Chapter 4: Chemical Effect of Current

Short Answer Questions

1. 2076 Set B Q.No. 1c 2067 Sup Q.No. 1c **Distinguish between ionic and electronic conduction.** [2]

The differences between the ionic and electronic conduction are given below;

Electronic conduction	Ionic conduction
1. The conduction of electricity takes place due to drifting of free electrons in metals is called electronic conduction.	1. The conduction of electyricity takes place due to movement of ions is called ionic conduction.
2. No chemical change takes place when the current passes through metal in electronic conduction.	2. The chemical decomposition takes place when current passes through the electrolyte.
3. No matter is transformed during electric conduction in metals.	3. Matter is transported in the form of positive and negative ions in case of electrolytes.
4. Eg. Electricity passing through copper wire.	4. Eg. Electricity passing through copper sulphate solution.
5. The resistance is less in electronic conduction.	5. The resistance is more in ionic conduction.

2. 2076 Set C Q.No. 1a 2074 Set B Q.No. 1f 2072 Set C Q.No. 1b **The conductivity of an electrolyte is low as compared to that of metal at room temperature. Why?** [2]

The conductivity of an electrolyte is low as compared to a metal because of following reasons.

i. The number of ions in an electrolyte is small as compared to the number of free electrons in the metallic conductors. The drift velocity is given by the relation $I = v_d neA$, since n is more in metal than that of electrolyte, then the current is more in metal.

ii. The mobility of ions in an electrolyte is small as compared to the mobility of free electrons in metallic conductors.

iii. The resistance offered by the electrolyte to ions is more than resistance offered by metal to free electrons.

3. 2075 GIE Q.No. 1c **A voltameter measures current more accurately than an ammeter, why?** [2]

The current flowing in a voltameter can be measured by using the relation, $I = \frac{m}{zt}$. All quantities of this relation can be accurately measured upto three decimal places. But in case of ammeter due to the presence of certain resistance in it, current can never be measured accurately. That's why, a voltameter measures electric current more accurately than an ammeter.

4. 2075 Set B Q.No. 1c 2071 Set C Q.No. 1 e **Why is the conductivity of an electrolyte low in comparison to that of metal?** [2]

Please refer to 2076 Set C Q.No. 1a

5. 2073 Set C Q.No. 1e **State the Faraday's laws of electrolysis.** [2]

Faraday gave two laws of electrolysis, they are stated as:

a. **Faraday's first law of electrolysis:** The mass of a substance liberated or deposited in electrolysis is directly proportional to the electric charge that passes through the electrolyte.

i.e., $m \propto Q \quad \Rightarrow m = Z Q$

where Z is electrochemical equivalent (ECE).

$\therefore \quad m = Z It \qquad (Q = I t)$

b. **Faraday's second law of electrolysis:** The mass of different substances liberated in electrolysis by the passage of same quantity of electric charge, is directly proportional to their respective chemical equivalent.

$$\frac{m}{E} = \text{constant}$$

6. 2072 Supp Q.No. 1b **Explain electrochemical equivalent of a substance.** [2]

Electrochemical equivalent: From Fraday's first law of electrolysis, the amount of ions deposited or liberated at an electrode in electrolysis is directly proportional to the quantity of electricity passed through the electrolysis.

i.e., $m \propto Q$ or, $m = ZQ$

Where, $Z = \frac{m}{Q}$ is electrochemical equivalent of a substance. Thus, electrochemical equivalent of a substance is defined as the mass of ions deposited or liberated at the electrode when one coulomb of charge is passed through electrolyte. Its unit is KgC^{-1}.

7. 2072 Set E Q.No. 1c **Why is the conductivity of an electrolyte very low as compared to a metal at room temperature?** [2]

Please refer to 2076 Set C Q.No. 1a

8. 2071 Supp Q.No. 1f 2056 Q.No. 10 c **What is meant by Faraday constant?** [2]

Faraday's constant (F): From Faraday's first and second laws of electrolysis, we get a combined equation

$$m \propto QE$$

where m is the mass of ions or substance liberated or deposited, Q is amount of charge deposited or liberated and E be chemical equivalent.

$$\text{Or, } m = \frac{1}{F}QE$$

where F is a universal constant called Faraday's constant. If m = E (numerically), then F = Q. thus, Faraday constant is defined as the quantity of charge required to liberate the mass of substance equal to its gram equivalent. Its value is equal to 96500Cmol-1.

9. 2070 Set C Q.No. 1 e **The conductivity of an electrolyte is low as compared to a metal. Why?** [2]

Please refer to 2076 Set C Q.No. 1a

10. 2070 Set D Q.No. 1 e **State and explain Faraday's laws of electrolysis.** [2]

Please refer to 2073 Set C Q.No. 1e

11. 2066 Old Q.No. 10 b **Define one Faraday.** [2]

Please refer to 2071 Supp Q.No. 1f

12. 2063 Q.No. 10 b **Why does voltameter measure current more accurately than an ammeter?** [2]

Please refer to 2075 GIE Q.No. 1c

Long Answer Questions

13. 2075 Set A Q.No. 5c 2071 Set D Q.No. 5 b 2069 (Set A) Q.No. 5c **State Faraday's laws of electrolysis. How will you verify Faraday's second law experimentally?** [4]

Faraday gave two laws of electrolysis, they are stated as:

a. **Faraday's first law of electrolysis:** The mass of a substance liberated or deposited in electrolysis is directly proportional to the electric charge that passes through the electrolyte.

i.e., $m \propto Q \quad \Rightarrow m = Z\,Q$

where Z is electrochemical equivalent (ECE).

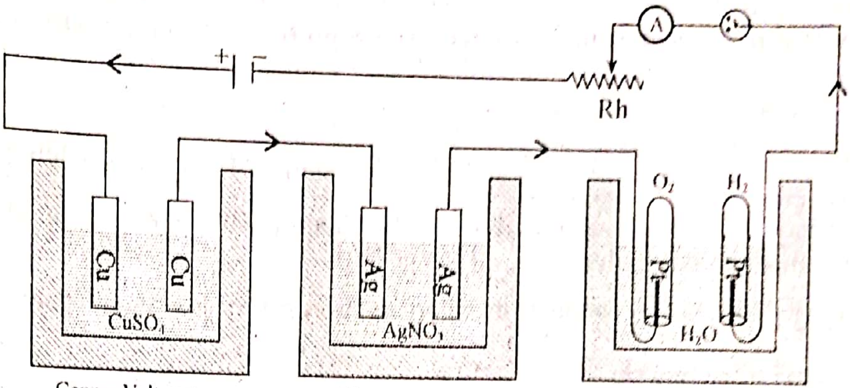
$\therefore \quad m = Z\,It \qquad (Q = I\,t)$

b. **Faraday's second law of electrolysis:** The mass of different substances liberated in electrolysis by the passage of same quantity of electric charge, is directly proportional to their respective chemical equivalent.

$$\frac{m}{E} = \text{constant}$$

Experimental verification:

Second law:



Copper Voltameter   Silver Voltameter   Water Voltameter

The experimental arrangement for the verification of Faraday's second law is as shown in figur There are three voltameters containing $CuSO_4$, $AgNO_3$ and acidified water as electrolytes and Cu, A and Pt are as respective electrodes. If I be the constant current flow in circuit, then in time 't', the ma of hydrogen gas liberated, silver and copper deposited on electrodes are calculated. If m_1, m_2 and m are masses of copper, silver and hydrogen deposited at the respective cathodes and E_1, E_2 and E_3 ar their chemical equivalents respectively, then, experimentally it is found that,

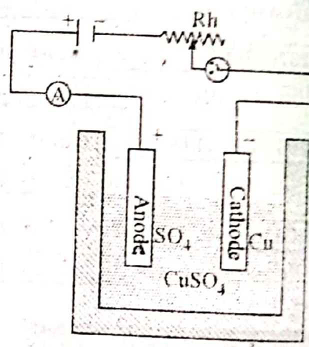
$\frac{m_1}{E_1} = \frac{m_2}{E_2} = \frac{m_3}{E_3}$ i.e., $m \propto E$. This verifies Faraday's second law of electrolysis.

14. 2070 Sup (Set A) Q.No. 5 c | 2062 Q.No. 11 a **State Faraday's laws of electrolysis and verify second law.** [4

Please refer to 2075 Set A Q.No. 5c

15. 2069 (Set B) Q.No. 5a **Verify Faraday laws of electrolysis.** [4

First law: The experimental arrangement to verify Faraday's first law of electrolysis in copper voltameter is as shown in figure. A clean and dry cathode plate is weighed and then it is placed in the voltameter. The electric circuit is completed by the series combination of voltameter with the battery, ammeter and a rheostat as shown in figure. When steady current I is passed for a certain time 't', the electrolyte $CuSO_4$ solution of electrolyte decompose into Cu^{++} and SO_4^{--}.



Let m_1 be the mass of copper deposited on cathode in time t with the passage of current I_1, then

$m_1 = Z I_1 t$ ... (i)

The experiment is repeated with current I_2 at same time t, the mass of copper deposited on cathode is m_2, then

$m_2 = Z I_2 t$ ... (ii)

From (i) and (ii), we get

$$\frac{m_1}{m_2} = \frac{I_1 t}{I_2 t} \Rightarrow \frac{m_1}{m_2} = \frac{Q_1}{Q_2}$$

i.e., $m \propto Q$, Similar procedure can be repeated by keeping current constant and varying time. This verifies the first law.

Statement and Second Law: Please refer to 2075 Set A Q.No. 5c

16. 2068 Old Q.No. 11 a or | 2058 Q.No. 11 a OR **State and explain Faraday's Laws of electrolysis and hence define Faraday's constant.** [3+2]

First law: Please refer to 2069 (Set B) Q.No. 5a

Statement and Second Law: Please refer to 2075 Set A Q.No. 5c

Faraday's constant (F): From fist law of electrolysis, we have

$m \propto Q$, where E is constant

From second law of electrolysis, we have

$m \propto E$, where Q is constant

Combining these two laws we get,

$m \propto QE$ where Q and E both vary.

Or, $m = \frac{1}{F}QE$

where F is a universal constant called Faraday's constant. If m = E (numerically), then F = Q. Thus, Faraday constant is defined as the quantity of charge required to liberate the mass of substance equal to its gram equivalent. Its value is equal to $96500 C mol^{-1}$.

17. 2064 Q.No. 11 a OR **State Faraday's law of electrolysis. Discuss the experiment to verify them.** **[4]**

First law: Please refer to 2069 (Set B) Q.No. 5a

Statement and Second Law: Please refer to 2075 Set A Q.No. 5c

Numerical Problems

18. 2074 Supp Q.No. 9b **It is desired to deposit 0.254 kg of copper on the cathode of a copper voltameter. How long will it take to deposit this amount if a steady current of 100 A is maintained? Relative Atomic mass of copper = 63.5 and Faraday's constant, F = 96500 C/mol.** **[4]**

Solution

Given,

Mass of copper deposited (m) = 0.254 kg = 254 g

Time (t) = ?

Current (I) = 100 A

Relative Atomic mass of copper (M) = 63.5

Faraday's constant (F) = 96500 C/mol

We have,

$m = ZIt$

or, $m = \frac{M}{VF} \times I \times t$

or, $t = \frac{m \cdot V \cdot F}{M \cdot I}$

$= \frac{254 \times 2 \times 96500}{63.5 \times 100}$

$= 7720 \text{ s}$

19. 2069 Supp Set B Q.No. 9 a **Assuming Faraday constant to be 96500 C $(mole)^{-1}$ and relative atomic mass of copper is 63, calculate the mass of copper liberated by 2 A current in 5 minutes.** **[4]**

Solution

Given,

Faraday constant (F) = $96500 C mol^{-1}$

Relative atomic mass of copper (M) = 63

Current (I) = 2A

Time (t) = 5 min = 5 × 60 = 300 sec.

Valency of copper (V) = 2

Mass of copper deposited (m) = ?

We have,

$m = ZIt$

$= \frac{E}{F} It$

$= \frac{M}{VF} It = \frac{63 \times 2 \times 300}{2 \times 96500} = 0.196 \text{ gm}$

20. 2066 Old Q.No. 11 b **In a copper plating system, an electrolysis current of 3 A is used. How many atoms of Cu^{2+} are deposited in 1.5 h? ($e = -1.6 \times 10^{-19}$C).** **[5]**

Solution

Given,

Current (I) = 3A

Time (t) $= 1.5h = 1.5 \times 3600 = 5400$ s

e $= 1.6 \times 10^{-19}$C

Now, Charge passed in 1.5 hour (Q) = It $= 3 \times 5400 = 16200$ C

Also, Charge carried by each Cu^{2+} atoms $= 2 \times 1.6 \times 10^{-19}C = 3.2 \times 10^{-19}C$

Then, No. of atoms deposited $= \dfrac{16200}{3.2 \times 10^{-19}} = 5.06 \times 10^{22}$

Hence, the required number of atoms is 5.06×10^{22}.

21. 2057 Q.No. 11 b Calculate the charge needed to deposit 2g of Oxygen in the electrolysis of water.(Relative molecular mass of Oxygen is 32, Faraday constant F is 965,000 C mol^{-1}). **[5]**

Solution

Given,

Mass of oxygen (m) = 2gm

Molecular mass of oxygen (M) = 32; Atomic mass $= \dfrac{32}{2} = 16$gm

Faraday constant (F) = 96500Cmol^{-1}

Charge needed (Q) = ?

Now,

Valency of oxygen (V)= 2

Then, we have

Chemical equivalent (E) = F × Z

or, $\dfrac{\text{Atomic mass}}{\text{Valency}} = F \times Z$

or, $\dfrac{16}{2} = 96500 \times Z$

$\therefore$ Z $= 8.29 \times 10^{-5}$ gmC^{-1}

Again, we have

m = Z × Q

or, 2 $= 8.29 \times 10^{-5} \times Q$

$\therefore$ Q = 24125.45C

Hence, the required amount of charge is 24125.45C

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