CHAPTER 4 CHEMICAL REACTIONS

EXERCISE 4.1: Key Chemical Reactions

a

burning → water

water → rusting

respiration → carbon dioxide

b

oxidation

c

- oxidised
- loses

d

i. CuO → reduction → Cu
H_2 → oxidation → H_2O

ii. Reducing agent

e

i.

- loss
- gain

ii. Cu^{2+} (aq) → reduction → Cu (s)
Zn (s) → oxidation → Zn^{2+} (aq)

iii. Cu(II) ions → oxidising agents

EXERCISE 4.2: The action of heat on metal carbonates

a

thermal decomposition

b

Gas produced: Carbon dioxide

Test: Bubble the gas through limewater.

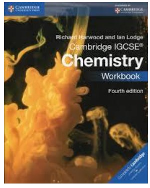
Result: Carbon dioxide turns limewater milky.

c

Metal	Name of Metal
A	Copper
B	Magnesium
C	Calcium
D	Sodium
E	Zinc

d

Zinc carbonate → Zinc oxide + carbon dioxide



EXERCISE 4.3: The nature of Electrolysis

a

During electrolysis ionic compounds are decomposed by the passage of an electric current. For this to happen, the compound must be either **molten** or in **solution**.
Electrolysis can occur when an electric **current** passes through a molten **electrolyte**.
'The two rods dipping into the electrolyte are called the **electrodes**.
In this situation, metals are deposited at the **cathode** and non-metals are formed at the **anode**.
When the ionic compound is dissolved in water, the electrolysis can be more complex. Generally, during electrolysis **positive** ions move towards the **cathode** and negative ions move towards the **anode**.
At the negative electrode (cathode) the metal or **hydrogen** ions gain electrons and form metal atoms or hydrogen **gas**.
At the positive electrode (anode) certain non-metal ions lose electrons and **oxygen** or chlorine is produced.

b

There are several important industrial applications of electrolysis, the most important economically being the electrolysis of **molten** aluminium oxide to produce aluminium. The aluminium oxide is mixed with molten **cryolite** to **lower** the melting point of the electrolyte.
A **concentrated** aqueous solution of sodium chloride contains **sodium**, chloride, hydrogen and **hydroxide** ions. When this solution is electrolysed, **hydrogen** rather than sodium is discharged at the negative electrode. The solution remaining is sodium hydroxide.
When a solution of copper(II) sulfate is electrolysed using **copper** electrodes, an unusual thing happens and the copper atoms of the **copper** electrode (anode) go into solution as copper ions. At the cathode the copper ions turn into copper atoms, and the metal is deposited on this electrode. This can be used as a method of refining or **purifying** impure copper.

EXERCISE 4.4: Displacement reactions of the halogens

a

Aqueous Halide solution	Aqueous Halogen solution	Change
Potassium chloride	Bromine	No reaction
Potassium chloride	Iodine	No reaction
Potassium bromide	Chlorine	Solution changes from colourless to brown, upper hexane layer turns brown
Potassium bromide	Iodine	No reaction
Potassium iodide	Chlorine	Solution changes from colourless to brown, upper hexane layer turns purple
Potassium iodide	Bromine	Solution changes from colourless to brown upper hexane layer turns purple

b

order of increasing reactivity:

Iodine → Bromine → Chlorine

EXERCISE 4.5: Self-heating cans, hand warmers and cool packs

a

exothermic

b

Expansion of the solid exerts pressure on the walls of the inner chamber of the can. This may cause the inner chamber to burst open resulting in mixing of the chemicals with the beverage.

c

Steam releasing valves may be used in the inner chamber to prevent build-up of excessive pressure.

d

Calcium oxide + Water → Calcium hydroxide

$CaO + H_2O \rightarrow Ca(OH)_2$

e

Limestone is heated in a lime kiln at a very high temperature.
It undergoes thermal decomposition to form Calcium oxide and carbon dioxide gas.
$CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$

f

$CuSO_4(s) + Zn(s) \rightarrow ZnSO_4(s) + Cu(s)$

Heat pads and hand warmers

a

Oxygen

b

Fe_2O_3

c

$4Fe + 3O_2 + 2xH_2O \rightarrow 2Fe_2O_3.xH_2O$

d

Salt speeds up the process of rusting.

e

i.
supersaturated

ii.
The salt can be dissolved again in the solution by shaking the warmer.

iii.
No.
Rusting is an irreversible change.

Cool packs

a

Ammonium nitrate is used as a fertiliser.

b

Advantage: no prior cooling required, portable

Disadvantage: cannot be reused

c

Use a 250 cm^3 measuring cylinder to add 200 cm^3 of water to a 500 cm^3 polystyrene beaker.
Suspend a thermometer in the water from a rigid stand.
Record the initial temperature of water.
Weigh 100 g of solid Ammonium nitrate in a beaker using an electronic balance.
Transfer Ammonium nitrate to the water using a spatula with constant stirring (using a glass rod).
Record the change in temperature after each transfer.
Stop the addition of Ammonium nitrate as soon as the temperature drops to 5°C.
Weigh the Ammonium nitrate remaining in the beaker and subtract the mass of Ammonium nitrate left from 100 g to calculate the mass of Ammonium nitrate added to 200 cm^3 of water to produce a temperature of 5°C.

Exercise 4.6: The movement of ions

a

Chromate

*Potassium ions are colourless.
Copper (II) ions are blue.

b

Chromate ions are yellow.
They are negatively charged, hence are attracted to the positive terminal (unlike charges attract).

c

Anions:
Sulfate SO_4^{2-}

Chromate CrO_4^{2-}

Cations:
Copper Cu^{2+}

Potassium K^+

d

Changes seen on the filter paper if the experiment is repeated with Copper chromate:

Yellow colour moves towards positive terminal as Chromate ions are yellow and negatively charged.

Blue colour moves towards negative terminal as Copper ions are blue and positively charged.

Exercise 4.7: Making and breaking Copper chloride

a

Ductile (drawn out)

Malleable (beaten into thin sheets)

b

Pale green / yellow-green

c

Chlorine gas is toxic / poisonous.

d

The reaction is exothermic (gives out heat energy) as indicated by the flash of flame that is observed.

The Dutch metal is used in the form of very thin sheets.
This feature increases the surface area for reaction resulting in a higher collision rate (hence faster reaction).

e

Formation of a pale blue-green solution (as Copper chloride is blue-green in colour)

f

$Cu\ (s) + Cl_2\ (g) \rightarrow CuCl_2\ (aq)$

g

Zinc chloride

Decomposing Copper (II) chloride

a

Copper(II) chloride → Copper + Chlorine

$CuCl_2 \rightarrow Cu + Cl_2$

b

Electrolysis is the breakdown of an ionic compound, molten or in aqueous solution, by the passage of electricity.

c

The gas can be tested using damp Litmus paper.
If the gas is Chlorine, the damp litmus paper will get bleached.

d

i.

The electrolysis must be carried out in a fume chamber as toxic Chlorine gas will be produced.

ii.

Damp litmus papers can be attached to the carbon anode closer to the electrolyte interface (above the electrolyte level).
As Chlorine gas is evolved, it will pass over the damp litmus and bleach it.

e

The decomposition of Copper(II) chloride is endothermic (heat energy is taken in).
The reaction involves the conversion of electrical energy to chemical energy.

f

At the anode:
$2Cl^- \rightarrow Cl_2 + 2e^-$

At the cathode:
$Cu^{2+} + 2e^- \rightarrow Cu$