ELECTROCHEMICAL CELLS

These are devices used for changing chemical energy into electrical energy.

There are two types of cells namely:

1. Primary cells: These are cells whose reactions (through which electric current is generated) are irreversible. They cannot be recharged after they have been used. They have high resistances and hence generate low currents. They are affected by local action and polarisation. Examples include Leclanche cell (also called dry cell) and the Daniel cell

2. Secondary cells: These are also called accumulators. They are the opposite of primary cells.

An electrochemical cell consists of two electrodes of which each has its own electrolyte. The two electrodes are connected by a salt bridge or a porous partition.

One electrode with its electrolyte is called a half-cell. The electrode is an element (mostly metals although it may me non-metals) and the electrolyte is a salt of the element. The element is said to be in contact with its own ions.

A half-cell can be represented as

An electrode has a quantitative property called the electrode potential.

Electrode potential is a measure in volts of the tendency of an atom of an element of the electrode to undergo oxidation and reduction.

of an electrode have the same value but different signs (one is negative while the other is positive).

When all the concentrations of aqueous solutions are 1moldm-3, all gases taking part in the reactions are at 1atm and the temperature is 25⁰C (Room temp), the electrode potential is called the standard electrode potential.

The standard hydrogen electrode was assigned a standard electrode potential of 0.000Volts

The standard electrode potentials of other elements can be determined using the standard hydrogen electrode as a reference.

The standard electrode potential of an element is the potential difference set up between a standard hydrogen electrode and a half-cell.

It is called the electromotive force (emf) when a standard hydrogen electrode is coupled to the electrode of the element.

NB:

1. Is represented as
2. is represented as

E.g.

Is represented as

When calculating the emf of a cell,

i. Write the anodic reaction (Oxidation)

ii. Write the cathode reaction (Reduction)

iii. Make electrons gain equal to electrons lost.

iv. Add the two electrode potentials i.e.

If the emf of a cell (after calculation) is positive, then the reaction is spontaneous and the Gibb’s free energy is negative.

If the emf is negative, the reaction will not take place.

The table below shows the standard potentials of elements.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Element | Half-cell reaction (Reduction) | Half-cell reaction (Oxidation) | Standard reduction potential | Standard oxidation potential | Reducing ability | Oxidising ability |
| K |  |  | -2.93 |  | Highest reducing ability (but can be easily oxidised) | Lowest oxidising ability |
| Na |  |  | -2.87 |  |  |  |
| Ca |  |  | -2.71 |  |  |  |
| Mg |  |  | -2.37 |  |  |  |
| Al |  |  | -1.67 |  |  |  |
| Zn |  |  | -0.76 |  |  |  |
| Fe |  |  | -0.44 |  |  |  |
| Sn |  |  | -0.14 |  |  |  |
| Pb |  |  | -0.13 |  |  |  |
| H |  |  | 0.00 |  |  |  |
| Cu |  |  | 0.34 |  |  |  |
| Hg |  |  | 0.79  0.85 |  |  |  |
| Ag |  |  | 0.80 |  |  |  |
| Au |  |  | 1.5 |  |  |  |
| OH |  |  | Not an element |  |  |  |
| I |  |  | 0.54 |  |  |  |
| Br |  |  | 1.09 |  |  |  |
| Cl |  |  | 1.36 |  |  |  |
| NO |  |  | Not an element |  |  |  |
| SO |  |  | Not an element |  |  |  |
| F |  |  | 2.87 |  | Lowest reducing ability | Highest oxidising ability |
|  |  |  |  |  |  |  |

DEFECTS OF PRIMARY CELLS

1. Local action: This is caused by the presence of impurities on the zinc plate electrode. The impurities on the electrode prevent the free flow of current. Local action can be prevented by Amalgamation. Amalgamation is the process of coating the zinc electrode with mercury. Local action can also be prevented by using a pure zinc electrode (which can be gotten from electrolytic process).

2. Polarization: This is defined as the process whereby hydrogen bubbles produced at the zinc electrode prevent free flow of current. The hydrogen bubbles also increase the resistance of the electrode. The bubbles produce what is known as Hydrogen Electrode. These bubbles also create a back emf.

Polarization can be prevented using chemical substances called Depolarizers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cell Name | Anode | Cathode | Electrolyte | Depolarizer | EMF value |
| Leclanche cell | Carbon (C) | Zinc (Zn) | Ammonium Chloride | Manganese (IV) oxide |  |
| Daniel Cell | Copper (Cu) | Zinc (Zn) | Tetraoxosulfate (VI) acid |  |  |
| Lead-acid accumulator | Lead oxide | Lead (Pb) |  | None |  |
| Alkaline accumulator | Nickel Hydroxide | Cadmium (Cd) or Iron (Fe) | Potassium Hydroxide | None |  |

DIFFERENCE BETWEEN THE ELECTROLYTIC CELL AND THE ELECTROCHEMICAL CELL

|  |  |
| --- | --- |
| Electrolytic cell | Electrochemical cell |
| Converts electrical energy to chemical energy | Converts chemical energy to electrical energy |
| Electrons are pushed by an outside force such as a battery | Electrons are generated by oxidation at the electrode (anode) |
| Cathode is negative electrode | Cathode is the positive electrode |
| Anode is the positive electrode | Anode is the negative electrode |
| Electrodes are in the same compartment | Electrodes are in separate compartments |
| Salt bridge is not needed | Salt bridge is needed |
| Only one electrolyte is used | Two electrolytes are used |
|  |  |
|  |  |
|  |  |

ARRANGEMENT OF CELLS

Series Arrangement: Cells are arranged in series in order to increase their effective emf

The reason it is plus or minus is because, some times if two terminals of the same sign are put together, there will be a minus

Cells are connected posive negative to positive negative to positive negative. However, if there is an error in connection and one gets connected negative to negative, there will be a loss of emf.

The effective internal resistance of the combined cells in series is expressed

Parallel Arrangement: Cells are arranged in parallel in order to reduce their effective internal resistance and hence increasing the amount of current

The effective emf of all the cells have is value in a parallel arrangement in the circuit.

EMF: The electromotive force of a circuit or cell is the work done in moving a unit charge round the entire circuit. It is also defined as the voltage across on an open circuit (i.e. when it is not delivering any current).

The emf can also be defined as the work done per unit charge.

It is seen above that the formula from electric fields has been repeated

So it can be understood that the electric potential (V) is actually a potential difference (E)

The emf of a cell is mathematically the sum of the terminal voltage (V) and the lost volt (L)

If there is no energy loss in the circuit

The lost volt equals zero

Therefore, for an ideal circuit,

EFFICIENCY OF A CELL

This is defined as the (percentage) ratio of the power output to the power input

The maximum power is transferred by the battery when load resistance (R) is equal to the internal resistance (r) of the battery.

However, the efficiency at that point will only be 50%.