Engineering Chemistry (DI01000071) - Winter 2024 Solution

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Question 1 [14 marks]

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

Solution

Answer:

Table 1. Q1 Answers

Question	Answer	Explanation
(1)	$[Ar]4s^1 3d^{10}$	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""

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

List the three importance of pH in various fields.

Solution

Answer:

Table 2. Importance of pH

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

Mnemonic

“”Buffers Help Faraday” (BHF)”

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

State the factors affecting the rate of corrosion.

Solution

Answer:

Table 3. Factors Affecting Corrosion

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)(1) [4 marks]

Compare between orbits and orbitals (four points each).

Solution

Answer:

Table 4. Orbits vs Orbitals

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:

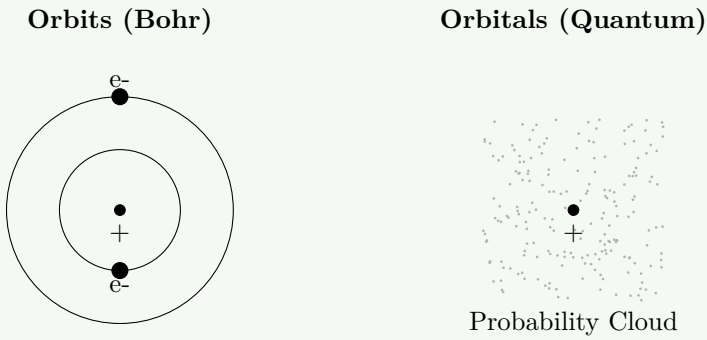

Figure 1. Bohr Orbits vs Quantum Orbitals

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:

Table 5. Classification of Fuels

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%

Chemical Reaction:

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

Mnemonic

“”Source Process Properties Applications” (SPPA)”

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

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

Solution

Answer:

Table 6. Solute, Solvent, Solution

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.

Solution

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

Diagram:

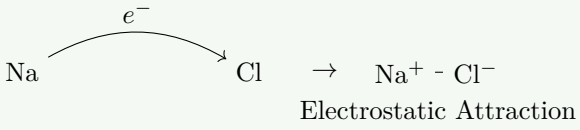

Figure 2. NaCl Bond Formation

Mnemonic

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

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

Explain Octane number for gasoline.

Solution

Answer:

Table 7. Octane Number

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)(1) [4 marks]

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

Solution

Answer:
Process:
- **Anode**: Impure copper dissolves
- **Cathode**: Pure copper deposits
- **Electrolyte**: $CuSO_4$ solution

Chemical Equations:
- At Anode: $Cu \rightarrow Cu^{2+} + 2e^-$
- At Cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

Diagram:

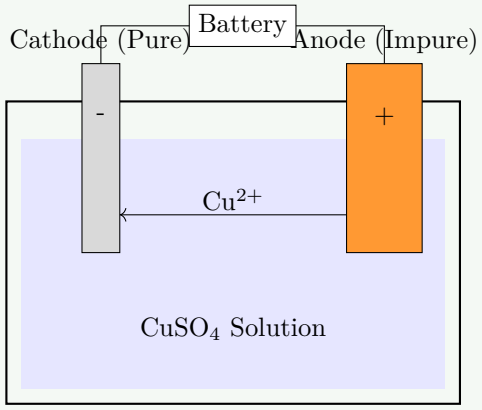

Figure 3. Electrorefining of Copper

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

Answer:
Preparation:

$$C_2H_5OH \xrightarrow{\Delta} C_2H_4 + H_2O \text{ (Dehydration of ethanol)}$$

Properties:
- **Physical**: Colorless gas, sweet smell
- **Chemical**: Unsaturated, undergoes addition reactions

Uses:
- **Industrial**: Manufacturing polyethylene
- **Agricultural**: Plant hormone for fruit ripening

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

Answer:
Preparation: Butadiene + Styrene → Buna-S rubber (Copolymerization)
Chemical Equation:

$$nC_4H_6 + nC_8H_8 \rightarrow [\text{-}C_4H_6\text{-}C_8H_8\text{-}]_n$$

Properties:
- **Mechanical**: Good abrasion resistance
- **Chemical**: Oil and fuel resistant

Uses:
- **Automotive**: Tire manufacturing
- **Industrial**: Conveyor belts, hoses

Mnemonic

“”Butadiene Styrene Makes Strong Rubber” (BSMSR)”

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

Explain metal clading for the prevention of corrosion of metals.

Solution

Answer:

Table 8. Metal Cladding

Aspect	Description
Process	Coating base metal with corrosion-resistant metal
Methods	Hot dipping, electroplating, roll bonding
Examples	Galvanized iron (Zn on Fe), Tin plating

Mechanism: Protective layer prevents oxygen/moisture contact with base metal

Mnemonic

“”Coating Protects Metal” (CPM)”

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

Explain waterline corrosion with chemical equations and labeled diagram.

Solution

Answer:
Process: Differential aeration causes corrosion at water-air interface
Chemical Equations:
- Anode: $Fe \rightarrow Fe^{2+} + 2e^-$
- Cathode: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

Diagram:

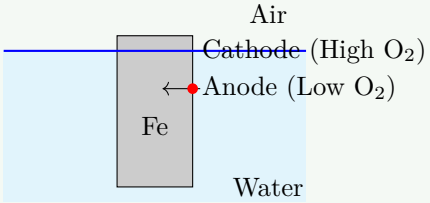

Figure 4. Waterline Corrosion

Mnemonic

“”Water Air Interface Corrodes” (WAIC)”

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

Explain the working principle of solar cells.

Solution

Answer:

Table 9. Solar Cell Principle

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 → Electron excitation → Current flow → Electrical energy

Mnemonic

“”Photo Voltaic Junction Creates Current” (PVJCC)”

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

Demonstrate the function of boundary lubrication with diagram.

Solution

Answer:
Function: Thin molecular layer adheres to metal surfaces, prevents direct contact
Mechanism:

- **Formation**: Lubricant molecules orient on metal surface
- **Protection**: Reduces friction and wear between surfaces
- **Load bearing**: Supports load when fluid film breaks down

Diagram:

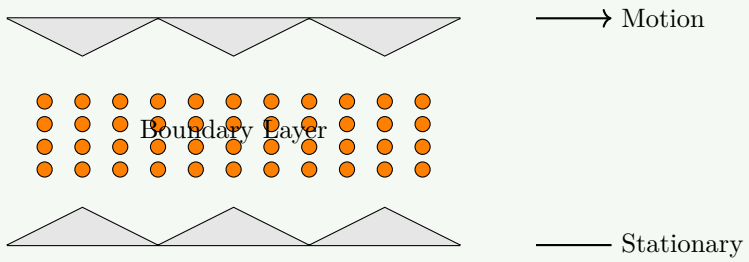

Figure 5. Boundary Lubrication

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

Answer:
Principle: Time taken for fixed volume of oil to flow through standard orifice
Procedure:

- **Setup**: Fill oil chamber, heat to required temperature
- **Measurement**: Record time for 50ml oil flow
- **Calculation**: Viscosity = Time × Constant

Diagram:

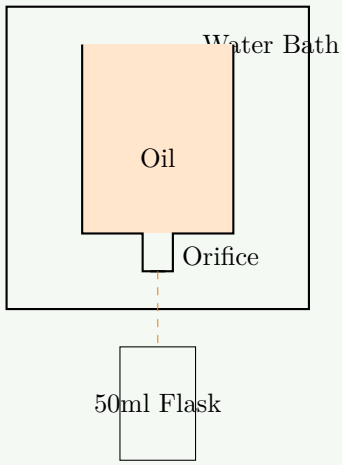

Figure 6. Redwood Viscometer

Mnemonic

“”Redwood Records Time” (RRT)”

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

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

Solution

Answer:

Table 10. Definitions

Term	Definition
Semiconductor	Material with electrical conductivity between conductor and insulator
Insulating material	Material that resists flow of electric current
Elastomer	Polymer with elastic properties, can stretch and return to original shape
Addition polymerization	Monomers join without elimination of small molecules

Examples: Si (semiconductor), Rubber (insulator), Rubber (elastomer), Polyethylene (addition)

Mnemonic

“”Semi Insulating Elastic Addition” (SIEA)”

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

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

Solution

Answer:
Given: [HCl] = 0.004 M = 4×10^{-3} M
Solution:

- HCl is strong acid, completely ionizes

H^+ = [HCl] = 4×10^{-3} M

- pH = -log[H^+] = -log(4×10^{-3})
- pH = -log 4 - log 10^{-3} = -0.6021 + 3 = 2.398
- pOH = 14 - pH = 14 - 2.398 = 11.602

Answer: pH = 2.40, pOH = 11.60

Mnemonic

“”Strong Acid, Simple Calculation” (SASC)”

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

Describe extrinsic semiconductors and it types with examples.

Solution

Answer:

Table 11. Extrinsic Semiconductors

Type	Dopant	Majority Carriers	Example
n-type	Donor atoms (Group V)	Electrons	Si + P
p-type	Acceptor atoms (Group III)	Holes	Si + B

Properties:

- **n-type**: Extra electrons increase conductivity
- **p-type**: Electron deficiency creates positive holes

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

Answer:

Table 12. Thermoplastic vs Thermosetting

Property	Thermoplastic	Thermosetting
Structure	Linear/branched chains	Cross-linked network
Heat effect	Softens on heating	Does not soften
Reversibility	Reversible process	Irreversible process
Examples	PVC, PE, PS	Bakelite, Epoxy

Mnemonic

“”Thermo-plastic = Reversible, Thermo-setting = Permanent” (TPRTSP)”

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

Describe hydrogen bond and its types with examples.

Solution

Answer:
Definition: Weak electrostatic attraction between hydrogen and electronegative atoms
Types:

Table 13. Hydrogen Bond Types

Type	Description	Example
Intermolecular	Between different molecules	$H_2O\cdots H_2O$
Intramolecular	Within same molecule	o-nitrophenol

Characteristics:
- **Strength**: 5-40 kJ/mol
- **Requirements**: H bonded to F, O, N

Diagram:

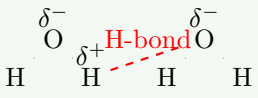

Figure 7. Hydrogen Bonding in Water

Mnemonic

“”Hydrogen Needs FON friends” (Fluorine, Oxygen, Nitrogen)”

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

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

Solution

Answer:

Table 14. Primary vs Secondary Cell

Aspect	Primary Cell	Secondary Cell
Rechargeability	Non-rechargeable	Rechargeable
Reaction	Irreversible	Reversible
Cost	Low initial cost	High initial cost
Examples	Dry cell, alkaline	Lead-acid, Li-ion

Applications:
- **Primary**: Remote controls, flashlights
- **Secondary**: Cars, phones, laptops

Mnemonic

“”Primary = Permanent, Secondary = Reversible” (PPSR)”

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

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

Solution

Answer:
Construction:
- **Anode**: Lead (Pb)
- **Cathode**: Lead dioxide (PbO_2)
- **Electrolyte**: Dilute H_2SO_4

Chemical Equations:
- **Discharge**: $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$
- **Charge**: $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2H_2SO_4$

Diagram:

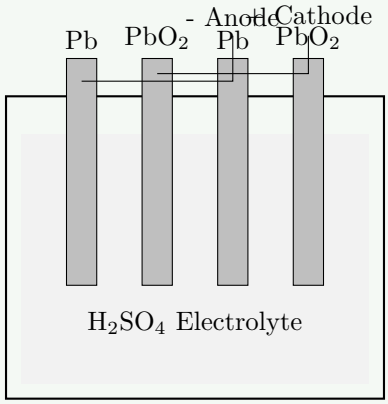

Figure 8. Lead-Acid Battery

Working: Chemical energy converts to electrical energy during discharge

Mnemonic

“”Lead Acid Storage = Reversible Energy” (LASRE)”