Engineering Chemistry (DI01000071)

Winter 2025 Exam Solutions

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Date of Exam: 16 January 2026

Exam Overview

Exam Details

Subject: Engineering Chemistry
Code: DI01000071
Date: 16-01-2026
Time: 10:30 AM – 01:00 PM
Marks: 70

Topics at a Glance

Q.2 Bonding, pH, Molarity
Q.3 Corrosion, Fuels, Petroleum
Q.4 Lubricants, Polymers
Q.5 Rubber, Cells, Solar energy

Paper Structure

Q.1 14 MCQs (1 mark each = 14)
Q.2–5 (A) any 2 $\times$ 3 marks = 6 each
(B) any 2 $\times$ 4 marks = 8 each

Q.1 — MCQ Answers (1–7) [14 marks]

#	Key word	Ans	Option
1	Bond from equal sharing of electrons	**B**	Co-valent bond
2	Full form of ppm	**B**	Parts per million
3	pH + pOH =	**D**	14
4	Solution with pH 7	**A**	Neutral
5	Metal used in galvanizing	**D**	Zn
6	Depositing tin on iron	**B**	Tinning
7	Measured by Bomb Calorimeter	**C**	Calorific value

Quick Recall

- **Covalent bond**: electrons *shared equally* between two non-metals
- **ppm** = parts per million (10^{-6})
- **pH + pOH = 14** at 25°C (water constant)
- **pH 7** = neutral solution
- **Zn** coats iron in galvanizing (anodic protection)
- **Bomb Calorimeter** measures calorific value of fuels

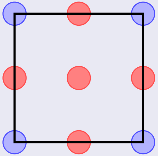
#	Key word	Ans	Option
8	First removed in fractional distillation	**A**	Petroleum gases
9	Determines viscosity of lubricating oil	**A**	Redwood viscometer
10	Solid lubricant	**C**	Graphite
11	Commercial name of phenol-formaldehyde	**C**	Bakelite
12	Monomer of polystyrene	**D**	Styrene
13	Potential of dry cell	**C**	1.5 V
14	Example of primary cell	**B**	Dry cell

Quick Recall

- **Petroleum gases** have lowest BP $\rightarrow$ exit first
- **Redwood viscometer** measures kinematic viscosity
- **Graphite** is the standard solid lubricant
- **Bakelite** = phenol + formaldehyde polymer
- **Styrene** ($C_6H_5CH{=}CH_2$) is polystyrene monomer
- **Dry cell** EMF = 1.5 V (primary, non-rechargeable)

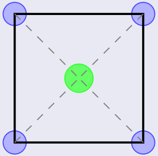
Q.2(A)(1) — FCC and BCC Crystal Structures [3 marks]

Face-Centred Cubic (FCC)



8 corner + 6 face-centre atoms
Effective atoms $= 8 \times \frac{1}{8} + 6 \times \frac{1}{2} = \mathbf{4}$
Examples: Cu, Al, Ni, Au

Body-Centred Cubic (BCC)



8 corner + 1 body-centre atom
Effective atoms $= 8 \times \frac{1}{8} + 1 = \mathbf{2}$
Examples: Fe, Cr, Na, Mo

Q.2(A)(2) — Characteristics of Ionic Bond Substances [3 marks]

Physical Properties

1. **High melting and boiling points** — strong electrostatic forces require large energy to break.
2. **Solid at room temperature** — ions held in rigid crystalline lattice.
3. **Hard but brittle** — planes shift under stress, causing like charges to repel and split.
4. **Crystalline structure** — ions arranged in regular 3D pattern.

Chemical/Electrical Properties

5. **Conduct electricity** only in molten or aqueous state (free ions); solid state does NOT conduct.
6. **Soluble in polar solvents** (water) but insoluble in non-polar solvents (benzene).
7. **Undergo ionic reactions** — fast reactions in solution.

Q.2(A)(3) — Molarity Calculation (NaOH) [3 marks]

Given

Mass of NaOH $= 2\,\text{g}$
Molar mass of NaOH $= 40\,\text{g/mol}$
Volume of solution $= 2\,\text{L} = 2000\,\text{mL}$

Formula

$$M = \frac{W \times 1000}{M.W. \times V_{mL}}$$

Solution

Step 1: Find moles of NaOH

$$n = \frac{\text{mass}}{M.W.} = \frac{2}{40} = 0.05\,\text{mol}$$

Step 2: Apply molarity formula

$$M = \frac{n}{V(\text{L})} = \frac{0.05}{2}$$

$$\boxed{M = 0.025\,\text{mol/L}}$$

This is a **dilute alkaline** solution.

Q.2(B)(1) — Importance of Hydrogen Bond [4 marks]

Physical Importance

1. **High boiling point of water (100°C)** — H-bonds between molecules require extra energy to break. Without H-bonding water would boil at $-80°C$.
2. **High surface tension and viscosity** of water — H-bonds create a network.
3. **Ice is less dense than water** — H-bonds form an open hexagonal structure in ice.

Biological Importance

4. **Protein secondary structure** — H-bonds stabilize α-helix and β-sheet conformations.
5. **DNA double helix** — Base pairs (A–T and G–C) held together by H-bonds, enabling heredity.
6. **Solubility** — Polar/H-bonding solutes (glucose, alcohol) dissolve well in water.

Q.2(B)(2) — Importance of pH in Different Fields [4 marks]

Field	pH Range / Value	Significance
Agriculture	6.0 – 7.0	Optimal soil pH for most crops; too acidic/basic inhibits nutrient absorption
Medicine	Blood: 7.35 – 7.45	Slight deviation causes acidosis or alkalosis; critical for enzyme activity
Water Treatment	6.5 – 8.5	Drinking water standard; pH outside range indicates contamination
Industry	Varies	Electroplating, dyeing, and paper industries control pH for quality
Food Industry	Acidic (3 – 5)	Acidic pH (vinegar, citric acid) prevents microbial growth for preservation

Q.2(B)(3) — pH of 0.1 M HCl [4 marks]

Given

Concentration of HCl $= 0.1\,\text{M} = 10^{-1}\,\text{M}$

Theory

pH is the negative logarithm of the hydrogen ion concentration:

$$\text{pH} = -\log[\text{H}^+]$$

HCl is a **strong acid** — it dissociates completely in water.

Solution

Complete dissociation:

$$\text{HCl} \longrightarrow \text{H}^+ + \text{Cl}^-$$

$$[\text{H}^+] = 0.1\,\text{M} = 10^{-1}\,\text{M}$$

$$\text{pH} = -\log(10^{-1})$$

$$\boxed{\text{pH} = 1}$$

Since $\text{pH} = 1 < 7$, the solution is **strongly acidic**.

Q.3(A)(1) — Types of Buffer Solutions [3 marks]

Definition

A **buffer solution** resists change in pH when small amounts of acid or base are added to it.

Type 1 — Acidic Buffer (pH < 7)

Composition: Weak acid + salt of weak acid with strong base

Example: $CH_3COOH + CH_3COONa$

pH range: 3.5 – 5.5

Action: CH_3COO^- ions neutralize added H^+; CH_3COOH neutralizes added OH^-

Type 2 — Basic Buffer (pH > 7)

Composition: Weak base + salt of weak base with strong acid

Example: $NH_4OH + NH_4Cl$

pH range: 8.0 – 10.0

Action: NH_4^+ neutralizes added OH^-; NH_4OH neutralizes added H^+

Q.3(A)(2) — Galvanizing of Iron [3 marks]

Definition & Process

Galvanizing is the process of coating iron with a layer of **zinc (Zn)** to protect it from corrosion.

Methods:

1. **Hot-dip galvanizing** — cleaned iron dipped in molten Zn (450°C)
2. **Electro-galvanizing** — Zn deposited by electrolysis

Why does Zn protect Fe?

Zn is more **electropositive** than Fe. It acts as a **sacrificial anode** — even if the Zn coating is scratched, Zn corrodes preferentially protecting the iron beneath.

Applications

- Iron pipes and water tanks
- Roofing sheets (GI sheets)
- Fences and railings
- Automobile bodies
- Buckets and dustbins

Q.3(A)(3) — Pitting Corrosion [3 marks]

Definition

Pitting corrosion is localized corrosion forming small deep holes (**pits**) on the metal surface while the surrounding area remains unaffected.

Mechanism

1. Protective oxide film breaks down locally at a weak spot.
2. The exposed spot becomes a small **anode**, surrounded by a large **cathode**.
3. High current density at the small anode causes rapid, deep attack.
4. The pit grows deeper while surface appears intact.

Why is it Dangerous?

- Difficult to detect visually
- Can perforate metal completely
- Causes sudden failure of pipes and tanks
- Common in SS in chloride (seawater) environments

Q.3(B)(1) — Factors Affecting Rate of Corrosion [4 marks]

Physical/Environmental Factors

1. **Temperature** — Higher temperature increases ion mobility and reaction rate, accelerating corrosion.
2. **Humidity/Moisture** — Water acts as electrolyte. No moisture = no electrochemical corrosion. Higher humidity = faster corrosion.
3. **Presence of electrolytes** — Salt water (NaCl) conducts electricity, greatly increasing corrosion rate.

Metal/Chemical Factors

4. **Nature of metal** — More active metals (higher in galvanic series) corrode faster. Impurities in metal create local galvanic cells.
5. **pH of environment** — Acidic conditions ($pH < 7$) dissolve oxide film and accelerate corrosion.
6. **Position in galvanic series** — Greater potential difference between two metals in contact $\rightarrow$ faster corrosion of the anodic metal.

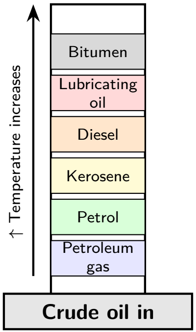
Q.3(B)(2) — Classification of Coal [4 marks]

Type	% Carbon	% Moisture	Properties	CV (kcal/kg)
Peat	50–60%	80–90%	Lowest grade, spongy, brown, high moisture	~2000–3000
Lignite	65–75%	30–50%	Brown coal, low calorific value, soft	~3000–5500
Bituminous	75–90%	2–15%	Most common, burns with flame and smoke, used in industry	~7000–8500
Anthracite	90–95%	$<$2%	Highest grade, hard, lustrous, smokeless, highest CV	~8500–9000

Order of Formation (Coalification Process)

Peat $\longrightarrow$ Lignite $\longrightarrow$ Bituminous $\longrightarrow$ Anthracite (increasing age, pressure, carbon %)

Fraction	BP (°C)	Use
Petroleum gases	<25	LPG, fuel
Petrol	40–75	Motor fuel
Naphtha	75–150	Solvent, chemicals
Kerosene	150–250	Jet fuel, lamps
Diesel	250–350	Diesel engines
Lubricating oil	350–400	Lubrication
Paraffin wax	400–500	Candles, polish
Bitumen/Tar	>500	Roads, roofing



Q.4(A)(1) — Characteristics of Ideal Fuel [3 marks]

Definition

A **fuel** is any combustible substance that, on burning, produces useful heat energy economically.

Properties 1–4

1. **High calorific value** — large heat per unit mass
2. **Low ignition temperature** — easy to ignite
3. **Moderate rate of combustion** — controllable burn
4. **No smoke/residue** — clean combustion

Properties 5–8

5. **Cheap and abundant** — economical to use
6. **Easy to store and transport** — safe handling
7. **Non-toxic products** — environment-friendly combustion
8. **Stable in storage** — does not decompose or evaporate on standing

Q.4(A)(2) — Lubricant: Definition & Functions [3 marks]

Definition

A **lubricant** is a substance applied between two **moving (sliding or rolling) surfaces** to reduce friction, heat generation, and wear.

Types

Solid (graphite, MoS_2) · Semi-solid (grease) · Liquid (mineral/synthetic oils)

Functions of Lubricant

1. **Reduce friction** between moving parts
2. **Reduce wear and tear** of surfaces
3. **Reduce heat** generated by friction (cooling)
4. **Prevent corrosion** — forms protective film
5. **Act as sealant** — prevents gas/fluid leakage
6. **Carry away contaminants** and metal particles

Q.4(A)(3) — Flash Point, Fire Point & Pour Point [3 marks]

Flash Point

The **minimum temperature** at which a lubricating oil produces vapors that momentarily **flash (ignite)** when a small flame is applied, but do not continue burning.

Significance: Should be **HIGH** for safe use at high temperatures.

Fire Point

The **minimum temperature** at which oil vapors continue to **burn for at least 5 seconds** when ignited.

Always **higher** than flash point by about 5–40°C.

Significance: Indicates fire hazard level.

Pour Point

The **lowest temperature** at which a lubricating oil **just ceases to flow** (becomes too viscous to pour) when cooled.

Significance: Should be **LOW** for use in cold climates and refrigeration systems.

Q.4(B)(1) — Classification of Lubricants [4 marks]

Type	Examples	Properties & Uses
Solid	Graphite, MoS_2 (molybdenite), Talc, PTFE	Used where liquid lubricant cannot be applied; high-temp, open gears, cutting tools
Semi-solid (Grease)	Calcium grease, Sodium grease, Lithium grease	Soap + mineral oil; for slow-moving heavy-load bearings, sealed units, chassis
Liquid (Oils)		
Animal/Vegetable	Lard oil, castor oil, olive oil	Biodegradable; used in food-grade applications
Mineral oil	Petroleum-derived (engine oil)	Most common; high VI, wide temperature range
Synthetic	Silicone oil, ester oil	Extreme temperature applications, jet engines
Emulsions	Cutting fluids (oil + water)	Cooling + lubrication in metal cutting

Q.4(B)(2) — Thermoplastics vs Thermosetting Plastics [4 marks]

Property	Thermoplastics	Thermosetting Plastics
Effect of heat	Softens on heating; can be re-shaped	Decomposes / chars on strong heating
Structure	Linear or branched chain polymer	3D cross-linked network polymer
Recyclability	**Can be recycled** and re-moulded	**Cannot be recycled**
Mechanical strength	Moderate; lower rigidity	Higher, hard and rigid
Solubility	Soluble in suitable organic solvents	Insoluble in all solvents
Moulding	Repeated moulding possible	Moulded only once (during manufacture)
Cost	Generally cheaper	Generally costlier
Examples	PVC, Polyethylene, Polystyrene, Nylon	Bakelite, Epoxy resin, Melamine, Urea-formaldehyde

Q.4(B)(3) — Classification of Polymers: Molecular Structure [4 marks]

1. Linear Polymers

Monomers linked end-to-end in a straight chain.

Properties:

- High tensile strength
- High melting point
- Can be crystalline

Examples: HDPE, PVC, Nylon

2. Branched Chain

Side branches on the main chain reduce close packing.

Properties:

- Lower density than linear
- More flexible
- Lower MP and strength

Examples: LDPE, Glycogen, Amylopectin

3. Cross-linked (Network)

Chains linked by covalent bonds in 3D network.

Properties:

- Rigid and hard
- Infusible (thermosetting)
- Chemically resistant

Examples: Bakelite, Vulcanized rubber

Q.5(A)(1) — Vulcanization of Natural Rubber [3 marks]

Definition & Process

Vulcanization is the process of heating natural rubber with **2–3% sulfur** at **140–160°C**.

Sulfur atoms form **cross-links** (–S–S– bridges) between adjacent polymer chains, converting soft, sticky rubber into a strong, elastic material.

Discovered by: Charles Goodyear (1839)

Properties Improved

Natural	Vulcanized
Low elasticity	High elasticity
Low strength	High strength
Sticky surface	Non-sticky
Solvent-soluble	Resistant
Narrow temp range	Wide range

Ebonite (Hard rubber)

Rubber + 30% sulfur = very hard, rigid ebonite (used in battery cases).

Q.5(A)(2) — Uses of Thermal Insulating Materials [3 marks]

Building & Industrial Uses

1. **Building construction** — Glass wool, rock wool, and expanded polystyrene insulate roofs and walls, reducing heating/cooling costs.
2. **Boilers and furnaces** — Asbestos, ceramic fibre, and refractory bricks reduce heat loss in industrial boilers.
3. **Pipelines** — Foamed polyurethane insulates steam pipes to prevent heat loss.

Other Applications

4. **Refrigeration** — Polyurethane foam insulates cold storage units and refrigerators, maintaining low temperature.
5. **Electrical insulation** — Rubber, PVC, and porcelain insulate cables and switchboards (also act as thermal insulators).
6. **Thermal clothing** — Wool and synthetic fibres trap air to provide thermal insulation.

Q.5(A)(3) — Bakelite: Production, Properties & Uses [3 marks]

Production

Condensation polymerization:

$$C_6H_5OH + HCHO \xrightarrow{\text{acid/base, } \Delta} \text{Bakelite} + H_2O$$

$$\text{Novolac (linear)} \xrightarrow{+HCHO} \text{Bakelite (3D)}$$

Properties

- **Thermosetting** — does not soften on reheating
- **Hard and rigid**
- **Excellent electrical insulator**
- **Heat and chemical resistant**
- **Non-flammable**
- Dark colour (brown/black)

Uses

- Electrical switches, plugs, sockets
- Radio and TV cabinets
- Telephone handsets
- Handles of cooking utensils
- Automobile parts
- Adhesives and coatings

Q.5(B)(1) — Primary Cell vs Secondary Cell [4 marks]

Property	Primary Cell	Secondary Cell
Recharging	**Cannot** be recharged; discarded after use	**Can be recharged** many times
Electrode reactions	Irreversible chemical reactions	Reversible reactions
Energy source	Chemical energy stored during manufacture	Energy stored by charging from external source
Life span	Short (single use)	Long (hundreds of charge cycles)
Weight	Lighter	Heavier
Cost	Cheap initially	More expensive initially
Maintenance	Not required	Requires periodic maintenance
EMF	Decreases as cell discharges	Relatively constant; restored on charging
Examples	Dry cell (Leclanché), Mercury cell	Lead-acid, Ni-Cd, Li-ion, Ni-MH

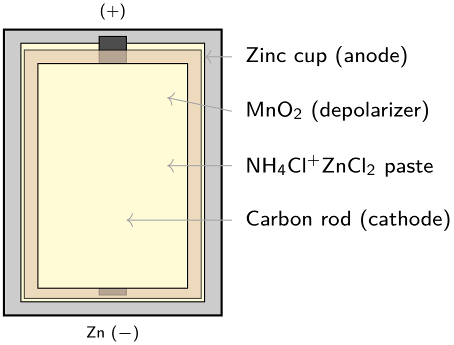
Q.5(B)(2) — Dry Cell: Principle & Structure [4 marks]

Construction

Anode (−): Zinc cup
Cathode (+): Carbon rod
Depolarizer: MnO_2
Electrolyte: $NH_4Cl + ZnCl_2$ paste
EMF: 1.5 V

Reactions

Anode: $Zn \rightarrow Zn^{2+} + 2e^-$
Cathode:
$2MnO_2 + 2NH_4^+ + 2e^- \rightarrow Mn_2O_3 + 2NH_3 + H_2O$
Overall: $Zn + 2MnO_2 + 2NH_4Cl \rightarrow$
$ZnCl_2 + Mn_2O_3 + 2NH_3 + H_2O$



Q.5(B)(3) — Solar Cell: Advantages, Disadvantages & Uses [4 marks]

Principle

A **solar cell** converts **sunlight directly into electricity** using the **photovoltaic effect** in a p-n junction (silicon). Photons create electron-hole pairs producing a potential difference.

Advantages

- Renewable & inexhaustible energy
- Zero pollution during operation
- No moving parts $\rightarrow$ low maintenance
- Long operational life (20–30 yrs)
- Suitable for remote areas

Disadvantages

- High initial cost
- Dependent on sunlight (no night/cloudy)
- Low efficiency (15–20%)
- Requires large surface area
- Energy storage (batteries) needed

Uses

- Powering satellites and spacecraft
- Solar power plants
- Rural electrification
- Water pumping systems
- Calculators, watches
- Traffic signals, street lights

Summary — Winter 2025 Solutions

Q	Topic	Marks
Q.1 (1–14)	MCQ Fill in the Blanks	14
Q.2(A)(1)	FCC and BCC structures	3
Q.2(A)(2)	Ionic bond characteristics	3
Q.2(A)(3)	Molarity of NaOH solution	3
Q.2(B)(1)	Importance of hydrogen bond	4
Q.2(B)(2)	pH importance in different fields	4
Q.2(B)(3)	pH of 0.1M HCl	4
Q.3(A)(1)	Buffer solutions: types	3
Q.3(A)(2)	Galvanizing of iron	3
Q.3(A)(3)	Pitting corrosion	3
Q.3(B)(1)	Factors affecting corrosion rate	4
Q.3(B)(2)	Classification of coal	4
Q.3(B)(3)	Petroleum refining + diagram	4

Q	Topic	Marks
Q.4(A)(1)	Ideal fuel characteristics	3
Q.4(A)(2)	Lubricant: definition + functions	3
Q.4(A)(3)	Flash, Fire & Pour point	3
Q.4(B)(1)	Classification of lubricants	4
Q.4(B)(2)	Thermoplastic vs Thermosetting	4
Q.4(B)(3)	Polymer: molecular structure	4
Q.5(A)(1)	Vulcanization of rubber	3
Q.5(A)(2)	Thermal insulating materials	3
Q.5(A)(3)	Bakelite: production, prop., uses	3
Q.5(B)(1)	Primary vs secondary cell	4
Q.5(B)(2)	Dry cell: structure + diagram	4
Q.5(B)(3)	Solar cell: adv., disadv., uses	4