

# Engineering Chemistry Solutions

DI01000071 – Winter 2024

Semester 1 Study Material

*Detailed Solutions and Explanations*

## Question 1 [14 marks]

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

### Solution

Answer:

(1)	$[\text{Ar}]4s^1 3d^{10}$	Cu has 29 electrons, exception to Aufbau rule
(2)	14	$\text{pH} + \text{pOH} = 14$ at $25^\circ\text{C}$
(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.

### Solution

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, pharmaceuticals

### Mnemonic

"Medical Agriculture Industry" (MAI)

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

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

### Solution

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.

### Solution

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

### Mnemonic

"Pure Temperature Humidity" (PTH)

## Question 2(B) [8 marks]

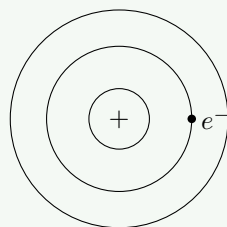
### Question 2(B)(1) [4 marks]

Compare between orbits and orbitals (four points each).

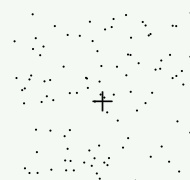
### Solution

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

Diagram:



Orbits (Bohr)



Electron Cloud

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.

#### Solution

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]

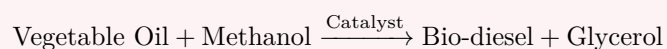
Explain bio-diesel with four important points.

#### Solution

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%.

#### Key Formula



#### 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.

#### Solution

Answer:	Component	Definition	Example
	Solute	Substance being dissolved	Salt (NaCl)
	Solvent	Substance doing the dissolving	Water (H <sub>2</sub> O)
	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]

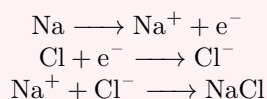
Explain the formation of Electrovalent bond in NaCl.

### Solution

#### Process:

1. **Step 1:** Na loses 1 electron  $\rightarrow \text{Na}^+$  (cation)
2. **Step 2:** Cl gains 1 electron  $\rightarrow \text{Cl}^-$  (anion)
3. **Step 3:** Electrostatic attraction between  $\text{Na}^+$  and  $\text{Cl}^-$  forms NaCl.

#### Key Formula



### Mnemonic

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

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

Explain Octane number for gasoline.

### Solution

Answer:	Aspect	Description	<b>Applications:</b> High octane fuel prevents engine knocking, improves performance.
	Definition	Measure of fuel's resistance to knocking	
	Scale	0-100, higher = better anti-knock properties	
	Standard	n-heptane = 0, iso-octane = 100	

### 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.

### Solution

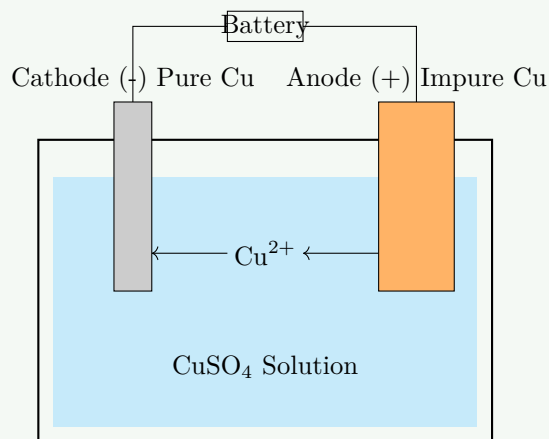
#### Process:

- **Anode:** Impure copper (Thick rod) - dissolves.
- **Cathode:** Pure copper (Thin strip) - deposits.
- **Electrolyte:** Acidified  $\text{CuSO}_4$  solution.

#### Chemical Equations:

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

#### Diagram:



### Mnemonic

"Anode Dissolves, Cathode Deposits" (ADCD)

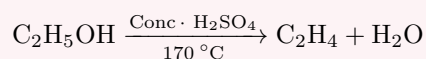
## Question 3(B)(2) [4 marks]

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

### Solution

**Preparation:** Dehydration of ethanol with conc.  $\text{H}_2\text{SO}_4$  at  $170^\circ\text{C}$ .

#### Key Formula



#### 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)

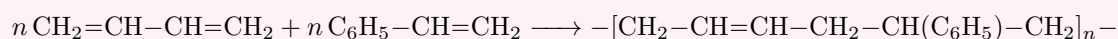
## Question 3(B)(3) [4 marks]

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

### Solution

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

#### Key Formula



(Butadiene + Styrene  $\rightarrow$  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.

**Solution****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]**

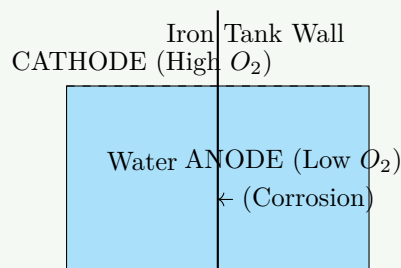
Explain waterline corrosion with chemical equations and labeled diagram.

**Solution**

**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.

**Key Formula**

- Anode:  $\text{Fe} \longrightarrow \text{Fe}^{2+} + 2\text{e}^-$  (Corrosion occurs here)
- Cathode:  $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \longrightarrow 4\text{OH}^-$

**Diagram:****Mnemonic**

"Water Air Interface Corrodes" (WAIC)

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

Explain the working principle of solar cells.

### Solution

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.

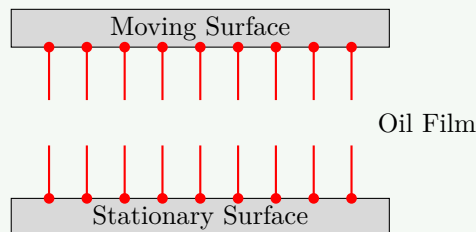
### Solution

**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.

### Solution

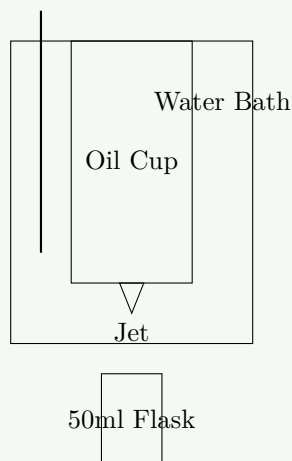
**Principle:** Measures viscosity in "Redwood Seconds" - time taken for 50ml of oil to flow through a standard orifice under gravity.

**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.

#### Solution

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

##### Solution:

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

Answer: pH = 2.40, pOH = 11.60

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

Describe extrinsic semiconductors and its types with examples.



### Solution

**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)

### Solution

<b>Answer:</b>	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.

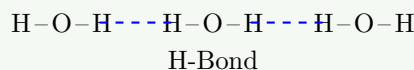
### Solution

**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<sub>2</sub>O, HF, Alcohol). raises BP.
2. **Intramolecular:** Within the same molecule (e.g., o-nitrophenol).

**Diagram (Intermolecular in Water):**



### Mnemonic

"Hydrogen Needs FON friends"

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

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

### Solution

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.

### Solution

#### Construction:

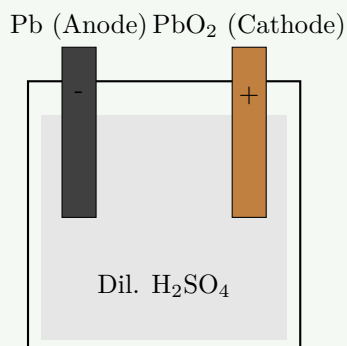
- **Anode:** Spongy Lead (Pb).
- **Cathode:** Lead Dioxide (PbO<sub>2</sub>).
- **Electrolyte:** Dilute H<sub>2</sub>SO<sub>4</sub> (density 1.25-1.30 g/cc).

#### Working (Discharge):

##### Key Formula

- Anode:  $\text{Pb} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 + 2\text{e}^-$
- Cathode:  $\text{PbO}_2 + 4\text{H}^+ + \text{SO}_4^{2-} + 2\text{e}^- \longrightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$
- Overall:  $\text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \longrightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} + \text{Energy}$

#### Diagram:



### Mnemonic

"LASRE = Lead Acid Storage Reversible Energy"