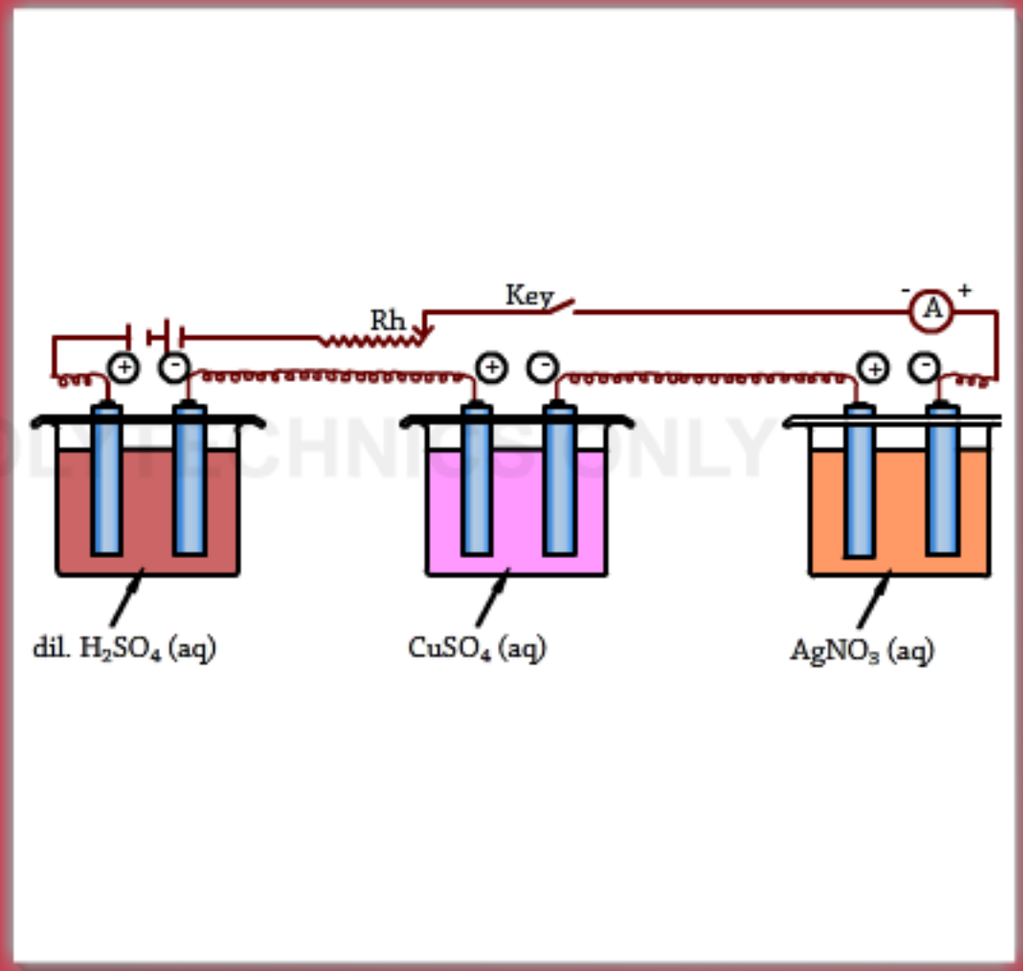
Faraday's laws of electrolysis

- Faraday's Laws
- Faraday's First Law of electrolysis
- Faraday's Second Law of electrolysis
- Relationship between Chemical equivalent and electro chemical equivalent



Recap

In previous period, we have discussed about

- The process of Electrolysis
- The electrolytic reactions of fused sodium chloride

OBJECTIVES

Upon completion of this period, you would be able to know

- Faraday's laws of electrolysis
- The relation between chemical equivalent and electro chemical equivalent

Faraday's laws

- First law indicates
  - The relationship between amount of substance produced at an electrode (w) and quantity of electricity (Q) passed through an electrolyte.
- Faraday's first law of electrolysis:
  - The amount of substance deposited or liberated or dissolved or underwent electrode reaction at an electrode is directly proportional to the quantity of electricity passed through an electrolyte .
- Faraday's second law of electrolysis:
  - When the same quantity of electricity is passed through different electrolytes, the amount of different elements produced at different electrodes is in the ratio of their chemical equivalents (equivalent weights).

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Faraday's first law of electrolysis

- The amount of substance deposited, liberated or dissolved at any electrode is directly proportional to the quantity of electricity passed through the electrolyte.
- Wt of the substance deposited α Quantity of electricity passed
- It is expressed as

$$W \alpha Q, \text{ since } Q = ct$$

$$W \alpha ct \quad \text{or} \quad W = ect$$

- W= Amount of element produced at an electrode in g.
- Q = Quantity of electricity passed in coulombs.
- c = Current strength passed in amperes.
- t = Time in sec.
- e = electro chemical equivalent of the element

- Electrochemical equivalent

- The amount of element deposited or liberated or dissolved at an electrode by passing one coulomb of electricity(1 A/1 sec).

$$W = eQ \quad \text{or} \quad W = ect$$

If c = 1A

t = 1 sec

i.e., Q = 1 coulomb

Then

$$W = e$$

- The unit of electro-chemical equivalent is g/coulombs or kg/coulombs.

- Significance of Faraday's first law
  - To calculate the values of electro chemical equivalents of different elements.
  - To calculate the amount of different elements resulted at electrodes.

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Faraday's second law of electrolysis

- When a definite quantity of electricity is passed through an electrolyte, the amount of element produced at an electrode is directly proportional to it's chemical equivalent or equivalent weight (E).
- Faraday's second law Indicates,
  - The relationship between amount of element produced at an electrode and it's chemical equivalent (equivalent weight).
- Faraday's second law - alternate statement :
  - When the same quantity of electricity is passed through different electrolytes, the amount of different elements produced at different electrodes is in the ratio of their chemical equivalents (equivalent weights).
- Illustration of Faraday's second law:

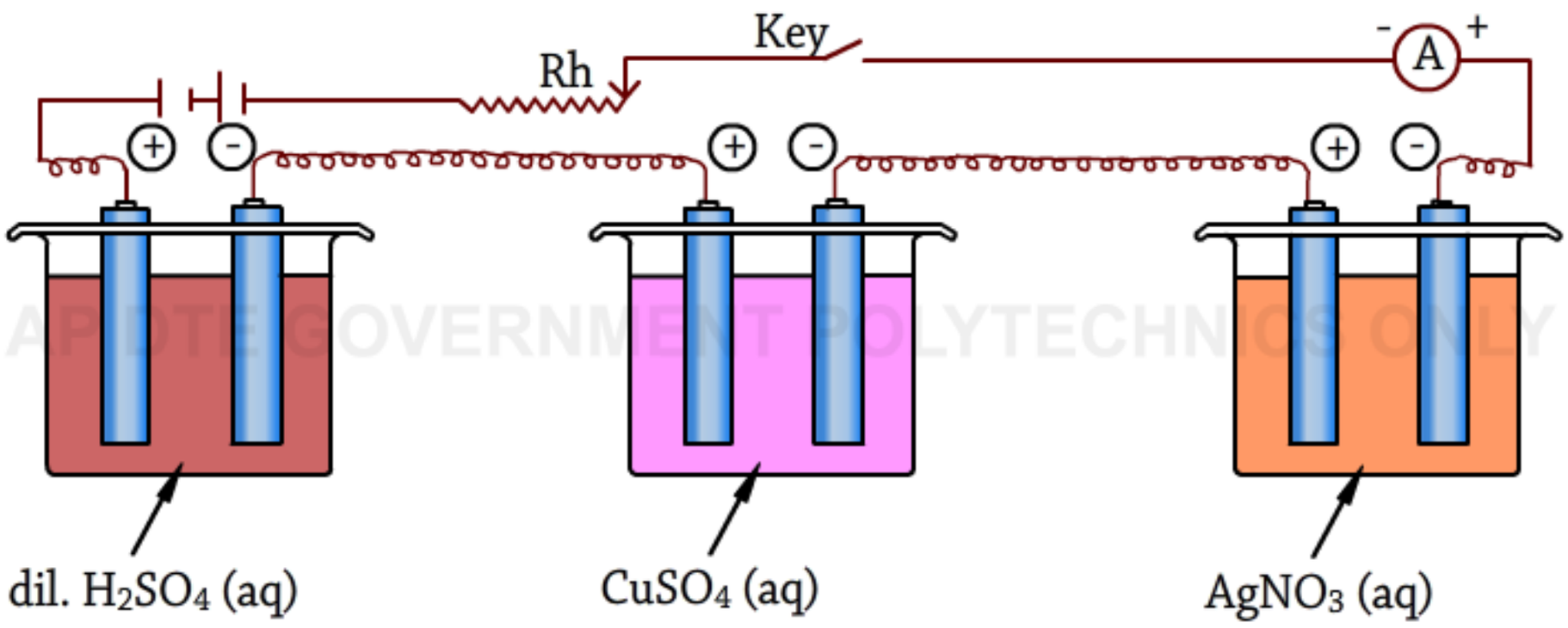

Fig 1: Illustration of Faraday's second

- It is expressed as

$$W \propto E \text{ or } \frac{W_1}{E_1} = \frac{W_2}{E_2}$$

W_1 = Amount of 1st element produced at an electrode .

W_2= Amount of 2nd element produced at another electrode.

E_1 = Chemical equivalent of 1st element.

E_2 = Chemical equivalent of 2nd element.

$$\frac{\text{weight of Copper}}{\text{weight of silver}} = \frac{\text{Eq. weight of copper}}{\text{Eq. weight of silver}}$$

Or

$$\frac{\text{weight of hydrogen}}{\text{weight of copper}} = \frac{\text{Eq. weight of hydrogen}}{\text{Eq. weight of copper}}$$

- Chemical Equivalent(equivalent weight):
  - The amount of substance deposited or liberated or dissolved or underwent electrode reaction at an electrode by the passage of one Faraday of electricity (96,500 coulombs) is called chemical equivalent.
  - It is represented by the letter E.
  - It is expressed by,

$$E = \frac{\text{Amount weight of element}}{\text{valency of element}}$$

- Faradays second law ensures,
  - Formation of 1 gram equivalent weight of a substance at an electrode by the passage of one Faraday of electricity.
  - Formation of equal number of gram equivalents of different substances at different electrodes when a given quantity of electricity is passed.
  - The number of gram equivalents of a substance formed at an electrode is equal to the number of Faradays of electricity passed.
- Significance of Faradays second law:
  - To calculate the equivalent weights (Chemical Equivalents) of different elements.
  - To calculate charge carried by an electron i.e., 1.602×10^{-19} Coulombs.
  - To calculate the value of Avogadro's number i.e., 6.023×10^{23}
  - To calculate the valance of an element.
  - To calculate number of electrons passed for given amount of substance produced at an electrode.

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Relationship between chemical equivalent and electro chemical equivalent

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

- e = Electro Chemical equivalent of a substance in g/coulomb
- E = Chemical equivalent (equivalent weight) of a substance.
- F = Faraday = 96,500 coulomb.

- Faraday (F):
  - It is the quantity of electricity required to produce 1gm equivalent weight of a substance at an electrode.
  - Faraday means flow of one mole of electrons.
  - The quantity of charge carried by one mole of electrons.

$$F = N * e^{-} = 6.02 \times 10^{23} \times 1.6 \times 10^{-19}$$

$$= 96,500 \text{ coulombs.}$$

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SUMMARY

In this period, we have discussed the following

- Faraday's I law
- Faraday's II law
- The relation between chemical equivalent and electro chemical equivalent

QUIZ

CHOOSE THE CORRECT ANSWER

1. Quantity of electricity is measured in _____ .

- ● Ampere-Sec
- ○ Ampere
- ○ Ampere/Sec
- ○ Sec/Ampere

2. Faraday's First law of electrolysis can be expressed as _____ .

- ● W a Q
- ○ W a 1/Q
- ○ W a Q_3
- ○ W a Q_2

3. One Faraday of current can deposit _____ .

- ○ One mole
- ○ 1g
- ● One gram equivalent
- ○ One electro chemical equivalent

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- State and Explain Faraday's Laws of electrolysis.
- Define electro chemical equivalent and chemical equivalent ? Give the relation between them.