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Chapter 3: Electrochemistry

NCERT Exemplar · Class 12 · Chemistry

I. Multiple Choice Questions (Type-I)

Question 1

Which cell will measure standard electrode potential of copper electrode?

A.

Pt (s) $\text{H}_2(\text{g}, 0.1 \text{ bar})$ $\text{H}^+(\text{aq}, 1 \text{ M})$ $\text{Cu}^{2+}(\text{aq}, 1 \text{ M})$ Cu

B.

Pt(s) $\text{H}_2(\text{g}, 1 \text{ bar})$ $\text{H}^+(\text{aq}, 1 \text{ M})$ $\text{Cu}^{2+}(\text{aq}, 2 \text{ M})$ Cu

C.

Pt(s) $\text{H}_2(\text{g}, 1 \text{ bar})$ $\text{H}^+(\text{aq}, 1 \text{ M})$ $\text{Cu}^{2+}(\text{aq}, 1 \text{ M})$ Cu

D.

Pt(s) $\text{H}_2(\text{g}, 1 \text{ bar})$ $\text{H}^+(\text{aq}, 0.1 \text{ M})$ $\text{Cu}^{2+}(\text{aq}, 1 \text{ M})$ Cu

Answer

Correct option: C

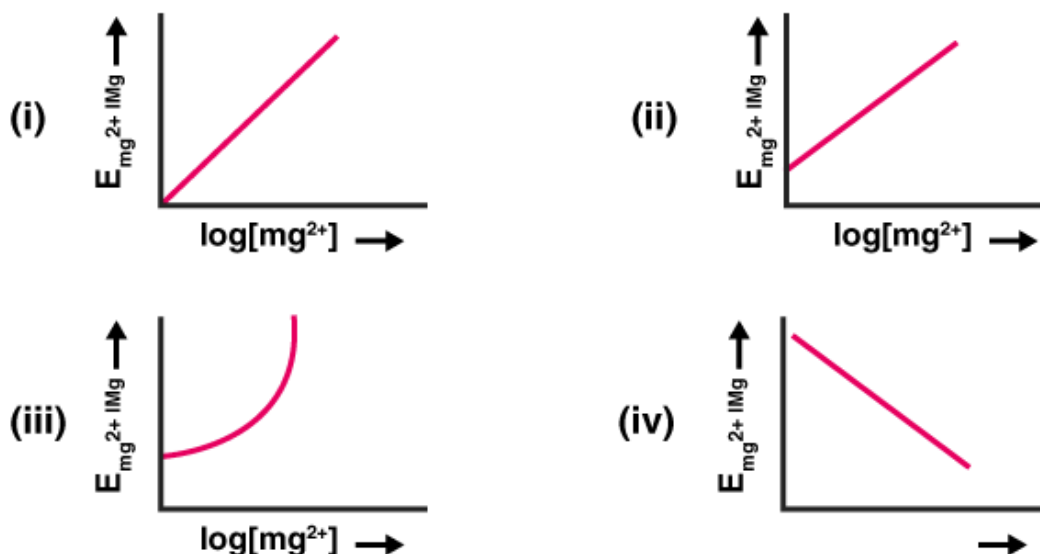
Solution

Option (iii) is the answer.

Question 2

Electrode potential for Mg electrode varies according to the equation

$E_{\text{Mg}^{2+}/\text{Mg}} = E^\circ_{\text{Mg}^{2+}/\text{Mg}} - 0.0591/2 \log_{10} [\text{Mg}^{2+}]$. The graph of $E_{\text{Mg}^{2+}/\text{Mg}}$ Vs $\log [\text{Mg}^{2+}]$ is



Solution

Option (ii) is the answer.

Question 3

Which of the following statement is correct?

A.

E_{cell} and Δ_rG of cell reaction both are extensive properties.

B.

E_{cell} and Δ_rG of cell reaction both are intensive properties.

C.

E_{cell} is an intensive property while Δ_rG of cell reaction is an extensive property.

D.

E_{cell} is an extensive property while Δ_rG of cell reaction is an intensive property.

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 4

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

A.

Cell potential

B.

Cell emf

C.

Potential difference

D.

Cell voltage

Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 5

Which of the following statement is not correct about an inert electrode in a cell?

A.

It does not participate in the cell reaction.

B.

It provides surface either for oxidation or for the reduction reaction.

C.

It provides a surface for conduction of electrons.

D.

It provides a surface for a redox reaction.

Answer

Correct option: D

Solution

Option (iv) is the answer.

Question 6

An electrochemical cell can behave like an electrolytic cell when _____.

A.

$E_{\text{cell}} = 0$

B.

$E_{\text{cell}} > E_{\text{ext}}$

C.

$E_{\text{ext}} > E_{\text{cell}}$

D.

$E_{\text{cell}} = E_{\text{ext}}$

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 7

Which of the statements about solutions of electrolytes is not correct?

A.

The conductivity of the solution depends upon the size of ions.

B.

Conductivity depends upon the viscosity of the solution.

C.

Conductivity does not depend upon solvation of ions present in solution.

D.

The conductivity of the solution increases with temperature.

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 8

Using the data given below to find out the strongest reducing agent.

$$E^\circ \text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+} = 1.33\text{V}$$

$$E^\circ \text{MnO}_4^-/\text{Mn}^{2+} = 1.51\text{V}$$

$$E^\circ \text{Cl}_2/\text{Cl}^- = 1.36\text{V}$$

$$E^\circ \text{Cr}^{3+}/\text{Cr} = -0.74\text{V}$$

A.

Cl^-

B.

Cr

C.

Cr^{3+}

D.

Mn

Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 9

Use the data given in Q.8 and find out which of the following is the strongest oxidising agent.

A.

Cl^-

B.

Mn^{2+}

C.

MnO_4^-

D.

Cr^{3+}

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 10

Using the data given in Q.8 find out in which option the order of reducing power is correct.

A.



B.



C.



D.



Answer

Correct option: B

Solution

Option (ii) is the answer.

Question 11

Use the data given in Q.8 and find out the most stable ion in its reduced form.

A.

Cl⁻

B.

Cr³⁺

C.

Cr

D.

Mn²⁺

Answer

Correct option: D

Solution

Option (iv) is the answer.

Question 12

Use the data of Q.8 and find out the most stable oxidised species.

A.

Cr³⁺

B.

MnO₄⁻

C.

Cr₂O₇²⁻

D.

Mn²⁺

Answer

Correct option: A

Solution

Option (i) is the answer.

Question 13

The quantity of charge required to obtain one mole of aluminium from Al_2O_3

is

_____.

A.

1F

B.

6F

C.

3F

D.

2F

Answer

Correct option: C

Solution

Option (iii) is the answer.

Question 14

The cell constant of a conductivity cell _____.

A.

changes with the change of electrolyte.

B.

changes with the change of concentration of electrolyte.

C.

changes with the temperature of the electrolyte.

D.

remains constant for a cell.

Answer

Correct option: D

Solution

Option (iv) is the answer.

Question 15

While charging the lead storage battery _____.

(i) PbSO_4 anode is reduced to Pb.

(ii) PbSO_4 cathode is reduced to Pb. (iii) (iii) PbSO_4 cathode is oxidised to Pb.

(iv) PbSO_4 anode is oxidised to PbO_2

Solution

Option (i) is the answer.

Question 16

$^0_{\text{m}}(\text{NH}_4\text{OH})$ is equal to _____.

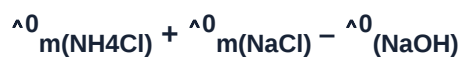
A.

$$^0_{\text{m}}(\text{NH}_4\text{OH}) + ^0_{\text{m}}(\text{NH}_4\text{Cl}) - ^0_{\text{m}}(\text{HCl})$$

B.

$$^0_{\text{m}}(\text{NH}_4\text{Cl}) + ^0_{\text{m}}(\text{NaOH}) - ^0_{\text{m}}(\text{NaCl})$$

C.



D.

**Answer**

Correct option: B

Solution

Option (ii) is the answer.

Question 17

In the electrolysis of aqueous sodium chloride solution which of the half cell reaction will occur at anode?

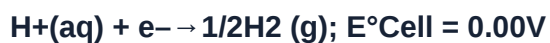
A.



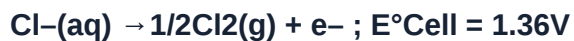
B.



C.



D.

**Answer**

Correct option: D

Solution

Option (iv) is the answer.

II. Multiple Choice Questions (Type-II)

Question 18

The positive value of the standard electrode potential of Cu^{2+}/Cu indicates that _____.

- (i) this redox couple is a stronger reducing agent than the H^+/H_2 couple.
- (ii) this redox couple is a stronger oxidising agent than H^+/H_2 .
- (iii) Cu can displace H_2 from acid.
- (iv) Cu cannot displace H_2 from acid.

Solution

Option (ii) and (iv) are the answers.

Question 19

E°_{Cell} for some half cell reactions are given below. Based on these mark the correct answer.

- (a) $\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2(\text{g})$; $E^\circ_{\text{cell}} = 0.00\text{V}$
- (b) $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$; $E^\circ_{\text{cell}} = 1.23\text{V}$
- (c) $2\text{SO}_4^{2-}(\text{aq}) \rightarrow \text{S}_2\text{O}_8^{2-}(\text{aq}) + 2\text{e}^-$; $E^\circ_{\text{cell}} = 1.96\text{V}$
- (i) In dilute sulphuric acid solution, hydrogen will be reduced at the cathode.
- (ii) In concentrated sulphuric acid solution, water will be oxidised at the anode.
- (iii) In dilute sulphuric acid solution, water will be oxidised at the anode.
- (iv) In dilute sulphuric acid solution, SO_4^{2-} ion will be oxidised to tetrathionate ion at the anode.

Solution

Option (i) and (iii) are the answers.

Question 20

$E^\circ_{\text{Cell}} = 1.1\text{V}$ for Daniel cell. Which of the following expressions are correct description of state of equilibrium in this cell?

(i) $1.1 = K_c$

(ii) $2.303RT/2F \log K_c = 1.1$

(iii) $\log K_c = 2.2/0.059$

(iv) $\log K_c = 1.1$

Solution

Option (ii) and (iii) are the answers.

Question 21

Conductivity of an electrolytic solution depends on _____.

(i) nature of electrolyte.

(ii) the concentration of electrolyte.

(iii) power of AC source.

(iv) distance between the electrodes.

Solution

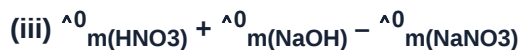
Option (i) and (ii) are the answers.

Question 22

$^0m(\text{H}_2\text{O})$ is equal to _____.

(i) $^0m(\text{HCl}) + ^0m(\text{NaOH}) - ^0m(\text{NaCl})$

(ii) $^0m(\text{HNO}_3) + ^0m(\text{NaNO}_3) - ^0m(\text{NaOH})$



Solution

Option (i) and (iii) are the answers.

Question 23

What will happen during the electrolysis of an aqueous solution of CuSO_4 by using platinum electrodes?

- (i) Copper will deposit at the cathode.
- (ii) Copper will deposit at the anode.
- (iii) Oxygen will be released at anode.
- (iv) Copper will dissolve at the anode.

Solution

Option (i) and (iii) are the answers.

Question 24

What will happen during the electrolysis of an aqueous solution of CuSO_4 in the presence of Cu electrodes?

- (i) Copper will deposit at the cathode.
- (ii) Copper will dissolve at the anode.
- (iii) Oxygen will be released at anode.
- (iv) Copper will deposit at the anode.

Solution

Option (i) and (ii) are the answers

Question 25

Conductivity κ , is equal to _____.

(i) $1/R \text{ I/A}$

(ii) G^*/R

(iii) $\wedge_m$

(iv) I/A

Solution

Option (i) and (ii) are the answers.

Question 26

Molar conductivity of ionic solution depends on _____.

(i) temperature.

(ii) distance between electrodes.

(iii) the concentration of electrolytes in solution.

(iv) the surface area of electrodes.

Solution

Option (i) and (iii) are the answers.

Question 27

For the given cell, $\text{Mg}|\text{Mg}^{2+}||\text{Cu}^{2+}|\text{Cu}$

(i) Mg is cathode

(ii) Cu is cathode

(iii) The cell reaction is $\text{Mg} + \text{Cu}^{2+} \rightarrow \text{Mg}^{2+} + \text{Cu}$

(iv) Cu is the oxidising agent

Solution:
Option (ii) and (iii) are the answers.

III. Short Answer Type

Solution

Solution coming soon.

Question 28

Can absolute electrode potential of an electrode be measured?

Solution

No. It cannot be measured. We can only measure the difference in electrode potential between the two half-cells. We can also measure electrode potential difference concerning a standard electrode.

Question 29

Can E°_{cell} or $\Delta_r G^\circ$ for cell reaction ever be equal to zero?

Solution

E°_{Cell} or $\Delta_r G^\circ$ can never be equal to zero. The only standard electrode potential which is arbitrarily assigned the value zero is the standard hydrogen electrode (SHE). Since everything else is measured concerning SHE; the E°_{cell} can never be zero.

Question 30

Under what condition is $E_{\text{Cell}} = 0$ or $\Delta_r G = 0$?

Solution

Electrolysis happens when a redox reaction occurs. Like all reactions, redox reaction moves towards equilibrium. At equilibrium condition, the cell has discharged completely, and cell potential drops to zero.

$$\Delta_r G = -nF E_{\text{cell}} = 0$$

Question 31

What does the negative sign in the expression $E^\circ_{\text{Zn}^{2+}/\text{Zn}} = -0.76\text{V}$ mean?

Solution

A negative value is that hydrogen gas is more stable than the reduced form of species. Here, the reduced form (Zn) is not stable. It is difficult to reduce Zn^{2+} to Zn. So, the reverse is more likely to happen. Zn would rather get oxidized to Zn^{2+} and H^{+} will get reduced

Question 32

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 the same or different? Explain your answer.

Solution

$$W = \frac{itE}{96500}$$

$$= \frac{1 \times 10 \times 60 \times 31.75}{96500}$$

Equivalent mass of Cu^{2+} is different from the equivalent mass of Ag^{+} so obviously the mass of copper deposited will not be the same as the mass of silver deposited.

Question 33

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

Solution

Anode- Oxidation half-cell: $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$

Cathode- Reduction half-cell: $2\text{Ag}^{+} + 2\text{e}^{-} \rightarrow 2\text{Ag}$

Overall reaction : $\text{Cu} + 2\text{Ag}^{+} \rightarrow \text{Cu}^{2+} + 2\text{Ag}$

$\text{Cu}|\text{Cu}^{2+}(\text{aq}, 1\text{M}) || \text{Ag}^{+}(\text{aq}, 1\text{M})|\text{Ag}$

Question 34

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 is Cl^{-} oxidised at anode instead of water?

Solution

The oxidation of water to oxygen is kinetically unfavourable and requires excess potential called over-potential. Over-potential is the excess potential required to drive a reaction at a particular rate.

Question 35

What is electrode potential?

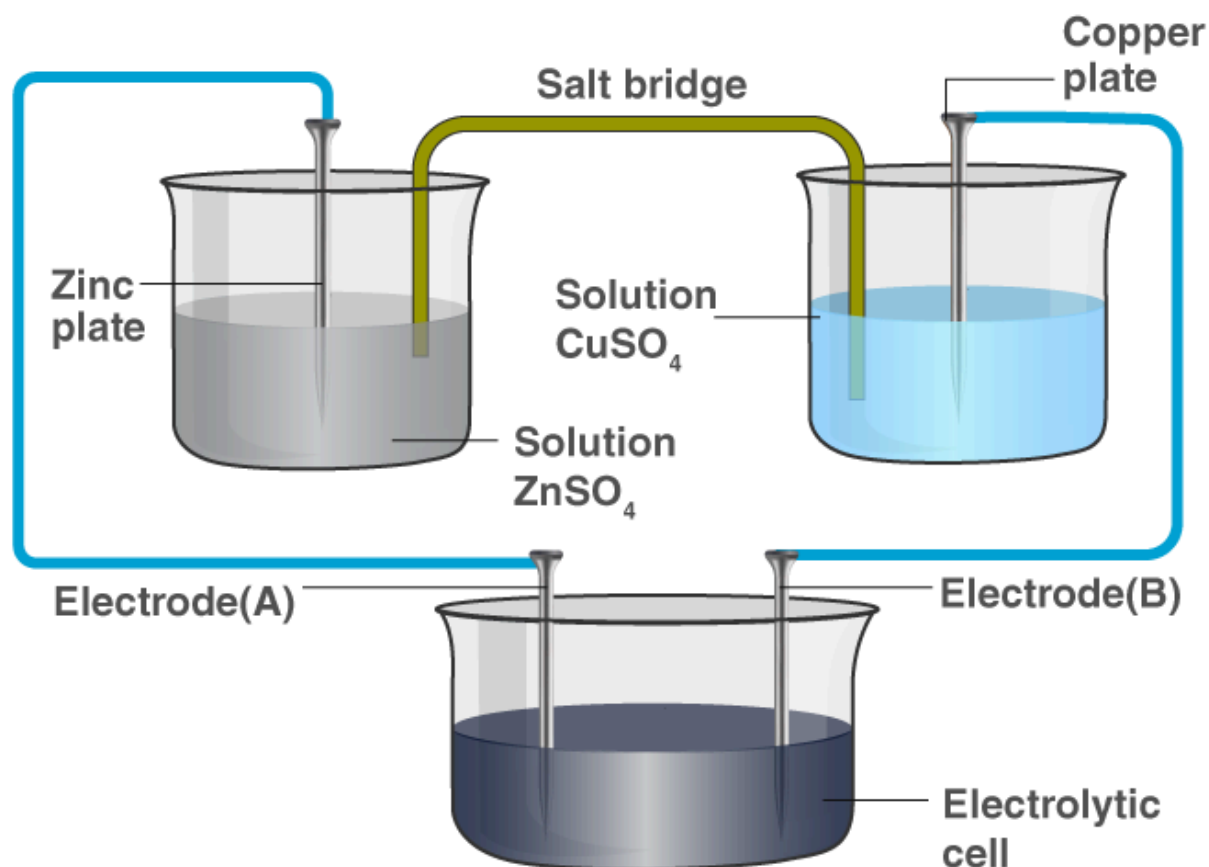
Solution

The potential difference developed between an electrode and electrolyte is called the electrode potential.

Standard electrode potential will be always reduction potential.

Question 36

Consider the following diagram in which an electrochemical cell is coupled to an electrolytic cell. What will be the polarity of electrodes 'A' and 'B' in the electrolytic cell?



Solution

Zinc goes into solution as Zn^{2+} and leaves behind the electrons on Electrode A making it negatively charged. Cu^{2+} from the solution deposits on Electrode B making it positively charged.

Electrode A polarity- negative

Electrode B polarity- positive.

Question 37

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

Solution

The alternating current keeps the concentration of ions constant whereas direct current changes the concentration of ions. That is why alternating current is used for measuring the resistance of an electrolytic solution.

Question 38

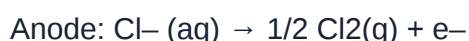
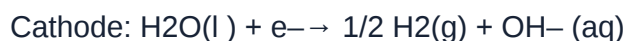
A galvanic cell has an electrical potential of 1.1V. If an opposing potential of 1.1V is applied to this cell, what will happen to the cell reaction and current flowing through the cell?

Solution

The cell reaction stops and there will be no flow of current through the cell when the opposing potential becomes equal to electrical potential. Therefore no chemical reaction takes place.

Question 39

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

Solution

NaOH is a strong base, they turn the brine solution basic and pH will increase.

Question 40

Unlike dry cell, the mercury cell has a constant cell potential throughout its useful life. Why?

Solution

The electrolyte is not consumed in the cell and thus the current will deliver at constant potential throughout,

overall reaction contains no ions whose concentration can change over time. So, the cell potential remains constant throughout the mercury cell life.

Question 41

Solutions of two electrolytes 'A' and 'B' are diluted. The 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

Electrolyte B is strong as on dilution the number of ions remains the same, only interionic attraction decreases; therefore, the increase in Λ_m is small.

Question 42

When acidulated water (dil. H_2SO_4 solution) is electrolysed, will the pH of the solution be affected? Justify your answer.

Solution

Anode: $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$

Cathode: $4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2$

Overall cell reaction: $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 2\text{H}_2(\text{g})$

pH remains the same because concentration of H^+ ions remains constant.

Question 43

In an aqueous solution, how does specific conductivity of electrolytes change with the addition of water?

Solution

The addition of water dilutes the electrolyte. The number of ions in a given volume decreases and conductivity also reduces.

Question 44

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

Solution

Standard hydrogen electrode (SHE) is used as a reference electrode. The potential of SHE is assigned the value zero. The electrode potential of other electrodes is measured with respect to this.

Question 45

Consider a cell given below



Write the reactions that occur at anode and cathode.

Solution

Galvanic cell: $\text{Cu}|\text{Cu}^{2+}||\text{Cl}-|\text{Cl}_2, \text{Pt}$

Anode- Oxidation half-cell: $\text{Cu(s)} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$

Cathode- Reduction half-cell: $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-$

Thus, Cu is anode as it is getting oxidised.

Question 46

Write the Nernst equation for the cell reaction in the Daniel cell. How will the E_{cell} be affected when the concentration of Zn²⁺ ions is increased?

Solution

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{RT}{nF} \ln \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

Galvanic cell reaction: $\text{Zn(s)}|\text{Zn}^{2+}(\text{aq})||\text{Cu}^{2+}(\text{aq})|\text{Cu(s)}$

Anode- oxidation half-cell: $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$

Cathode- reduction half-cell: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$

Overall reaction: $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.059}{2} \log \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

Question 47

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

Solution

Fuel cells are cells that convert the energy of combustion of fuels like hydrogen, methanol into electrical energy. Fuel cells run continuously as long as reactants are supplied. Primary batteries discharge and are one-time use only, and secondary batteries can be recharged, but recharging takes a lot of time.

Question 48

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

Density decreases as the product water form dilute the H₂SO₄ concentration during the discharge of the battery.

Question 49

Why on dilution the α_m of CH₃COOH increases drastically, while that of CH₃COONa increases gradually?

Solution

CH₃COOH is a weak electrolyte and CH₃COONa is a strong electrolyte. A weak electrolyte has a lower degree of dissociation at higher concentration but upon dilution, the degree of dissociation increases, the number of ions per unit volume increases, and this lead to an increase in.