {SO_4}^{2-} + 2\,e^- \longrightarrow PbSO_4 + 2\,H_2O$
- Overall: $Pb + PbO_2 + 2\,H_2SO_4 \longrightarrow 2\,PbSO_4 + 2\,H_2O + \text{Energy}$

Diagram:



Mnemonic: "LASRE = Lead Acid Storage Reversible Energy"