13-1 Basic Concepts:

* Electrochemistry is the study of the relationship between chemical change and electrical work. It involves chemical reactions which involve reduction and oxidation process.

* Electrochemistry is the study of the interchange of chemical and electrical energy.

Redox Reaction:

A redox reaction involves transfer of electrons from one species to another. ie oxidation and Reduction taking place in the reaction.

$$\underset{\text{oxidizing agent}}{Fe^{3+}} + \underset{\text{Reducing agent}}{V^{2+}} \longrightarrow Fe^{2+} + V^{3+}$$

Fe^{3+} is the oxidising agent because it takes an electron from V^{2+}.

V^{2+} is the reducing agent because it gives an electron to Fe^{3+}.

Here Fe^{3+} is reduced, and V^{2+} is oxidised.

Oxidation:

A species is said to be oxidised when it loses electrons.

Eg.

$V^{2+} \longrightarrow V^{3+} + e^-$

Reduction:

A species is said to be Reduced when it gains electrons.

Eg.

$Fe^{3+} + e^- \longrightarrow Fe^{2+}$

Oxidising agent:

An oxidising agent, also called an oxidant, takes electrons from another substances and becomes reduced.

Reducing agent:

A reducing agent, also called a reductant, gives electrons to another substance and is oxidised in the process.

oxidation :

Loss of electrons.

Reduction :

Gain of electrons.

oxidising agent :

Takes electrons.

Reducing agents :

Gives electrons.

Relation between chemistry and electricity:

* The quantity of electrons that flow from a reaction is proportional to the quantity of analyte that reacts.

* The electric force (voltage) is related to the identity and concentrations of reactants and products.

Electric charge: (q):

Electric charge (q) is measured in coulombs (c).

The magnitude of the charge of a single electron is 1.602×10^{-19} C.

1 mole of electrons has a charge of 9.649×10^{4} C which is called the Faraday constant (F).

Relation between charge and moles:

$$\underset{\text{coulombs}}{q} = \underset{\text{moles}}{n} \cdot \underset{\frac{\text{coulombs}}{\text{mole}}}{F}$$

Faraday:

Faraday is the quantity of electricity needed to deposit 1 mole of the substance.

$$1 \text{ Faraday} = 96485.381 \text{ C/mol.}$$

Electric current : (I)

The quantity of charge flowing each second through a circuit is called the current.

The unit of current is the ampere (A).

$$\text{Current} = \frac{\text{charge}}{\text{Unit time}}$$

$$\text{Amp} = \frac{\text{Coulomb}}{\text{Sec.}}$$

$$I = \frac{Q}{S}$$

$$A = \frac{C}{S}$$

Electric potential : E

The difference in electric potential (E) between two points is a measure of the work that is needed when an electric charge moves from one point to another.

potential difference is measured in volts (V).

Electrical energy = voltage acting on an electrical charge.

Energy = Joule = Coulomb × volt.

$$\text{Electric potential} = \frac{\text{Energy}}{\text{unit charge}}$$

$$= V = E$$

$$V = \frac{J}{C}$$

Relation between work and voltage:

$$\text{work} = E \cdot q$$

Joules volts. Coulombs.

One joule of energy is gained or lost when one coulomb of charge moves between points whose potentials differ by one volt.

The greater the potential difference between two points, the stronger will be the "push" on a charge particle travelling between those points.

A 12V battery will push electrons through a circuit 8 times harder than a 1.5V battery.

Cell potential:

Depending on the nature of the chemical reactions occurring, the driving force on the electrons to flow in the circuit will be different. We term this the cell potential (E_{cell}) or the electromotive force (emf).

Electromotive force is typically measured in terms of voltage.

The cell potential is expressed in volts.

$$\text{Volts} = \frac{\text{work (J)}}{\text{Charge (Coulombs)}}$$

Work:

Electrochemical work.

$$\text{Work} = \text{potential} \times \text{current} \times \text{Time}$$

$$= \text{potential} \times \text{Charge}$$

$$\text{Work} = E\,q$$

$$\text{Joule} = (\text{volts})(\text{Coulombs})$$

Free Energy :-

The free energy change, ΔG, for a chemical reaction conducted reversibly at constant temperature and pressure equals the maximum possible electrical work that can be done by the reaction on its surroundings.

$$\text{work done on surroundings} = -\Delta G$$

$$\therefore \Delta G = -\text{work} = -E.q$$

Relation between free energy difference and electric potential difference:

$$\boxed{\Delta G = -nFE}$$

$\Delta G = \Delta H - T\Delta S$,

if $\Delta G > 0$, reaction is disfavored.

$\Delta G < 0$, reaction is favored.

Ohm's law:

current, I, is directly proportional to the potential difference (voltage) and inversely proportional to the resistance, R, of the circuit.

∴ E or V

$$\text{Ohm's law:} \quad I = \frac{E}{R}$$

Units of resistance are ohms, assigned the Greek symbol Ω (omega).

$$E = IR$$

$$\boxed{V = A\Omega}$$

Power:

Power P, is the work done ~~by~~ per unit time. The SI unit of power is J/s, better known as the watt (W).

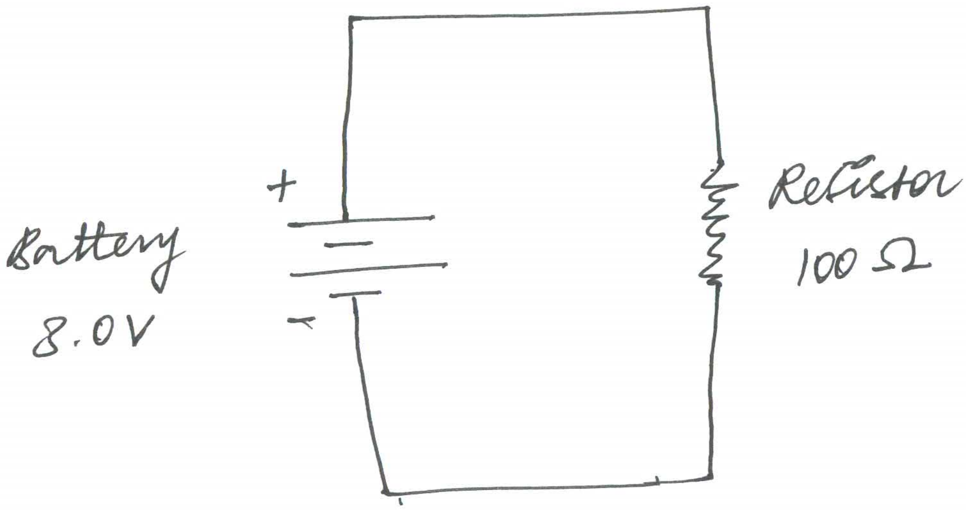
$$\text{Power} = \frac{\text{work}}{\text{Unit time}} = \frac{E \cdot q}{s} = E \cdot \frac{q}{s}$$

$$\boxed{\therefore \; P = EI}$$

$\frac{q}{s}$ is the current I

Example:

Using Ohm's law:



(i) $E = IR$

$$I = \frac{E}{R}$$

$$= \frac{3.0\,V}{100\,\Omega} = 0.030\,A = 30\,mA.$$

$$\boxed{\therefore I = 30\,mA}$$

(ii) $P = EI$

$$= 3.0\,V \times 0.030\,A$$

$$= 0.090\,W$$

$$= 90\,mW$$

$$\boxed{\therefore P = 90\,mv}$$

Summary of Symbols, units, and Relationship from the section 14-1:

① Relation between charge and moles:

$$q = n \cdot F$$

Charge (coulombs, C)   moles   C/mol

② Relation between work and voltage:

$$\text{work} = E \cdot q$$

Joules, J   volts V   coulombs.

③ Relation between free energy difference and electric potential difference:

$$\Delta G = -nFE$$

Joules.

④ Ohm's law:

$$I = E / R$$

Current A   volts V   Resistance ohms, Ω

(5) Electric power:

$$P = \frac{\text{work}}{s} = E \cdot I$$

power (watts, W)　　J/s　　Volts . Amperes.