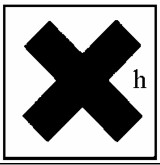
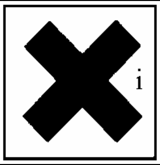
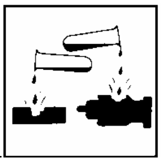
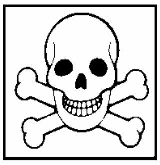
GCSE Science (Modular) - Module 7 Revision Guide (Chemistry)

Foundation Tier

You should be able to **recognise** and **draw** diagrams of simple chemical apparatus. You should be able to recognise, and explain the meaning of, these hazard symbols and give an example of each type of substance:

	**Oxidising** These provide oxygen which allows other materials to burn more fiercely.		**Harmful** These are similar to toxic substances but less dangerous.		**Irritant** These are not corrosive but can cause reddening or blistering of the skin.
	**Highly flammable** These easily catch fire.		**Corrosive** These attack and destroy living tissues, including eyes and skin.		**Toxic** These can cause death when swallowed, breathed in or absorbed through the skin.

How can we speed up, or slow down, chemical reactions?

The rate of a chemical reaction can be followed by measuring the rate at which the **products are formed**, or the rate at which the **reactants are used up**. This allows the changing rate of a chemical reaction under different conditions to be studied. You should be able to interpret graphs showing the amount of product formed (or reactant used up) against time. Chemical reactions can only occur when reacting particles **collide** with each other and with **sufficient energy**. The minimum amount of energy particles must have to react is the **activation energy**. Increasing the rates of chemical reactions is important in industry because it helps to reduce costs. The speed (rate) of a chemical reaction increases:

- If the temperature increases, the speed of the reacting particles increases so that they collide more frequently and with more energy. This increases the rate of reaction.
- If the concentration of dissolved reactants or the pressure of gases increases, the frequency of collisions increases, and so increases the rate of reaction.
- If solid reactants are in smaller pieces (greater surface area), more of the solid reactant particles come into contact with the other reactants.
- If a catalyst is used. A catalyst increases the rate of a reaction but it is not used up during the reaction. It is used over and over again. Different reactions need different catalysts.

How can we use living things to do our chemistry for us?

Living things produce catalysts called **enzymes**. These allow chemical reactions to occur quite quickly at ordinary temperatures and pressures. The chemical reactions in living cells are quite fast in conditions that are warm rather than hot. This is because enzymes are protein molecules which are usually damaged by temperatures above about 45ºC. Different enzymes work best at different pH values.

Enzymes are widely used in the food industry. For example, bacteria are used to produce yoghurt from milk. They convert the sugar in milk (lactose) to lactic acid. Yeast cells convert sugar into carbon dioxide and alcohol. This process is called fermentation and is used:

- to produce the alcohol in beer and wine;
- to produce the bubbles of carbon dioxide which make bread dough rise (a simple laboratory test for carbon dioxide is that it turns lime-water milky).

"Biological detergents" contain proteases, which digest proteins, and lipases, which digest fat.
Enzymes are used in industry to bring about reactions at normal temperatures and pressures that would otherwise require expensive, energy demanding equipment. For example:

- proteases are used to “pre-digest” the protein in some baby foods;
- carbohydrases are used to convert starch syrup into sugar syrup;
- isomerase is used to convert glucose syrup into fructose syrup, which is much sweeter and therefore can be used in smaller quantities in slimming foods.

You should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of using microorganisms and enzymes to bring about chemical reactions.

Chemical reactions and energy diagrams

When fuels burn, energy is released as heat. In chemical reactions, energy is usually transferred:

- **exothermic** reactions give out energy, often as heat, **to** the surroundings.
- **endothermic** reactions take in energy, often as heat, **from** the surroundings.

In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called **reversible reactions** and are shown as: $A + B \rightleftharpoons C + D$

For example: ammonium chloride ⇌ ammonia + hydrogen chloride

If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case. For example:

hydrated copper sulphate (blue) $\xrightarrow{\text{heat energy}}$ anhydrous copper sulphate (white) + water

The reverse reaction can be used as a test for water.

How do chemists produce the fertiliser we need to grow food?

Air is almost 80% nitrogen. The nitrogen can be used to manufacture several important chemicals, including nitrogen-based fertilisers. Nitrogen-based fertilisers are important in agriculture for increasing the yields of crops. Nitrates can, however, create problems if they find their way into streams, rivers or groundwater and so contaminate our drinking water. You should be able, when provided with appropriate information, to reach balanced judgements concerning the benefits of using nitrate fertilisers and the contamination of drinking water they can cause.

Ammonia is manufactured in the **Haber process**. The raw materials are nitrogen from the air and hydrogen obtained from natural gas. The purified gases are passed over an iron catalyst at a high temperature (about 450°C) and a high pressure (about 200 atmospheres). Some of the hydrogen and nitrogen reacts to form ammonia. The ammonia cools, liquefies and is removed. The remaining hydrogen and nitrogen is recycled. The reaction is reversible, which means that ammonia also breaks back down into nitrogen and hydrogen:

nitrogen + hydrogen ⇌ ammonia $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The reaction conditions are chosen to produce a reasonable yield of ammonia quickly.

Ammonia can be oxidised to produce **nitric acid**. Ammonia gas reacts with oxygen over a hot platinum catalyst to make nitrogen monoxide. This is cooled and reacted with water and oxygen to form nitric acid.

Ammonium nitrate fertiliser is made by the neutralisation reaction between ammonia and nitric acid.

How do we know how much of each reactant to use in a chemical reaction?

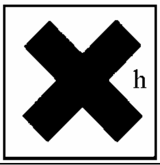
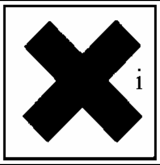
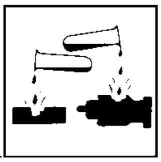
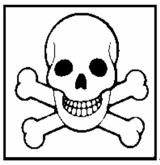
Atoms of different elements have different masses. To be able to work out exactly what is happening in chemical reactions we need to know how the masses of atoms compare with each other, i.e. their relative atomic masses, A_r. The Data Sheet contains A_r values of elements. You should be able to:

- calculate the relative formula mass, M_r of compounds whose formulae are supplied;
- calculate the percentage of an element in a compound whose formula is supplied.

GCSE Science (Modular) - Module 7 Revision Guide (Chemistry)

Higher Tier

You should be able to **recognise** and **draw** diagrams of simple chemical apparatus. You should be able to recognise, and explain the meaning of, these hazard symbols and give an example of each type of substance:

	**Oxidising** These provide oxygen which allows other materials to burn more fiercely.		**Harmful** These are similar to toxic substances but less dangerous.		**Irritant** These are not corrosive but can cause reddening or blistering of the skin.
	**Highly flammable** These easily catch fire.		**Corrosive** These attack and destroy living tissues, including eyes and skin.		**Toxic** These can cause death when swallowed, breathed in or absorbed through the skin.

How can we speed up, or slow down, chemical reactions?

The rate of a chemical reaction can be followed by measuring the rate at which the **products are formed**, or the rate at which the **reactants are used up**. This allows the changing rate of a chemical reaction under different conditions to be studied. You should be able to interpret graphs showing the amount of product formed (or reactant used up) against time. Chemical reactions can only occur when reacting particles **collide** with each other and with **sufficient energy**. The minimum amount of energy particles must have to react is the **activation energy**. Increasing the rates of chemical reactions is important in industry because it helps to reduce costs. The speed (rate) of a chemical reaction increases:

- If the temperature increases, the speed of the reacting particles increases so that they collide more frequently and with more energy. This increases the rate of reaction.
- If the concentration of dissolved reactants or the pressure of gases increases, the frequency of collisions increases, and so increases the rate of reaction.
- If solid reactants are in smaller pieces (greater surface area), more of the solid reactant particles come into contact with the other reactants.
- If a catalyst is used. A catalyst increases the rate of a reaction but it is not used up during the reaction. It is used over and over again. Different reactions need different catalysts.

How can we use living things to do our chemistry for us?

Living things produce catalysts called **enzymes**. These allow chemical reactions to occur quite quickly at ordinary temperatures and pressures. The chemical reactions in living cells are quite fast in conditions that are warm rather than hot. This is because enzymes are protein molecules which are usually damaged by temperatures above about 45ºC. Different enzymes work best at different pH values.

Enzymes are widely used in the food industry. For example, bacteria are used to produce yoghurt from milk. They convert the sugar in milk (lactose) to lactic acid. Yeast cells convert sugar into carbon dioxide and alcohol. This process is called fermentation and is used:

- to produce the alcohol in beer and wine;
- to produce the bubbles of carbon dioxide which make bread dough rise.

A simple laboratory test for carbon dioxide is that it turns lime-water milky.

“Biological detergents” contain proteases, which digest proteins, and lipases, which digest fat.

Enzymes are used in industry to bring about reactions at normal temperatures and pressures that would otherwise require expensive, energy demanding equipment. For example:

- proteases are used to "pre-digest" the protein in some baby foods;
- carbohydrases are used to convert starch syrup into sugar syrup;
- isomerase is used to convert glucose syrup into fructose syrup, which is much sweeter and therefore can be used in smaller quantities in slimming foods.

H only

You should be able, when provided with appropriate information, to evaluate the advantages and disadvantages of using microorganisms and enzymes to bring about chemical reactions.

Successful industrial processes depending on enzymes usually:

- stabilise the organism to keep it functioning for a long period;
- immobilise the enzyme by trapping it in an inert solid support or carrier such as alginate beads;
- allow a continuous process rather than batch process

Chemical reactions and energy diagrams

When fuels burn, energy is released as heat. In chemical reactions, energy is usually transferred:

- **exothermic** reactions give out energy, often as heat, **to** the surroundings.
- **endothermic** reactions take in energy, often as heat, **from** the surroundings.

In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called **reversible reactions** and are shown as: $A + B \rightleftharpoons C + D$

For example: ammonium chloride $\rightleftharpoons$ ammonia + hydrogen chloride

If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case. For example:

hydrated copper sulphate (blue) $\xrightarrow{\text{heat energy}}$ anhydrous copper sulphate (white) + water

The reverse reaction can be used as a test for water.

H only

During a chemical reaction, energy is supplied to break bonds, and energy is released when bonds are made. In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds. In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds. You should be able to:

- interpret simple energy level diagrams in terms of bond breaking and bond formation (including the idea of activation energy and the effect on this of catalysts);
- calculate the nett energy transfer in reactions, using energy level diagrams or supplied bond energies.

How do chemists produce the fertiliser we need to grow food?

Air is almost 80% nitrogen. The nitrogen can be used to manufacture several important chemicals, including nitrogen-based fertilisers. Nitrogen-based fertilisers are important in agriculture for increasing the yields of crops. Nitrates can, however, create problems if they find their way into streams, rivers or groundwater and so contaminate our drinking water.

You should be able, when provided with appropriate information, to reach balanced judgements concerning the benefits of using nitrate fertilisers and the contamination of drinking water they can cause.

The Haber process

Ammonia is manufactured in the **Haber process**. The raw materials are nitrogen from the air and hydrogen obtained from natural gas. The purified gases are passed over an iron catalyst at a high temperature (about 450°C) and a high pressure (about 200 atmospheres). Some of the hydrogen and nitrogen reacts to form ammonia. The ammonia cools, liquefies and is removed. The remaining hydrogen and nitrogen is recycled. The reaction is reversible, which means that ammonia also breaks back down into nitrogen and hydrogen:

nitrogen + hydrogen ⇌ ammonia … or in symbols … $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The reaction conditions are chosen to produce a reasonable yield of ammonia quickly.

The Ostwald process

Ammonia can be oxidised to produce **nitric acid**. Ammonia gas reacts with oxygen over a hot platinum catalyst to make nitrogen monoxide. This is cooled and reacted with water and oxygen to form nitric acid.

H only

Ammonium nitrate fertiliser is made by the neutralisation reaction between ammonia and nitric acid.

Equilibria

When a reversible reaction occurs in a closed system, an **equilibrium** is reached when the reaction occurs at exactly the same rate in each direction.

The relative amounts of the reacting substances at equilibrium depend on the conditions of the reaction:

- In an endothermic reaction, if the temperature is increased, the yield of products is increased; if the temperature is decreased, the yield of products is decreased.
- In an exothermic reaction, if the temperature is increased, the yield of products is decreased; if the temperature is decreased, the yield of products is increased.
- In gaseous reactions, an increase in pressure will favour the reaction which produces the least number of molecules, as shown by the symbol equation for that reaction.

These factors, and reaction rate, are important when working out the optimum conditions in processes like the Haber process. You should be able to explain the details of these processes in chemical terms, including energy transfers during the reaction, reaction rates, and equilibrium conditions in reversible reactions. You should should also be able to outline and evaluate the economic factors associated with the conditions under which the Haber process is normally carried out.

How do we know how much of each reactant to use in a chemical reaction?

Atoms of different elements have different masses. Given the A_r (see Data Sheet), you should be able to:

- calculate the relative formula mass, M_r of compounds whose formulae are supplied;
- calculate the percentage of an element in a compound whose formula is supplied.

H only

You should be able to use supplied balanced symbol equations and supplied data about the masses or volumes of some reactants or products to work out:

- the masses or volumes of other reactants or products;
- the ratios of atoms in compounds from supplied masses or precentage composition (empirical formulae).

With electrolysis, you should be able to use given half equations for reactions at the electrodes and given data about the mass or volume of one of the products to calculate the mass or volume of the other product.