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

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

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

List the three importance of pH in various fields.

Solution

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)

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

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

Solution

- **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)

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

State the factors affecting the rate of corrosion.

Solution

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]

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

Compare between orbits and orbitals (four points each).

Solution

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 Model)          Orbitals (Quantum Model)

     e{-                              }



     +
```

Mnemonic

"Definite Shape Energy Location" (DSEL)

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

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

Solution

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)

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

Explain bio-diesel with four important points.

Solution

- **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:

```
Vegetable Oil + Methanol \rightarrow Bio-diesel + Glycerol
```

Mnemonic

"Source Process Properties Applications" (SPPA)

Question 3(A) [6 marks]

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

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

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)

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

Explain the formation of Electrovalent bond in NaCl.

Solution

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:

```
Na        Na^{+  +  e^{-}}
Cl + e^{-      Cl^{-}}

Na^{+  +  Cl^{-}    Na^{+}Cl^{-} (NaCl)}
```

Mnemonic

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

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

Explain Octane number for gasoline.

Solution

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]

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

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

Solution

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

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

Diagram:

```
    Battery

   {-    +}


  Cathode   Anode
  (Pure Cu) (Impure Cu)


     CuSO_{4   }
     Solution
```

Mnemonic

"Anode Dissolves, Cathode Deposits" (ADCD)

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

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

Solution

Preparation: $C_2H_5OH \rightarrow C_2H_4 + H_2O(Dehydration of ethanol)$
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)

0.0.12 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: Butadiene + Styrene $\rightarrow Buna-S rubber(Copolymerization)$
Chemical Equation:

```
nC_{4}H_{6} + nC_{8}H_{8} \rightarrow [-C_{4}H_{6}-C_{8}H_{8}-]_{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) [6 marks]

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

Explain metal clading for the prevention of corrosion of metals.

Solution

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)

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

Explain waterline corrosion with chemical equations and labeled diagram.

Solution

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:

```
    Air

    Water (O_{2 rich)}
    ↓ Cathode
  Fe
    ↑ Anode
    Water (O_{2 poor)}
```

Mnemonic

"Water Air Interface Corrodes" (WAIC)

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

Explain the working principle of solar cells.

Solution

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 $\rightarrow Electron excitation \rightarrow Current flow \rightarrow Electrical energy$

Mnemonic

"Photo Voltaic Junction Creates Current" (PVJCC)

Question 4(B) [8 marks]

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

Demonstrate the function of boundary lubrication with diagram.

Solution

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:

```
Moving Surface


            Boundary layer


Stationary Surface
```

Mnemonic

"Boundary Barriers Prevent Metal Contact" (BBPMC)

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

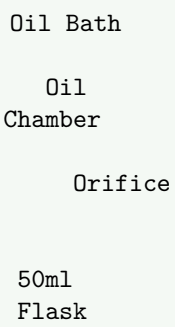
Explain how viscosity is measured through redwood viscometer with labelled diagram.

Solution

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 $\times Constant$

Diagram:



Mnemonic

"Redwood Records Time" (RRT)

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

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

Solution

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) [6 marks]

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

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

Solution

Given: [HCl] = 0.004 M = $4 \times 10^{-3} M$
Solution:

- HCl is strong acid, completely ionizes

$H^+ = [HCl] = 4 \times 10^{-3} M$

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

Solution

pH = 2.40, pOH = 11.60

Mnemonic

"Strong Acid, Simple Calculation" (SASC)

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

Describe extrinsic semiconductors and it types with examples.

Solution

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)

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

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

Solution

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) [8 marks]

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

Describe hydrogen bond and its types with examples.

Solution

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

Type	Description	Example
Intermolecular	Between different molecules	H_2OH_2O
Intramolecular	Within same molecule	o-nitrophenol

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

Diagram:

```
H_{2O···H_{2}O···H_{2}O}

 ^{+     ^{-}     ^{+}}
```

Mnemonic

"Hydrogen Needs FON friends" (Fluorine, Oxygen, Nitrogen)

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

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

Solution

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)

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

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

Solution

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:

```
   Pb     PbO_{2    }
 ({-)       (+)    }
Anode    Cathode


   H_{2SO_{4}       }
 Electrolyte
```

Working: Chemical energy converts to electrical energy during discharge

Mnemonic

"Lead Acid Storage = Reversible Energy" (LASRE)