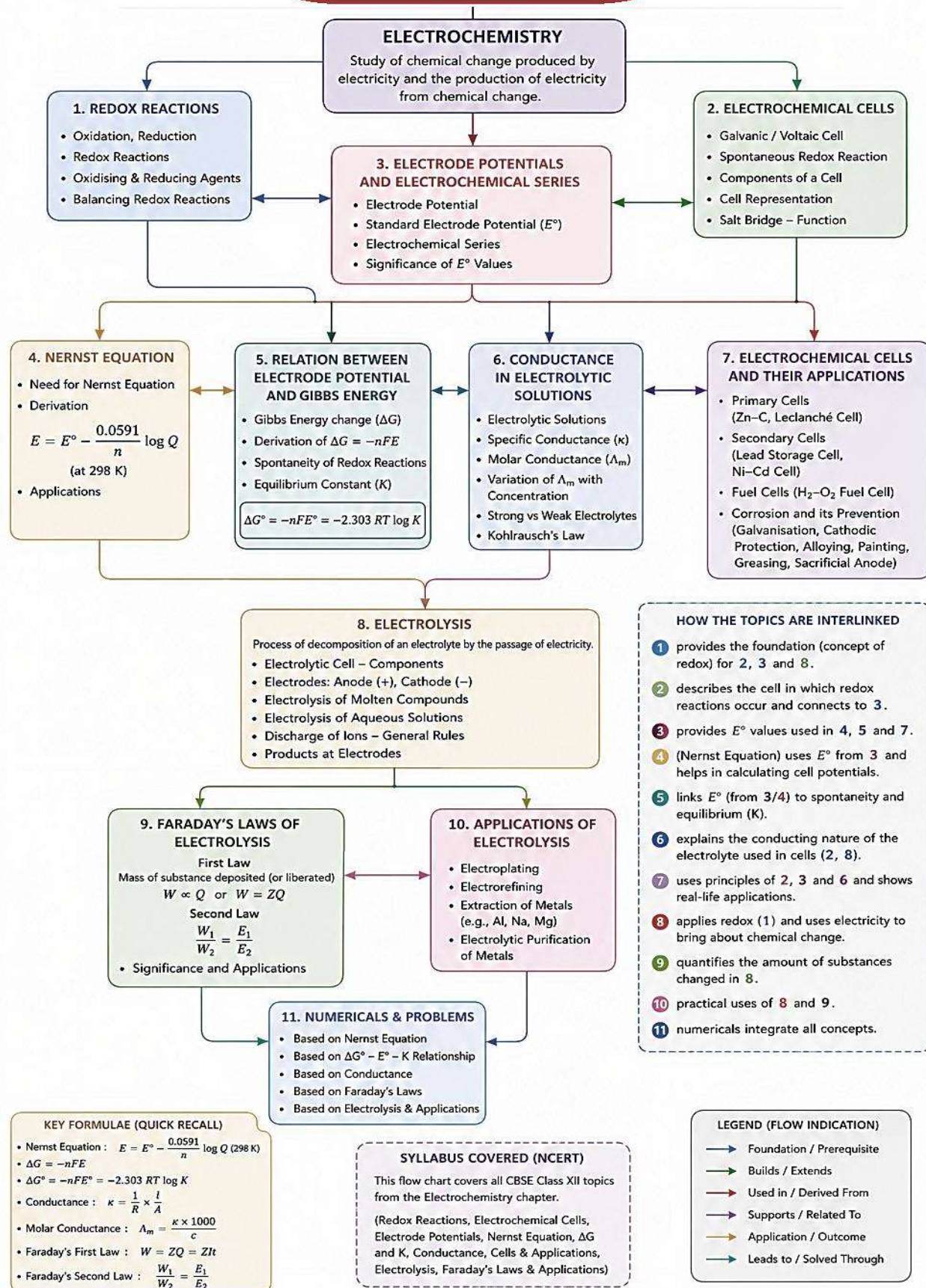


Unit-3: Electrochemistry



QUESTION BANK
SECTION- A (1 MARK)

Q.1). An electrochemical cell can behave like an electrolytic cell when _____.

- (a) $E_{\text{cell}} = 0$ (b) $E_{\text{cell}} > E_{\text{ext}}$
(c) $E_{\text{cell}} = E_{\text{ext}}$ (d) $E_{\text{ext}} > E_{\text{cell}}$

Q.2) The difference between the electrode potentials of two electrodes when no current is drawn through the cell is called

- (a) Cell potentials (b) Cell emf
(c) Potential difference (d) Cell voltage

Q.3) The most durable metal plating on iron to protect against corrosion is

- (a) nickel plating (b) copper plating
(c) tin plating (d) zinc plating

Q.4) The electric charge for electrode decomposition of one gram equivalent of substance is

- (a) one ampere per second
(b) 96500 coulombs per second
(c) one ampere for one hour
(d) charge on one mole of electrons

Q.5) $\Lambda^{\circ}_m(\text{NH}_4\text{OH})$ is equal to _____

- (a) $\Lambda^{\circ}_m(\text{NH}_4\text{OH}) + \Lambda^{\circ}_m(\text{NH}_4\text{Cl}) - \Lambda^{\circ}_m(\text{HCl})$
(b) $\Lambda^{\circ}_m(\text{NH}_4\text{Cl}) + \Lambda^{\circ}_m(\text{NaOH}) - \Lambda^{\circ}_m(\text{NaCl})$
(c) $\Lambda^{\circ}_m(\text{NH}_4\text{Cl}) + \Lambda^{\circ}_m(\text{NaCl}) - \Lambda^{\circ}_m(\text{NaOH})$
(d) $\Lambda^{\circ}_m(\text{NaOH}) + \Lambda^{\circ}_m(\text{NaCl}) - \Lambda^{\circ}_m(\text{NH}_4\text{Cl})$

Q6. Which device converts chemical energy of a spontaneous redox reaction into electrical energy?

- (a) Galvanic cell (b) Electrolytic cell
(c) Daniell cell (d) Both (a) and (c)

Q.7) Which of the following batteries cannot be reused?

- (a) Lead storage battery (b) Ni-Cd cell
(c) Mercury cell (d) Both (b) and (c)

Q.8) Specific conductance of 0.1 M HNO_3 is $6.3 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$. The molar conductance of the solution is

- (a) $100 \text{ ohm}^{-1} \text{ cm}^2$ (b) $515 \text{ ohm}^{-1} \text{ cm}^2$
(c) $630 \text{ ohm}^{-1} \text{ cm}^2$ (d) $6300 \text{ ohm}^{-1} \text{ cm}^2$

Q.9) If salt bridge is removed from two half-cells the voltage

- (a) drops to zero (b) does not change
(c) increases gradually (d) increases rapidly

Q.10) For the galvanic cell $\text{Zn} \mid \text{Zn}^{2+} (0.1\text{M}) \parallel \text{Cu}^{2+} (1.0\text{M}) \mid \text{Cu}$; the cell potential increase if:

- (a) $[\text{Zn}^{2+}]$ is increased
(b) $[\text{Cu}^{2+}]$ is increased
(c) $[\text{Cu}^{2+}]$ is decreased
(d) surface area of anode is increased

B.) ASSERTION-REASON TYPE QUESTIONS:

In the following questions Q.11 to Q.15, each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

Q.11 **Assertion** : On increasing dilution, the specific conductance keep on increasing.

Reason : On increasing dilution, degree of ionisation of weak electrolyte increases and molality of ions also increases.

Q.12 **Assertion**: Assertion : E_{Cell} should have a positive value for the cell to function.

Reason: $E_{\text{cathode}} < E_{\text{anode}}$

Q.13 **Assertion** :Salts like KCl, KNO_3 i.e., inert electrolytes are used in salt bridge.

Reason: An inert electrolyte can easily be filled in the U-tube.

Q.14) **Assertion** : Electrolysis of NaCl solution gives chlorine at anode instead of O_2 .

Reason: Formation of oxygen at anode requires overvoltage.

Q.15) **Assertion**: The electrode potential of standard hydrogen electrode is zero.

Reason: There is no potential difference at the electrode – solution interface in this case.

ANSWERS

MULTIPLE CHOICE QUESTIONS

1.d	2.b	3.d	4.d	5.b
6.d	7.c	8.c	9.a	10.b

ASSERTION REASON QUESTIONS

11.d	12.c	13.c	14.a	15.a
------	------	------	------	------

SECTION –B (TWO MARKS)

Q.1)Why on dilution the Λ_m of CH_3COOH increases drastically, while that of CH_3COONa increases gradually?

Hint : In the case of CH_3COOH , which is a weak electrolyte, the number of ions increase on dilution. In the case of strong electrolyte such as CH_3COONa , the number of ions remains the same but the interionic attraction decreases.

Q.2)Why does mercury cells give constant voltage?

Hint : Overall cell reaction does not include any ion in the solution whose concentration changes during its lifetime.

Q.3)Consider a cell given below $\text{Cu} | \text{Cu}^{2+} || \text{Cl}^- | \text{Cl}_2, \text{Pt}$. Write the reactions that occur at anode and cathode..

Hint : Cu is anode as it is getting oxidised. Cl_2 is cathode as it is getting reduced.

Q.4)Why in a concentrated solution, a strong electrolyte shows deviations from Debye-Huckle-Onsager equation?

Hint :Because interionic forces of attractions are large.

Q.5)Electrolysis of KBr(aq) gives Br_2 at anode but KF(aq) does not give F_2 . Give a reason.

Hint : Oxidation potential of Br^- , H_2O , F^- are in the following order. $\text{Br}^- > \text{H}_2\text{O} > \text{F}^-$

Therefore in the Aqueous Solution of KBr. Br⁻ ions are oxidized to Br₂ in preference to H₂O. On the other hand, in the aqueous solution of KF, H₂O is oxidized in preference to F⁻. Thus in this case oxidation of H₂O at anode gives O₂ and no F₂ is produced.

SECTION-C (THREE MARKS)

Q.1) Calculate emf of the following cell at 298K.

Zn/Zn²⁺(10⁻⁴M) || Cu²⁺(10⁻²M)/Cu (Given E⁰_{Zn²⁺/Zn} = -0.76 V, E⁰_{Cu²⁺/Cu} = +0.34V)

Hint : Cell reaction is as follows.

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$, Use Nernst equation and put values

$n = 2$ and $T = 298\text{ K}$ (Ans. $E_{cell} = +1.1591\text{ V}$)

Q.2) What happens when a piece of copper is added to

a. An aqueous solution of FeSO₄? b. An aqueous solution of FeCl₃?

Hint : a.) No reaction as $E^0_{Cu^{2+}/Cu} (-0.34\text{V}) > E^0_{Fe^{2+}/Fe} (-0.44\text{V})$

b.) copper will dissolve in an aq. solution of FeCl₃, as $E^0_{Fe^{3+}/Fe^{2+}} (+0.77\text{V}) > E^0_{Cu^{2+}/Cu} (-0.34\text{V})$

Q.3) The molar conductivity of a 1.5 M solution of an electrolyte is found to be 138.9 S cm²mol⁻¹.

Calculate the conductivity of this solution.

Hint : $K = \Lambda_m \times C / 1000 = 138.9 \times 1.5 / 1000 = 0.20835\text{ S cm}^{-1}$

Q.4) How many grams of chlorine can be produced by the electrolysis of molten NaCl with a current of 1.02 A for 15 min?

Hint : use formula ;

$$w = \frac{\text{m.wt of Cl} \times i \times t \text{ in sec}}{n \times F}$$

Ans: 0.331 gm.

Q.5) Why is it necessary to platinize the electrodes of a conductivity cell before it is used for conductance measurement?

Hint : platinization increases the surface area of the electrode and lead to better conduction measurement.

SECTION –D CASE BASED/SITUATION BASED QUESTIONS (4Marks)

PASSAGE 1

Read the passage given below and answer the following questions:

"Replacing fossil fuels with sustainable, environmentally benign, and affordable energy sources and carriers is amongst the most pressing challenges for future socio-economic development. To that goal, hydrogen is presumed to be the most promising energy carrier.

Electrocatalytic water splitting, if driven by green electricity, would provide hydrogen with a minimal CO₂ footprint. The viability of water electrolysis hinges on the availability of durable, earth-abundant electrocatalyst materials and the overall process efficiency.

This review spans the fundamentals of electrocatalytically initiated water splitting to the latest scientific findings from university and institutional research, also covering specifications and special features of current industrial processes.

Recently developed strategies for the optimization and discovery of active and durable materials for electrodes increasingly harness first-principles calculations and machine learning. Additionally, a techno-economic analysis of water electrolysis is included to assess the extent to which large-scale implementation of water splitting can help combat climate change."

(Source: Adapted from "Water electrolysis: from textbook knowledge to the latest scientific strategies and industrial developments," Chemical Society Reviews, 2022, published by the Royal Society of Chemistry.)

Q.1) What is the primary goal of electrocatalytic water splitting as described in the passage, and why is hydrogen considered a promising energy carrier in this context?

Hint : To produce hydrogen with a minimal CO₂ footprint by using green electricity. Hydrogen is considered a promising energy carrier because it can replace fossil fuels.

Q.2) Why might the use of earth-abundant materials be critical for the large-scale implementation of this technology ?

Hint : because they are more readily available and cost-effective compared to rare or expensive materials.

Q.3) Water electrolysis system using Nickel Oxide as an electrocatalyst has an efficiency of 75%, If 1000 kWh of green electricity is supplied to the system, calculate the energy available for hydrogen production?

Ans. $\text{Efficiency} = 75\% = 0.75$

$\text{Energy Available} = \text{Input Energy} \times \text{Efficiency}$

$\text{Energy Available} = 1000 \text{ kWh} \times 0.75 = 750 \text{ kWh}$

OR

Q.3) Calculate the total cost of operating three water electrolysis systems, each using a different electrocatalyst material, for 5,000 hours. Assume the cost of operation is \$0.10 per kWh of energy, and each system consumes 200 kW of power continuously?

Ans. $\text{Energy Used} = \text{Power Consumption} \times \text{Operating Time}$

$= 200 \text{ kW} \times 5,000 \text{ hours} = 1,000,000 \text{ kWh}$

$\text{Operating Cost} = \text{Energy Used} \times \text{Cost per kWh}$

$\text{Operating Cost} = 1,000,000 \text{ kWh} \times \$0.10/\text{kWh}$

$= \$100,000$ (same for all, as cost depends on input energy).

PASSAGE 2

Read the passage given below and answer the following questions:

"Corrosion, the spontaneous deterioration of metals through chemical or electrochemical interaction with their environment, poses a significant challenge to industrial and societal infrastructure. This natural process often converts refined metals into more stable forms, such as oxides, hydroxides, or sulfides, driven by thermodynamic favorability.

Electrochemical corrosion, the most prevalent type, occurs in the presence of an electrolyte, where anodic oxidation releases electrons from the metal, and cathodic reactions, such as oxygen reduction or hydrogen evolution, consume them. The rate of the rate of corrosion depends on factors like the nature of the metal, the presence of impurities, the electrolyte's pH, temperature, and oxygen availability.

Recent advances leverage computational tools, including first-principles calculations and machine learning, to predict corrosion behavior and design corrosion-resistant materials. Protective strategies, such as coatings, cathodic protection, and inhibitors, are critical to mitigating corrosion, which costs the global economy approximately \$2.5 trillion annually, underscoring the need for innovative solutions to enhance durability and sustainability."

(Source: Adapted from "Corrosion Science and Technology: Advances in Understanding and Mitigation," Chemical Reviews, 2021, published by the American Chemical Society.)

Q.1) What are the two primary types of reactions involved in electrochemical corrosion?

Hint : anodic oxidation and cathodic reactions

Q.2) Name two forms that metals can turn into during corrosion, as mentioned in the passage.

[Hint : oxides and hydroxides]

Q.3) If you notice a car's metal body rusting near the ocean. Based on the passage, what factor might be speeding up the corrosion?

OR

Q.3) steel bridge component has a corrosion rate of 0.8 mm/year, as noted in the sample database. If the component is 10 mm thick and exposed to corrosion for 5 years without protection, calculate the thickness lost and the remaining thickness.

Hint : Thickness Lost = Corrosion Rate $\times$ Exposure Time

$$\text{Thickness Lost} = 0.8 \text{ mm/year} \times 5 \text{ years} = 4.0 \text{ mm}$$

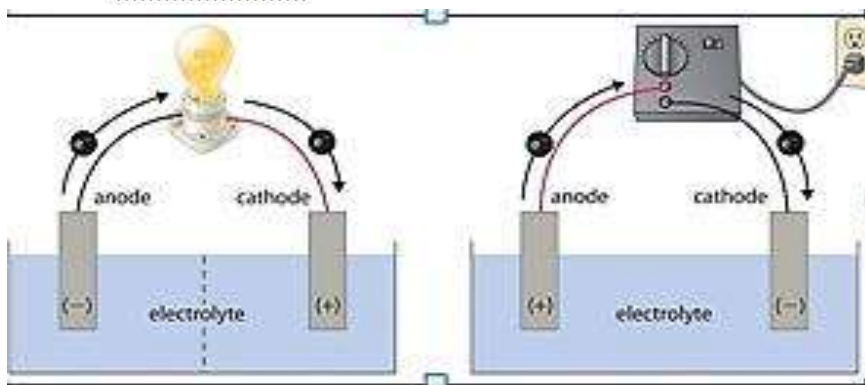
$$\text{Remaining thickness} = 6.0 \text{ mm.}$$

SECTION-E (5 MARKS)

Q.1) a.)

Observe the figures A and B and answer the following questions:

- In which figure the redox reaction is non-spontaneous?
- In which cell EMF is positive?
- Assuming the electrolyte in fig B is CuCl_2 solution and Pt electrodes. Predict the electrode reactions.



b) A solution of magnesium sulfate (MgSO_4) has a conductivity of $0.00635 \text{ S cm}^{-1}$ at 25°C when its concentration is 0.01 M. Calculate the molar conductivity. If the solution is diluted to 0.005 M and the conductivity drops to $0.00350 \text{ S cm}^{-1}$, what is the new molar conductivity?

Hint : b.) $\Lambda_m = (\kappa \times 1000) / c$

$$\Lambda_m = (0.00635 \text{ S cm}^{-1} \times 1000) / 0.01 \text{ mol L}^{-1} = 635 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\text{Initial molar conductivity} = 635 \text{ S cm}^2 \text{ mol}^{-1}$$

Molar Conductivity After Dilution

$$\begin{aligned} \Lambda_m &= (0.00350 \text{ S cm}^{-1} \times 1000) / 0.005 \text{ mol L}^{-1} \\ &= 700 \text{ S cm}^2 \text{ mol}^{-1} \end{aligned}$$