Class 12 Electrochemistry Important Questions with Answers

Short Answer Type Questions

1. Can absolute electrode potential of an electrode be measured?

Solution: No, the absolute potential of an electrod can not be measured because the half-cell containing a single electrode cannot work of its own. It can work only in combination with another half cell.

2. Can E^0_{cell} or Δ_rG^0 for a cell reaction ever be equal to zero?

Solution: No, it cannot be equal to zero for a cell reaction proceeding in a particular direction (forward or backward direction)

3. Under what conditions is $E^0_{cell} = 0$ and $\Delta_rG^0 = 0$?

Solution: At the condition of equilibrium, $E^0_{cell} = 0$ and $\Delta_rG^0 = 0$

4. What does the negative sign in the expression $E^0_{Zn2+/Zn} = -0.76$ V means?

Solution: It implies that Zn is more reactive than hydrogen or it is a stronger reducing agent. In a cell containing zinc electrode and standard hydrogen electrode present in two half cells, zinc will be oxidised to Zn^{2+} ions while H^+ ions will get reduced to hydrogen.

5. Aqueous copper sulphate solution and aqueous silver nitrate solution are electrolysed by 1 ampere current for 10 minutes in separate electrolytic cells. Will the mass of copper and silver deposited on the cathode be same or different ? Explain your answer.

Solution: The mass of copper and silver deposited on the cathode in the two electrolytic cells will not be the same.
According to second law of Electrolysis.
(Mass of Cu deposited /mass of Ag deposited) = (equivalent mass of Cu/equivalent mass of Ag)
= 31.75/ 108.

6. Depict the galvanic cell in which the cell reaction is : $Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$.

Solution: In the cell reaction: $Cu + 2Ag^+ \rightarrow 2Ag + Cu^{2+}$
At anode : $Cu \rightarrow Cu^{2+} + 2e$
At Cathode : $2 Ag^+ + 2e \rightarrow 2Ag$

The representation of cell = Cu(s) | Cu^{2+}(aq) || Ag^+(aq) | Ag (s)

7. Value of standard electrode potential for the oxidation of Cl^- ions is more positive than that of water, even then in the electrolysis of aqueous sodium chloride, why are Cl^- ions oxidised at anode instead of water ?

Solution: The oxidation reactions taking place at anode is:
$2Cl^-$ (aq) $\rightarrow$ Cl_2 (g) + $2e^-$ $E^0_{(oxid)} = -1.36$ V
$2H_2O$ (l) $\rightarrow$ O_2 (g) + $4H^+$ (aq) + $4e^-$ $E^0_{(oxid)} = -1.23$ V
Due to the overvoltage of oxygen (O_2), its liberation is kinetically slower than that of Cl ions. Therefore, Cl ions are oxidised to Cl_2 gas.

8. What is electrode potential ?

Solution: Electrode potential appears at the interface between an electrode and electrolyte due to the transfer of charged species across the interface.

9. Why is alternating current used for measuring resistance of an electrolytic solution?

Solution: Alternate current is used for measuring the resistance of an electrolytic solution because direct current will cause the electrolysis of the electrolyte. As a result Concentration of the ions in the solution will change.

10. How will the pH of brine (NaCl solution) be affected when it is electrolysed?

Solution: NaCl is a salt of strong acid and strong base. It is neutal in nature. pH of NaCl solution is 7. However, upon electrolysis of the aqueous solution, Na^+ and OH^- ions are formed. The solution becomes basic and its pH rises.

11. Solutions of two electrolytes 'A' and 'B' are diluted. The Λ_m of 'B' increases 1.5 times while that of A increases 25 times. Which of the two is a strong electrolyte? Justify your answer.

Solution: Dilution of the electrolyte mainly decreases interionic attractive force, therfore Λ_m increases. In case of strong electrolyte it dissocited completely in solution so on dilution Λ_m increases to a small extent. On the other hand, the electrolyte weak is ionised only to a small extent. Upon dilution, its ionisation or dissociation increases to a large extent. That is why, Λ_m for weak electrolyte is more higer on dilution.
From the available information A is a weak electrolytes and B is a strong electrolyte.

12. In an aqueous solution how does specific conductivity of electrolytes change with addition of water?

Solution: The specific conductivity or conductivity (κ) of electrolytes decrease with addition of water or upon dilution because the number of ions per unit volume decrease.

13. Which reference electrode is used to measure the electrode potential of other electrodes ?

Solution**:** Standard hydrogen electrode (SHE) is used as reference electrode to measure the electrode potential of other electrodes. Its electrode potential is assumed as zero. The electrode potential of any electrode as measured with respect to a standard hydrogen electrode is known as its standard electrode potential (E).

14. Consider a cell given below
$Cu | Cu^{2}+ || Cl- | Cl_2, Pt$
Write the reactions that occur at anode and cathode.

Solution: The reaction taking place at the two electrodes are:
At anode : $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
At cathode: $Cl_2 (g) + 2e^- \rightarrow 2 Cl^-$

15. Write the Nernst equation for the cell reaction in the Daniell cell. How will the E_{cell} be affected when concentration of Zn^{2+} ions is increased ?

Solution: Daniell cell involves the redox reaction :
$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4 (aq) + Cu(s)$

Thus in the cell Zn(s) is oxidised to $Zn^{2}+$ (aq) ions in the oxidation half cell while $Cu^{2}+$ (aq) ions are reduced to Cu(s) in the reduction half cell.
According to Nernst equation,
$E_{cell} = E^0_{cell} - (0.059/2) \{\log[Zn^{2+}(aq)] / [Cu^{2+}(aq)]$
Hence E_{cell} decreases as the $[Zn^{2+}(aq)]$ increases.

16. What advantage do the fuel cells have over primary and secondary batteries?

Solution: Primary batteries or cells contain a limited amount of reactants and are discharged when the reactants are consumed. Secondary batteries or cells can be recharged but the process takes a long time. Fuel cells work continuously as long the reactants (i.e. fuel) are supplied.

17. Write the cell reaction of a lead storage battery when it is discharged. How does the density of the electrolyte change when the battery is discharged?

Solution: The cell reaction of a lead storage battery when it is discharged, may be given as:

$Pb(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow PbO_2(s) + 2PbSO4\ (s) + 2H_2O(l)$

Density of the electrolyte i.e. conc.H_2SO_4 solution decreases because of the dilution of electrolyte taking place since water is formed as one of the products.

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

Solution: CH_3COOH is a weak electrolyte and is dissociated to small extent. With dilution, its degree of dissociation increases i.e. more ions are released in solution. Therefore, Λ_m of CH_3COOH increases drastically. On the other hand, CH_3COONa is a strong electrolyte and is almost completely dissociated in aqueous solution. With dilution, only interionic forces of attraction increase resulting in only small increase in the value of Λ_m .

Matching Types Questions

1. Match the terms given in Column I with the units given in Column II.

Column I	Column II
(a) Λ_m	(i) S cm^{-1}
(b) E_{cell}	(ii) m^{-1}
(c) K	(iii) S cm^2 mol^{-1}
(d) G*	(iv) V

Solution: (a) - (iii); (b) - (iv); (c) - (i); (d) - (ii)

2. Match the items of Column I and Column II.

Column I	Column II
(a) Lead storage battery	(i) maximum efficiency
(b) Mercury cell	(ii) prevented by galvanisation
(c) Fuel cell	(iii) gives steady potential
(d) Rusting	(iv) Pb is anode, PbO_2 is cathode

Solution: (a) - (iv); (b) - (iii); (c) - (i); (d) - (ii)

3. Match the items of Column I and Column II.

Column I	Column II
(a) K	(i) I x t
(b) Λ_m	(ii) Λ_m / Λ^0_m
(c) α	(iii) K /c
(d) Q	(iv) G*/R

Solution: (a) - (iv); (b) - (iii); (c) - (ii); (d) - (i)

4. Match the items of Column I and Column II.

Column I	Column II
(a) Lechlanche cell	(i) cell reaction $2H_2 + O_2 \rightarrow 2H_2O$
(b) Ni-Cd cell	(ii) does not involve any iron in solution and is used in hearing aids.
(c) Fuel cell	(iii) rechargeable
(d) Mercury cell	(iv) reaction at anode, $Zn \rightarrow Zn^{2+} + 2e^-$
	(v) converts energy of combustion into electrical energy.

Solution: (a) - (iv); (b) - (iii); (c) - (i),(v); (d) - (ii)

Assertion-Reason Type Questions

Note: In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices:

(a) Both assertion and reason are true and the reason is correct explanation for assertion.
(b) Both assertion and reason are true and the reason is not correct explanation for assertion.
(c) Assertion is true but the reason is false.
(d) Both assertion and reason are false.
(e) Assertion is false but reason is true.

1. Assertion : Cu is less reactive than hydrogen.
Reason : $E^0_{Cu2+/Cu}$ is negative.

Solution: (c) Assertion is true but the reason is false.

2. Assertion: E_{cell} should have a positive value for the cell to function.
Reason: $E_{cathode} < E_{anode}$

Solution:(c) Assertion is true but the reason is false.

3. Assertion : Conductivity of all electrolytes decreases on dilution.
Reason : On dilution number of ions per unit volume decreases.

Solution: (a) Both assertion and reason are true and the reason is correct explanation for assertion.

4. Assertion : Λ_m for weak electrolytes shows a sharp increase when the electrolytic solution is diluted.
Reason : For weak electrolytes degree of dissociation increases with dilution of solution.

Solution: (a) Both assertion and reason are true and the reason is correct explanation for assertion.

5. Assertion :Mercury cell does not give steady potential.
Reason: In the cell reaction, ions are not involved in solution.

Solution:(e) Assertion is false but reason is true.

Long Answer Types Questions.

1. Define the terms specific conductance, molar conductance and equivalent conductance. Derive the relationship between molar conducrance and equivalent conductance.

Solution:
(a) Specific conductance:
The reciprocal of specific resistance is termed as specific conductance or it is the conductance of one centimeter cube of a conductor.
It is denoted by the symbol κ (kappa).
$\kappa = 1/\rho$ or $\kappa = (l/a) \times C$
Specific conductance is also called conductivity.
(b) Molar conductane:
Molar conductance is defined as the conductance of all the ions produced by ionisation of 1 g- mole of an electrolyte when present in per litre of solution. It is denoted by Λ_m.

Molar conductance Λ_m = k x 1000/M

(c) Equivalent conductane:

Equivalent conductance is defined as the conductance of all ions produced by one gram-equivalent of an electrolyte present per litre of solution. It is denoted by Λ_{eq}.

Equivalent conductance Λ_{eq} = k x 1000/N.

Relationship between molar conductance and equivalent conductance.

Λ_m = k x 1000/M , Λ_{eq} = k x 1000/N

$\therefore \Lambda_m / \Lambda_{eq} = n$

Where n= valence factor.

2. State Kohlrausch's law. How does the law help in calculating Λ^0_∞ CH_3COOH ?

Solution:

At infinite dilution, when dissociation is complete, each ion makes a definite contribution towards equivalent conductance of the electrolyte irrespective of the nature of the ion with which it is associated and the value of equivalent conductance at infinite dilution for any electrolyte is the sum of contribution of its constituent ions", i. e. anions and cations.

$\Lambda_\infty = \lambda_a + \lambda_c$

The λ_a and λ_c are called the ionic conductances of cation and a anion at infinite dilution respectively. The molar conductivity of an strong electrolyte at infinite dilution is the sum of the ionic conductivity of the cations and anions.

In caseof weak electrolytes, it is not possible to determine the value of limiting molar conductance at infinite dilution. However this can be determine by using Kohlrausch's law.

Example CH3COOH is a weak electrolyte.

Λ^∞_m (CH3COOH) = λ_m^∞ (CH3COO-) + λ_m^∞ (H^+)

=[λ_m^∞ (CH3COO-) + λ_m^∞ (Na^+)] + [λ_m^∞ (H^+) + λ_m^∞ (Cl^-)] - [λ_m^∞ (Na^+) + λ_m^∞ (Cl^-)]

= Λ^∞_m (CH3COONa) + Λ^∞_m (HCl) - Λ^∞_m (NaCl)

3. What is the relationship between Gibbs free energy of the cell reaction in a galvanic cell and the emf of t ? When will the maximum work be obtained from a galvanic cell ?

Solution:

The relation may be given as :

$\Delta G = -nF E_{cell}$

If the redox reaction is under standard conditions, then

$\Delta G^\circ = -nFE_{cell}$

Here nF is the quantity of charge passed. In case we want to obtain maximum work from the galvanic charge has to be passed reversibly. As pointed above, the reversible work done by the galvanic cell is equal decrease in its Gibbs free energy.

4. What is Nernst equation ? write the Nernst equation for the reaction.

$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$

Solution:

Nernst equation is an equation relating the capacity of an atom/ion to take up one or more electrons (reduction potential) measured at any conditions to that measured at standard conditions (standard reduction potentials) of 298K and one molar or one atmospheric pressure.

$E_{cell} = E^0 - [RT/nF] \ln Q$

Where,

E_{cell} = cell potential of the cell

E^0 = cell potential under standard conditions

R = universal gas constant

T = temperature

n = number of electrons transferred in the redox reaction

F = Faraday constant

Q = reaction quotient

In the equation : $2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$

$E_{cell} = E^0 - [RT/nF] \ln Q$

$E_{cell} = E^0 - [RT/nF] \ln \{[Cr^{3+}]^2 / [Cd^{2+}]^3\}$

5. State Faraday's first law of electrolysis. How much charge in terms of Faraday is required for reduction of 1 mole of Cu^{2+} ions to Cu?

Solution:

When an electric current is passed through an electrolyte, the amount of substance deposited is proportional to the quantity of electric charge passed through the electrolyte.

If W be the mass of the substance deposited by passing Q coulomb of charge, then according to the law, we have the relation:

$W \propto Q$

A coulomb is the quantity of charge when a current of one ampere is passed for one second. Thus, amount of charge in coulombs,

Q = current in amperes x time in seconds

$Q = I \times t$

$W \propto I \times t$

$W = Z \times I \times t$

where, Z is a constant, known as electrochemical equivalent, and is characteristic of the substance deposited.

When a current of one ampere is passed for one second,i.e one coulomb (Q = 1), then

W = Z

The electrode reaction is $Cu^{2+} + 2e^- \rightarrow Cu$

∴ quantity of charge required for reduction of 1 mole of Cu2+ =2F

$Cu^{2+} = 2F = 2 \times 96500 = 193000C$