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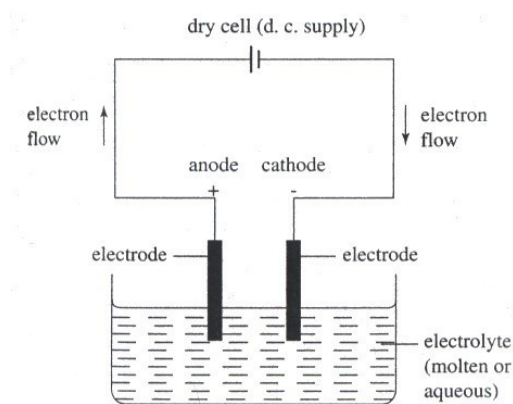
Class: 4CYA

Electricity and Chemistry

Introduction

- We have learnt that ionic compounds conduct electricity only when molten or aqueous.
- When an electric current passes through such compounds, they become decomposed in a chemical reaction.
- The process of decomposing a compound into its constituent elements by electricity is known as _____.

Electrolytic Cell



- A simple electrolytic cell is made up of :
 - a cell or battery
 - two electrodes
 - an electrolyte
 - other electrical devices ~ bulb, switch, resistor, voltmeter, ammeter.

Electrodes

- The plates which carry the electricity into the electrolyte are called electrodes.
- They are usually made of inert materials such as carbon (graphite), platinum and mercury.
- The electrode connected to the
 - negative terminal of the battery is called the _____.
 - positive terminal of the battery is called the _____.
- The electrodes are also the terminals through which electrons enter and leaves the electrolyte.
- Electrons enter via the _____ and leave via the _____.

Electrolyte

- An electrolyte is a compound which conducts an electric current when molten or dissolved in water, and is decomposed by the electric current.
- Electrolytes are usually :
 - (i) _____
 - (ii) _____
- Example:

Weak Electrolytes - Weak acids and alkalis	Strong Electrolytes - Strong acids, alkalis and salt solution

- Non- electrolytes are the _____ that do not contain ions .

Why Can't Solid Ionic Compounds Conduct Electricity?

The ions in solid ionic compounds are held in fixed positions in a lattice. They are unable to move to conduct electricity.

Elements and Compounds Conduct Electricity Differently

Element - By mobile electrons and element remains unchanged as electricity passes

Compound - By mobile ions and Decomposes and forms new substances

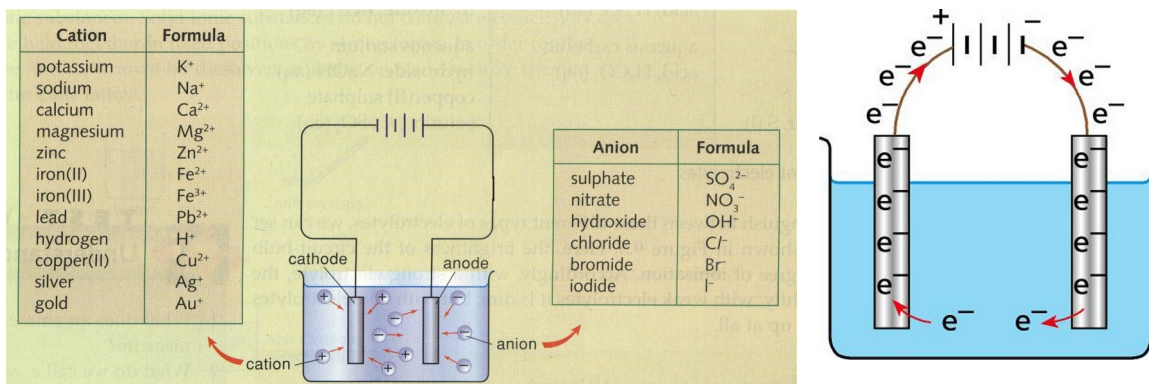
Electrolysis

- When electricity is passed through an electrolyte, chemical decomposition occurs.
- This involves the splitting up of the electrolyte into positive and negative ions.
 - Positive ions are called _____.
 - Negative ions are called _____.
- During electrolysis, the _____ are attracted to the _____ while _____ are attracted to the _____.

anions → anode

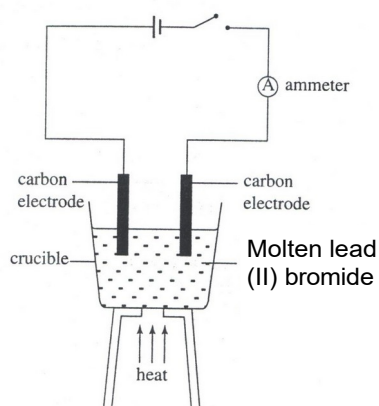
cations → cathode

During electrolysis, electrons flow from the negative terminal to the positive terminal of the battery.



- On reaching the respective electrodes, these ions are _____.
- The process of gaining or losing electrons at the electrodes is called discharge.
- i.e. they lose their charges and form neutral atoms or molecules.
 - At the anode, anions are discharged by _____ (oxidation).
 - At the cathode, cations are discharged by _____ (reduction).

Example 1: Molten lead (II) bromide



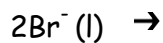
Electrolyte:

Electrodes:

 Ions produced: (cations)
(anions)

At the anode (positive electrode):

- _____ migrate to the anode and are discharged.
- Each bromide ion loses one electron and is _____.



- _____ is produced.

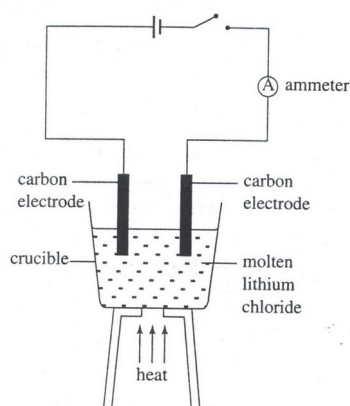
At the cathode (negative electrode):

- _____ migrate to the cathode and are discharged.
- Each lead (II) ion gains two electrons and is _____.



- _____ are deposited.

Example 2: Molten lithium chloride



Electrolyte:

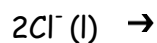
Electrodes:

Ions produced: (cations)

(anions)

At the anode:

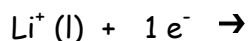
- _____ migrate to the anode and are discharged.
- each chloride ion loses one electron and is _____.



- _____ is produced.

At the cathode:

- _____ migrate to the cathode and are discharged.
- each lithium ion gains one electrons and is _____.



- _____ are deposited.

Exercise: Complete the table below.

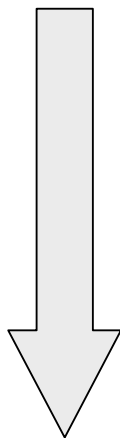
Molten electrolyte	Product at cathode	Product at anode
Calcium chloride, CaCl_2		
Sodium iodide, NaI		
Magnesium oxide, MgO		
Lead (II) oxide, PbO		

Electrolysis of Aqueous Electrolytes

- Aqueous electrolytes are mixtures of two electrolytes - the compound itself and water.
- During electrolysis, water will ionise to produce _____ and _____.
- With the presence of more than one type of anions and cations, we must now determine what ions will be discharged.
- There are 3 things we need to consider:
 - _____
 - _____
 - _____

The electrochemical series

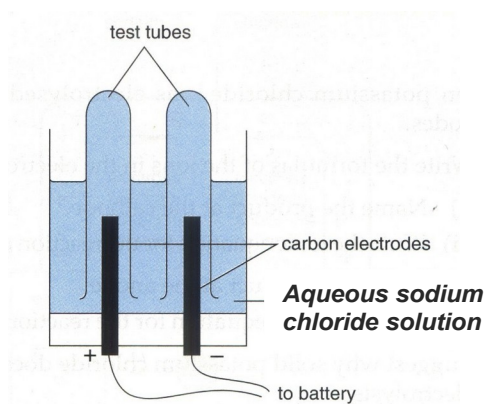
anions	cations
$K^+ (aq)$	$F^- (aq)$
$Na^+ (aq)$	$SO_4^{2-} (aq)$
$Ca^{2+} (aq)$	$NO_3^- (aq)$
$Mg^{2+} (aq)$	$Cl^- (aq)$
$Zn^{2+} (aq)$	$Br^- (aq)$
$Fe^{2+} (aq)$	$I^- (aq)$
$Pb^{2+} (aq)$	$OH^- (aq)$
$H^+ (aq)$	
$Cu^{2+} (aq)$	



Ion lowest in the series will be discharged first if present.

The electrolytic cell used for electrolysis of aqueous electrolyte is shown below.

- Any gases produced in the process can be collected in the test-tubes and then identified by simple tests.

Example 1: Aqueous sodium chloride solution

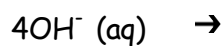
Electrolyte:

Electrodes:

 Ions produced: (cations)
(anions)

At the anode:

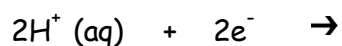
- _____ migrate to the anode and are discharged.
- each hydroxyl ion loses one electron and is _____.



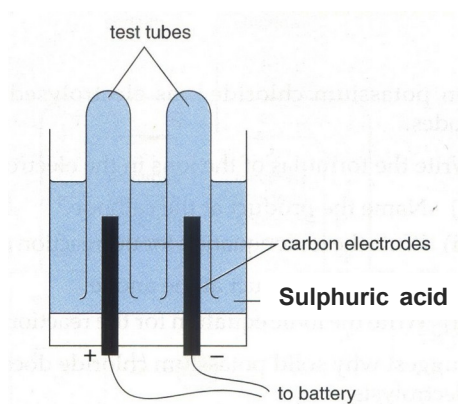
- _____ are liberated.

At the cathode:

- _____ migrate to the cathode and are discharged.
- each hydrogen ion gains one electrons and is _____.



- _____ is produced
(hydrogen gas burns with a pop sound).

Example 2: Aqueous sulphuric acid, H_2SO_4 

Electrolyte:

Electrodes:

 Ions produced: (cations)
 (anions)

At the anode:

- _____ migrate to the anode and are discharged.
 - each hydroxyl ion loses one electron and is _____.
- $$4\text{OH}^- (\text{aq}) \rightarrow$$
- _____ are liberated.

At the cathode:

- _____ migrate to the cathode and are discharged.
 - each hydrogen ion gains one electrons and is _____.
- $$2\text{H}^+ (\text{aq}) + 2\text{e}^- \rightarrow$$
- _____ is produced.

Exercise: Name the ions in the solution and the products formed at the cathode and anode when the following compounds are electrolysed:

Electrolyte	Ions in solution	Product at cathode	Product at anode
Aq. copper (II) sulphate solution CuSO_4			
Aq. nitric acid, HNO_3			
Aq. sodium hydroxide, NaOH			

How the concentration of ions affect the choice of ions to be discharged.

Very often, ion present in _____ tends to crowd out other ions and _____.

Example 1: Electrolysis of concentrated hydrochloride acid, HCl.

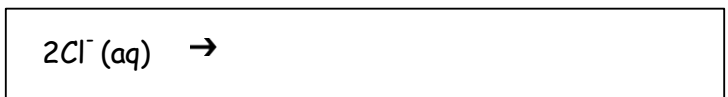
What do you think are the ions produced when the electrolyte decompose ?

Cation: _____

Anion: _____

At the anode:

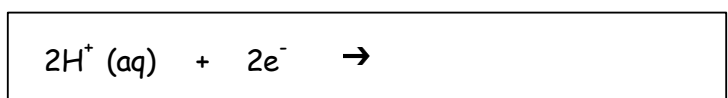
- _____ migrate to the anode and are discharged.
- each chloride ion loses one electron and is _____.



- _____ is liberated.

At the cathode:

- _____ migrate to the cathode and are discharged.
- each hydrogen ion gains one electrons and is _____.



- _____ is produced.

Note

Some ions are not discharge even though they are present at high concentration.

They include: _____

How the type of electrode used affect the choice of ions discharged ?

If the electrode used is not inert, it will take part in the electrolysis reaction.

For example, electrode made of _____ will dissolve in the process.

Remember that electrolysis reaction always begins at the _____.

Therefore if we use an active electrode, we find that the anode will dissolve into the solution.

Comparison

Electrolysis of aq. copper (II) sulphate, CuSO_4 with

	carbon electrode	copper electrode
Anion produced		
Cation produced		

Exercise

Name the ions in the solution and the products formed at the cathode and anode when silver nitrate solution (AgNO_3) is electrolysed

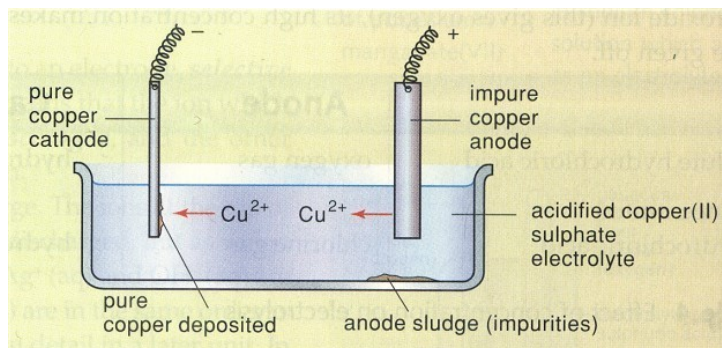
Electrode	Ions in solution	Product at cathode	Product at anode
Carbon			
Silver			

Industrial Applications of Electrolysis

1. Manufacturing of _____

2. _____: to refine or purify metals.

An example is the refining of copper.



- When electricity flows, the copper will dissolve from the impure anode and goes into the solution as copper ions.
- Impurities in the anode do not dissolve and simply fall off the anode as an anode sludge.
- At the pure copper cathode, the copper ions will be deposited as pure metal.

3. _____: forming a thin protective coating of a metal on the surface of another which is likely to corrode.

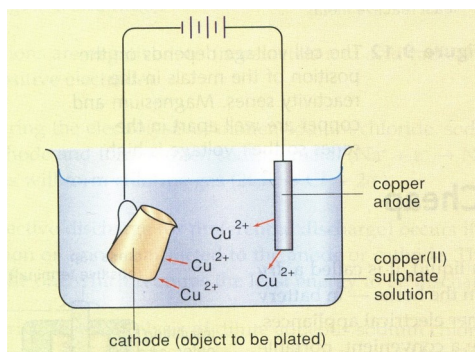
For example, iron can be electroplated with a layer of zinc to prevent rusting.

Electroplating	
metal	object
zinc (galvanise)	dustbins, buckets
chromium	car bumpers, bicycle handle bars
silver	watches, bracelets
copper	saucepans
nickel (EPNS)	cutlery (electroplated nickel steel)
gold	jewellery, watches

Why electroplating ?

- carried out to _____
- to improve _____

The diagram below shows the process in general



Here the copper anode will dissolve.

To electroplate

- the object to be plated is made the _____
- the metal used for coating is made the _____
- the electrolyte is to contain the salt of the anode
e.g. if the anode is copper, the electrolyte will be copper (II) sulphate solution, CuSO_4 .
- the ions produced will be _____

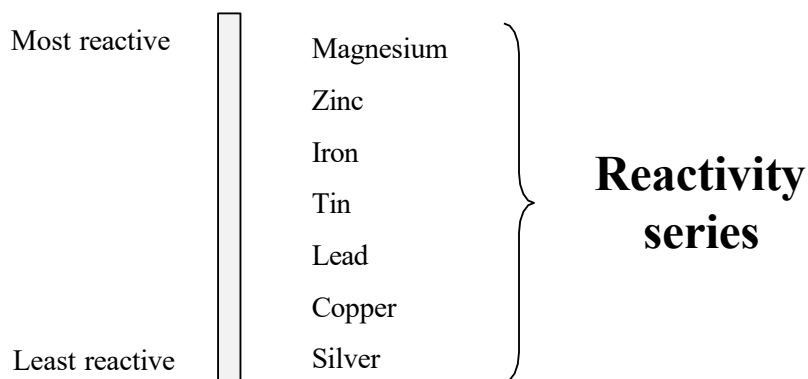
4. _____ from their ores using electrolysis.

An example is the _____.

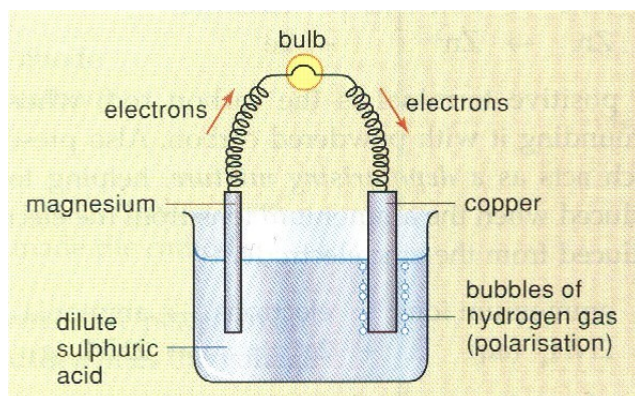
5. Electric cells: a device which converts chemical energy into electrical energy

- Basically the _____ of electrons during electrolysis generate electricity.
- A simple cell will consist of _____ (different metals) and an electrolyte solution (acid or salt solution)
- Of the two metals,
 - the _____ metal become the anode and undergo oxidation
 - the _____ metal become the cathode
- The voltage produced will depend on _____ of the two metals in the reactivity series.

- The _____, the larger the voltage produced.



Example



- Magnesium being more reactive will be the negative
- Mg will dissolve in the electrolyte producing magnesium ion, Mg^{2+} and releasing electrons.
- The reaction can be written

$$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^{-}$$
- The electrons released will then move to the copper electrode and produce hydrogen gas.
- As electrons are taken in at the copper, we call it the positive
- The reaction can be written

$$2H^{+}(aq) + 2e^{-} \rightarrow H_2(s)$$