



Cambridge IGCSE Chemistry

Topic 5: Electricity and chemistry

Notes



Define electrolysis as...

- The breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity

Describe the electrode products and the observations made during the electrolysis of: molten lead(II) bromide, concentrated hydrochloric acid, concentrated aqueous sodium chloride, dilute sulfuric acid between inert electrodes (platinum or carbon)

- When you have a ionic solution (NOT a molten ionic compound), your solution
- will contain: the ions that make up the ionic compound, and the ions in water
- (OH^- and H^+)
- at the cathode (-):
 - hydrogen (from H^+ in water) is produced UNLESS the + ions in the ionic compound are from a metal less reactive than hydrogen
 - if the metal is less reactive, it will be produced instead
- at the anode (+):
 - oxygen (from OH^- in water) will be produced UNLESS the ionic compound contains halide ions (Cl^- , Br^- , I^-)
 - if there are halide ions, the halogen will be produced instead (e.g. Cl_2)
- Electrolysis of:
 - Molten lead (II) bromide
 - Pb^{2+} to cathode, Pb (s) is produced (not in solution so these are the only + ions present)
 - Br^- to anode, Br_2 (l) is produced (not in solution so these are the only - ions present)
 - Concentrated hydrochloric acid
 - H^+ ions go to cathode, H_2 (g) is produced (H^+ is present in both water and HCl)
 - Cl^- ions go to anode, Cl_2 (g) is produced (Cl^- are halide ions)
 - Sodium chloride solution
 - H^+ ions go to cathode, H_2 (g) is produced (Na is more reactive than hydrogen)
 - Cl^- ions go to anode, Cl_2 (g) is produced (Cl^- are halide ions)
 - Dilute sulfuric acid
 - H^+ to cathode, H_2 (g) is produced (these are the other ions present in sulfuric acid H_2SO_4)
 - OH^- to anode, O_2 (g) is produced (SO_4^{2-} ions are not halide ions)





(Extended only) Relate the products of electrolysis to the electrolyte and electrodes used, exemplified by the specific examples in the Core together with aqueous copper(II) sulfate using carbon electrodes and using copper electrodes (as used in the refining of copper)

- Electrolysis of copper (II) sulfate solution
 - Cu^+ ions go to cathode, Cu (s) is produced (Cu is less reactive than hydrogen)
 - OH^- ions go to anode, O_2 (g) is produced (SO_4^{2-} ions are not halide ions)

Copper electrodes:

- set up:
 - anode is made of impure copper (that you are purifying)
 - cathode is made of pure copper
 - the solution is copper sulfate
- what happens:
 - Cu^{2+} ions from the anode move to the cathode, where they gain electrons and are discharged as pure copper
 - impurities form as sludge below the anode
- the cathode will increase in mass as it gains pure copper, whilst the anode will lose mass as copper ions are lost (they replace the ones from the CuSO_4 solution that go to the cathode) and so are impurities

Carbon electrodes :

- at the cathode Cu (s) is produced (Cu is less reactive than hydrogen)
- at the anode O_2 is produced (SO_4^{2-} ions are not halide ions)
- this leaves H^+ and SO_4^{2-} ions in the solution, which will react to form H_2SO_4 - sulfuric acid

(Extended only) Describe electrolysis in terms of the ions present and reactions at the electrodes in the examples given

- During electrolysis, positively charged ions (cations) move to the negative electrode (cathode), and negatively charged ions (anions) move to the positive electrode (anode).
- Ions are discharged at the electrodes producing elements.





State the general principle that...

- Metals or hydrogen are formed at the negative electrode (cathode), and that non-metals (other than hydrogen) are formed at the positive electrode (anode)

Predict the products of the electrolysis of a specified binary compound in the molten state

- if ionic compounds are molten it is much more simple to predict the products of electrolysis as there are no ions present except those in the ionic compound:
 - identify which ions there are within the ionic compound
 - the + ions will go to the cathode
 - the - ions will go to the anode

(Extended only) Predict the products of electrolysis of a specified halide in dilute or concentrated aqueous solution

- Halide ions are negative ions e.g. Cl^- , Br^- , I^- etc...
 - Therefore, they go to the positive electrode (anode) and the product will be either Cl_2 or Br_2 or I_2 dependent on which halide ions are in the solution

Describe the electroplating of metals

- electroplating is a method of coating objects with a metal, using electrolysis
- Negative electrode = object to be electroplated
- Positive electrode = metal to coat the object with
- Electrolyte = solution of the coating metal (with ions of the coating metal in)
- the metal ions from solution are deposited on the negative electrode, and metal ions are released from the positive electrode to replace those lost in solution

Outline the uses of electroplating

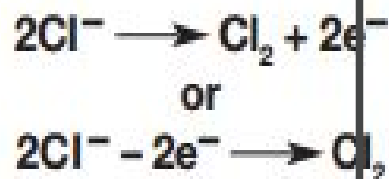
- Coating a cheaper metal with a more expensive one e.g. silver or copper
- Silver
 - E.g. Cutlery
- Copper
 - E.g. Metal pan





(Extended only) Construct ionic half-equations for reactions at the cathode

- This is an example of a half equation; the small number is always the same as the 2 larger numbers within the equation. & electrons are represented by the symbol 'e⁻'



- writing half equations for the reactions at each electrode:
 - negative electrode: $\text{X}^+ \rightarrow \text{X}$, so ionic equation must be:
 $\text{X}^+ + \text{e}^- \rightarrow \text{X}$, electrons gained, so positive ions are reduced
 - positive electrode: $\text{X}^- \rightarrow \text{X}$, so ionic equation must be:
 $\text{X}^- \rightarrow \text{e}^- + \text{X}$, electrons are lost, so negative ions are oxidised
- Oxidation Is Loss (of electrons) and Reduction Is Gain (of electrons) - OIL RIG
- ANODE – loss of electrons, oxidation (positive electrode) anions come to it
- CATHODE – gain of electrons, reduction (negative electrode) cations come to it

Describe the reasons for the use of copper and (steel-cored) aluminium in cables, and why plastics and ceramics are used as insulators

- Aluminium – good conductor of electricity, therefore is used in overhead power cables
- Copper – good conductor of electricity, therefore is used for electrical wiring
- Plastics & ceramics do not conduct electricity – therefore they are used as insulators

(Extended only) Describe the transfer of charge during electrolysis to include: the movement of electrons in the metallic conductor, the removal or addition of electrons from the external circuit at the electrodes, the movement of ions in the electrolyte

- Movement of electrons in the metallic conductor
 - Electrons move in the wire
 - Move from positive electrode to negative electrode
- Movement of ions in the electrolyte
 - Positive ions move to negative electrode to receive electrons and are reduced
 - Negative ions move to positive electrode to lose electrons and are oxidised



(Extended only) Describe the production of electrical energy from simple cells, i.e. two electrodes in an electrolyte (this should be linked with the reactivity series)

- This is a very similar set up to electrolysis, but isn't the same
- you have 2 metal electrodes in an electrolyte solution and connect the 2 electrodes by a wire (outside of the solution), this creates a current of electrons and so creates electrical energy
- More reactive metal will lose electrons, least reactive will gain them

(Extended only) Describe, in outline, the manufacture of: aluminium from pure aluminium oxide in molten cryolite, chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride (starting materials and essential conditions should be given but not technical details or diagrams)

- Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite using carbon as the positive electrode (anode).
 - o Aluminium oxide has a very high melting point, so it would be too expensive to melt it, which is why it is mixed with cryolite
 - o the positive electrodes need to be continually replaced because oxygen is formed, which reacts with the carbon of the positive electrodes, forming carbon dioxide, and they gradually burn away
- Sodium chloride
 - o Chlorine gas forms at the positive electrode
 - o Hydrogen gas forms at the negative electrode
 - o Solution of sodium hydroxide forms
 - o Must use inert electrodes since the products are reactive

