Chapter 10 - Atmosphere and oceans

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The developing atmosphere

About 4500 million years ago the planets in the solar system were formed. Each planet had a thick layer of gases, mainly hydrogen and helium, surrounding its core. This layer of gas is known as the **primary atmosphere** (Figure 10.1). Over a period of time intense solar activity caused these lighter gases to be removed from this primary atmosphere of planets nearest to the Sun. During this time the Earth was cooling to become a molten mass upon which a thin crust formed.

b Aurora borealis.

a Lightning flashes.

c A tornado or 'twister'.

Figure 10.1 The Earth's atmosphere formed over many millions of years and involved various atmospheric phenomena.

Volcanic activity through the crust pushed out huge quantities of gases, such as ammonia, nitrogen, methane, carbon monoxide, carbon dioxide and a small amount of sulphur dioxide, which formed a secondary atmosphere around the Earth (Figure 10.2a).

About 3800 million years ago, when the Earth had cooled below 100°C, the water vapour in this secondary atmosphere condensed and fell as rain. This caused the formation of the first oceans, lakes and seas on the now rapidly cooling Earth. The structure of the surface of the Earth, as we know it today, has evolved as a result of the presence of these large expanses of water (Figure 10.2b). The oceans are even today an important reservoir for carbon dioxide gas, removing it from the atmosphere.

Eventually, early forms of life developed in these oceans, lakes and seas at depths which prevented potentially harmful ultraviolet light from the Sun affecting them. About 3000 million years ago the first forms of bacteria appeared. These were the predecessors of algae-like organisms which used the light from the Sun, via photosynthesis, to produce their own food, and oxygen was released into the atmosphere as a waste product. This process also acted to reduce the amount of CO_2 in the atmosphere.

The process of photosynthesis can be described by the following equation:

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyl}]{\text{sunlight}} \text{glucose} + \text{oxygen}$$

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(q) + 6O_2(g)$$

The ultraviolet radiation broke down some of the oxygen molecules, which had been released, into oxygen atoms.

$$\text{oxygen molecules} \xrightarrow{\text{UV light}} \text{oxygen atoms}$$

$$O_2(g) \rightarrow 2O(g)$$

Some of the highly reactive oxygen atoms reacted with molecules of oxygen to form ozone molecules, $O_3(g)$.

$$\text{oxygen atom} + \text{oxygen molecule} \rightarrow \text{ozone}$$

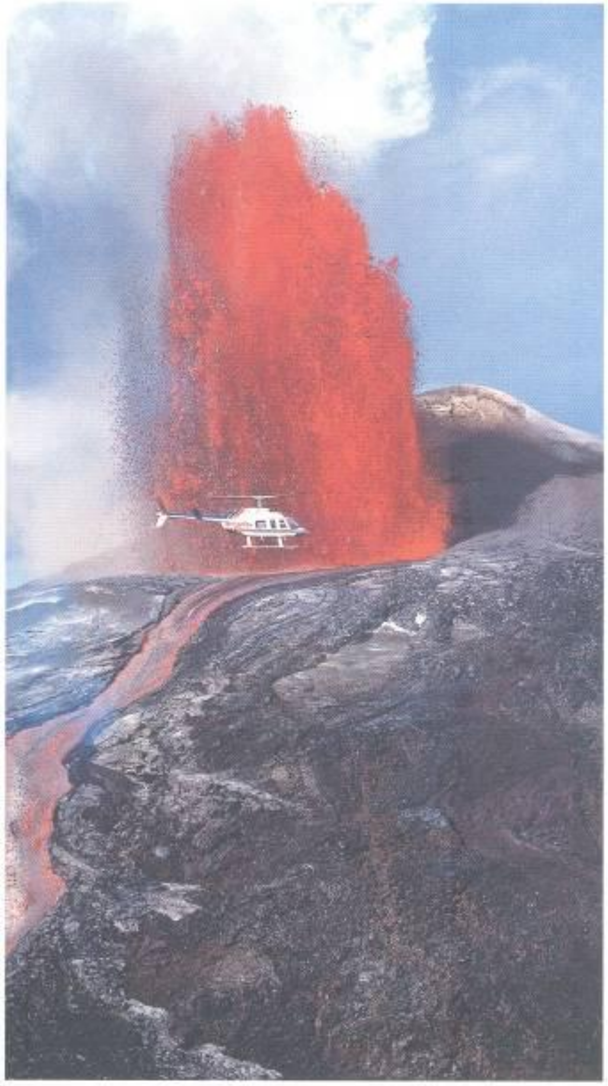
$$O(g) + O_2(g) \rightarrow O_3(g)$$

Ozone is an unstable molecule which readily decomposes, under the action of ultraviolet radiation, into single oxygen atoms and oxygen molecules.

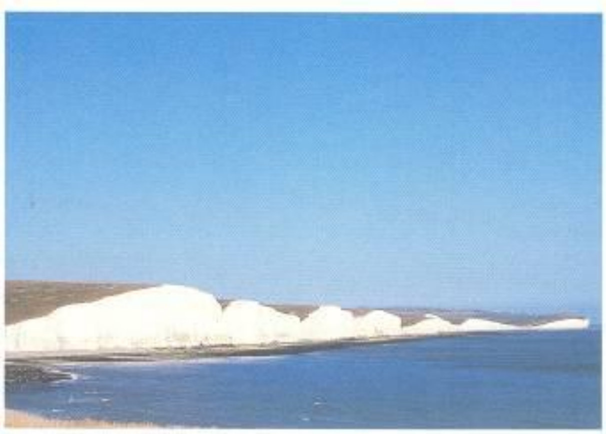
$$\text{ozone} \xrightarrow{\text{UV light}} \text{oxygen atom} + \text{oxygen molecule}$$

$$O_3(g) \rightarrow O(g) + O_2(g)$$

However, the single oxygen atoms would react quickly, re-forming ozone molecules.



a Volcanic activity expelled gases through the crust to form a secondary atmosphere.



b The Seven Sisters in Sussex. The Earth's surface has evolved as a result of lakes and other large expanses of water.

Figure 10.2

Ozone is an important gas in the atmosphere (stratosphere). It prevents harmful ultraviolet radiation from reaching the Earth. Over many millions of years the amount of ultraviolet radiation was reduced significantly. About 400 million years ago the first land plants appeared on the Earth, and so the amount of oxygen and hence ozone increased.

Oxygen is a reactive gas, and over millions of years organisms have adapted to make use of it. The oxygen from the atmosphere was used, along with the carbon they obtained from their food, to produce energy in a process known as **respiration**. The process of respiration can be represented as:

glucose + oxygen → carbon dioxide + water + energy

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) + \text{energy}$$

Over recent years, scientists have become aware of a reduction in the amount of ozone in our atmosphere and of the formation of ozone holes (Figure 10.3). The reduction of ozone in our atmosphere will lead to an increased risk of skin cancer as more harmful ultra-violet radiation reaches the surface of the Earth.

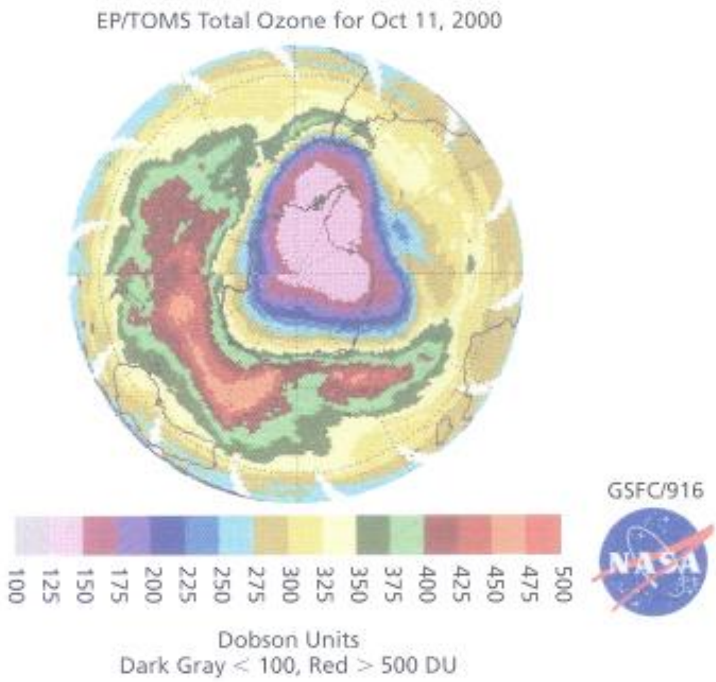


Figure 10.3 This diagram comes from NASA's ozone monitoring programme TOMS (Total Ozone Mapping Spectrometer). You can view diagrams similar to this at http://toms.gsfc.nasa.gov/. The ozone hole over the Antarctic (shown in purple and pink on the diagram) is largest in the Antarctic spring. Note: Dobson Units are a measure of the total amount of ozone in a vertical column from the ground to the top of the atmosphere.

Question

1. What precautions are necessary to prevent an increase in skin cancers?

The structure of the atmosphere

The gases in the atmosphere are held in an envelope around the Earth by its gravity. The atmosphere is 80 km thick (Figure 10.4) and it is divided into four layers:

- troposphere
- stratosphere
- mesosphere
- thermosphere.

About 75% of the mass of the atmosphere is found in the layer nearest the Earth called the troposphere. Beyond this layer the atmosphere reaches into space but becomes extremely thin beyond the mesosphere.

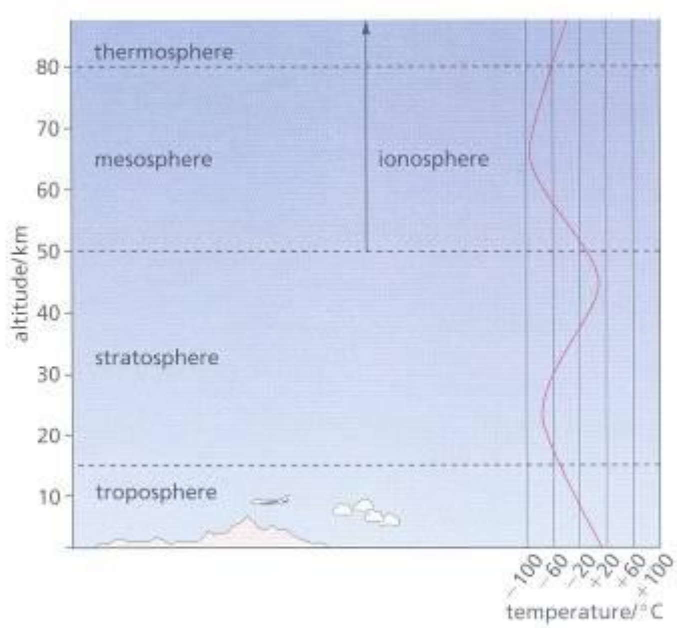


Figure 10.4 The Earth's atmosphere.

The composition of the atmosphere

If a sample of dry, unpolluted air was taken from any location in the troposphere and analysed, the composition by volume of the sample would be similar to that shown in Table 10.1.

Table 10.1 Composition of the atmosphere.

Component	**%**
Nitrogen	78.08
Oxygen	20.95
Argon	0.93
Carbon dioxide	0.03
Neon	0.002
Helium	0.0005
Krypton	0.0001
Xenon plus minute amounts of other gases	0.000 01

Measuring the percentage of oxygen in the air

When 100 cm^3 of air is passed backwards and forwards over heated copper turnings it is found that the amount of gas decreases (Figure 10.5). This is because the reactive part of the air, the oxygen gas, is reacting with the copper to form black copper (II) oxide (Figure 10.6). In such an experiment the volume of gas in the syringe decreases from 100 cm^3 to about 79 cm^3, showing that the air contained 21 cm^3 of oxygen gas. The percentage of oxygen gas in the air is:

$$\frac{21}{100} \times 100 = 21\%$$

The composition of the atmosphere is affected by the following factors:

- respiration
- photosynthesis
- volcanic activity
- radioactive decay, in which helium is formed
- human activity, involving burning of fossil fuels, in which carbon dioxide and water vapour are produced as well as other gases.

Compare the components of our atmosphere with those of the other planets in the solar system (Table 10.2).

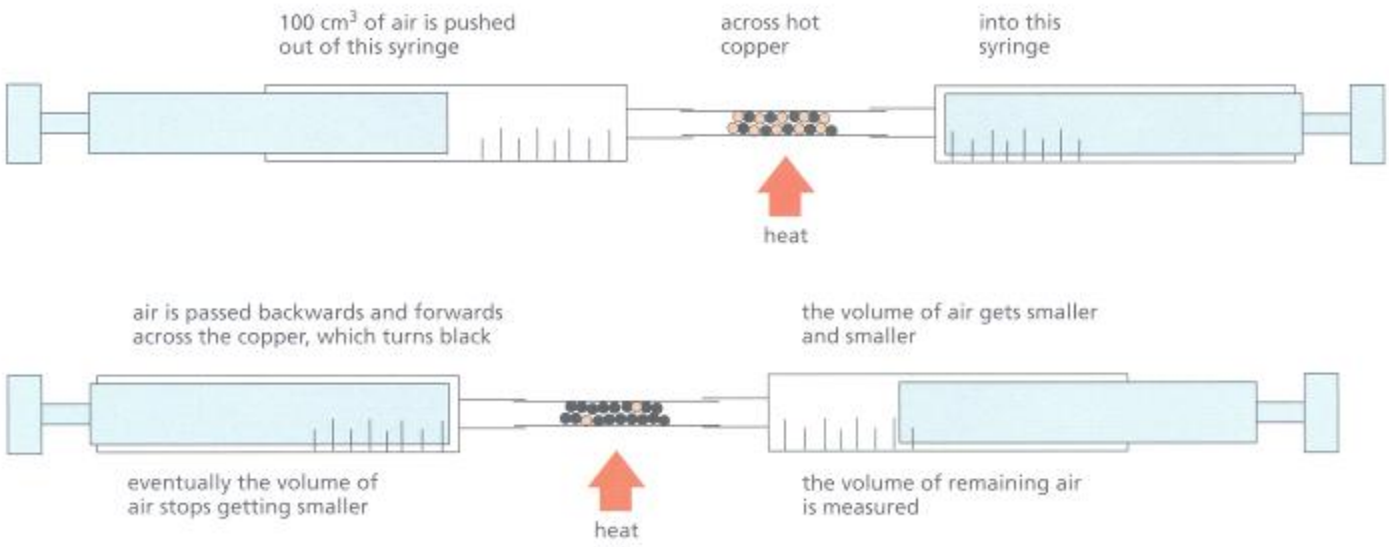


Figure 10.5 This apparatus can be used to find out the volume of oxygen gas in the air.

Figure 10.6 Copper turnings before and after reaction.

Table 10.2 Atmospheres of the other planets in the solar system.

Planet	**Atmosphere**
Mercury	No atmosphere - the gases were burned off by the heat of the Sun
Venus	Carbon dioxide and sulphur dioxide
Mars	Mainly carbon dioxide
Jupiter	Ammonia, helium, hydrogen, methane
Saturn	Ammonia, helium, hydrogen, methane

Uranus	Ammonia, helium, hydrogen, methane
Neptune	Helium, hydrogen, methane
Pluto	No atmosphere; it is frozen

Questions

1. Draw a pie chart to show the data given in Table 10.1.

2. Is air a compound or a mixture? Explain your answer.

3. Design an experiment to find out how much oxygen there is in exhaled air.

Fractional distillation of liquid air

Air is the major source of oxygen, nitrogen and the noble gases. The gases are obtained by fractional distillation of liquid air but it is a complex process, involving several different steps (Figure 10.7).

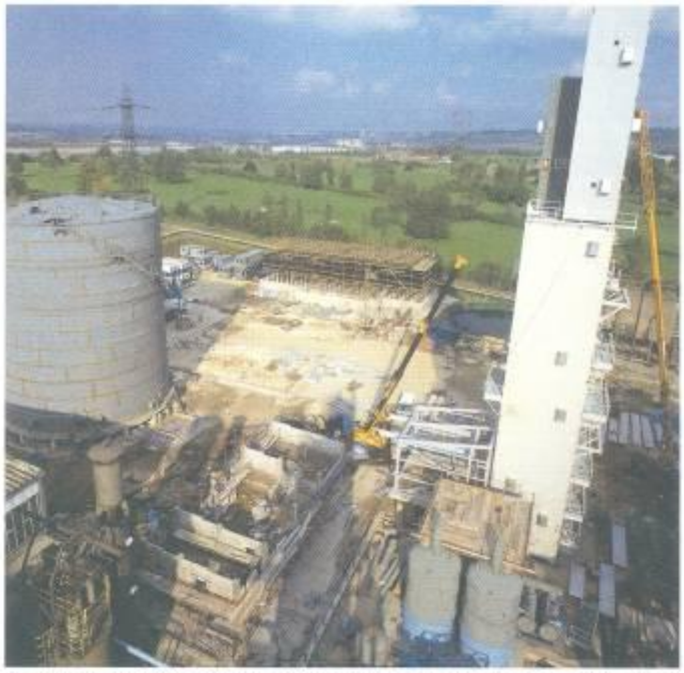


Figure 10.7 BOC produces large amounts of gases obtained from the fractional distillation of liquid air.

- The air is passed through fine filters to remove dust.

- The air is cooled to about -80°C to remove water vapour and carbon dioxide as solids. If these are not removed, then serious blockages of pipes can result.

- Next, the cold air is compressed to about 100 atm of pressure. This warms up the air, so it is passed into a heat exchanger to cool it down again.

- The cold, compressed air is allowed to expand rapidly and that cools it still further.

- The process of compression followed by expansion is repeated until the air reaches a temperature below -200°C. At this temperature the majority of the air liquefies (Table 10.3).

- The liquid air is passed into a fractionating column and it is fractionally distilled.

- The gases are then stored separately in large tanks and cylinders.

Table 10.3 Boiling points of atmospheric gases.

Gas	Boiling point/°C
Helium	-269
Neon	-246
Nitrogen	-196
Argon	-186
Oxygen	-183
Krypton	-157
Xenon	-108

It should be noted that the noble gases neon, argon, krypton and xenon are obtained by this method; however, helium is more profitably obtained from natural gas.

Question

1. Use information given in the text to construct a flow chart to show the processes involved in the extraction of gases from air.

Uses of the gases

Oxygen

- Large quantities are used in industry to convert pig iron into steel (Chapter 9) and for producing very hot flames for welding by mixing with gases such as ethyne (acetylene).
- It is used in hospitals to help patients with breathing difficulties (Figure 10.8).
- People such as mountaineers and divers use oxygen.
- It is carried in space rockets so that the hydrogen and kerosene fuels can burn.
- Space shuttles use oxygen gas in fuel cells which convert chemical energy into electrical energy.
- Astronauts must carry their own supply of oxygen, as do fire-fighters.
- It is used to restore life to polluted lakes and rivers and in the treatment of sewage.

Figure 10.8 The incubator has its own oxygen supply.

Nitrogen

- Nitrogen is used in large quantities in the production of ammonia gas

(Chapter 15), which is used to produce nitric acid. Nitric acid is used in the manufacture of dyes, explosives and fertilisers.

- Liquid nitrogen is used as a refrigerant. Its low temperature makes it useful for freezing food quickly.

- Because of its unreactive nature, nitrogen is used as an inert atmosphere for some processes and chemical reactions. For example, empty oil tankers are filled with nitrogen to prevent fires.

- It is used in food packaging, for example in crisp packets, to keep the food fresh and in this case to prevent the crisps being compressed (Figure 10.9).

Figure 10.9 Inert nitrogen gas is used in food packaging.

Noble gases

Argon is used:

- to fill ordinary and long -life light bulbs to prevent the tungsten filament from reacting with oxygen in the air and forming the oxide (Figure 10.10)

- to provide an inert atmosphere in arc welding and in the production of titanium metal.

Neon is used:

- in advertising signs, because it glows red when electricity is passed through it

- in the helium-neon gas laser (Figure 10.11)

- in Geiger-Muller tubes, which are used for the detection of radioactivity.

Helium is used:

- to provide an inert atmosphere for welding

- as a coolant in nuclear reactors

- with 20% oxygen as a breathing gas used by deep-sea divers

- to inflate the tyres of large aircraft

- to fill airships and weather balloons (Figure 10.12)

- in the helium-neon laser

- in low-temperature research, because of its low boiling point.

Krypton and xenon are used:

- in lamps used in photographic flash units, in stroboscopic lamps and in lamps used in lighthouses.

Figure 10.10 This long-life bulb contains argon.

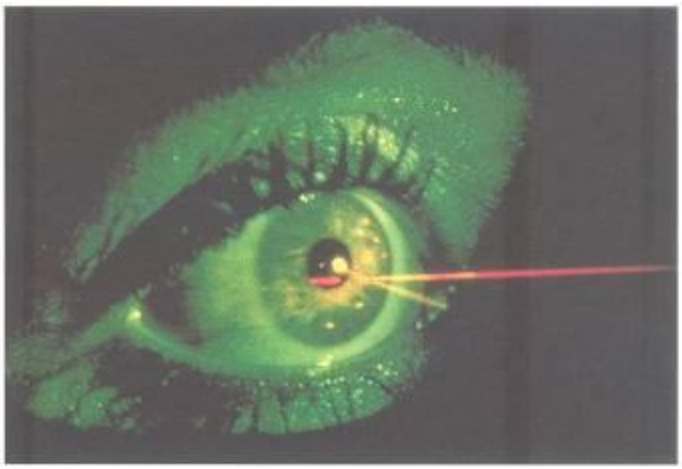


Figure 10.11 A helium–neon laser used in eye surgery.

Figure 10.12 Helium is used to fill this airship as it has a low density and is unreactive.

Questions

1. How does oxygen help to restore life to polluted lakes?

2. Why is it important to have nitrogen in fertilisers?

3. Why is helium needed to produce an inert atmosphere for welding?

Resources in the oceans

In some hot, arid countries the sea is the main source of pure water for drinking. The water is obtained by a process known as desalination (Chapter 2).

Sea water contains about 35 g of dissolved substances in each kilogram. A typical analysis of the varied elements present in sea water is shown in Table 10.4. Some elements, such as bromine, are extracted from sea water on a commercial basis.

Table 10.4 Elements present in sea water.

Element	**Concentration/gdm^{-3} of sea water**
Bromine	0.07
Calcium	0.4
Chlorine	19.2
Magnesium	1.3
Potassium	0.4
Sodium	10.7
Sulphur	0.9
Other elements	1.4

Bromine

Eighty per cent of the world's supply of bromine is extracted from sea water. Bromine is extracted in this way in a chemical plant at Amlwch, Anglesey, Wales, but one of the biggest factories for extracting bromine is to be found on the south-west shores of the Dead Sea in Israel. The Dead Sea is a particularly rich source of bromine as it contains 5.2 g of the element per dm^3 of sea water.

Worldwide 55000 tonnes of bromine are harvested from the sea each year.

The extraction of bromine from sea water begins with the evaporation of the sea water using energy from the Sun, forming a more concentrated solution. The bromine is present in solution as bromide ions ($Br^-(aq)$), which can be converted to bromine via a displacement reaction with chlorine gas. The process is as follows.

- Chlorine gas is bubbled through the warm, partially evaporated Dead Sea water and displacement takes place.

chlorine gas + bromide ions → bromine gas + chloride ions

$$Cl_2(g) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$$

- Steam is blown through the resulting solution and the volatile bromine is given off as bromine vapour mixed with steam.

- Bromine is not very soluble in water and therefore two separate layers form when the bromine and steam condense. The less dense water floats on top of the denser bromine layer. The bromine layer is then run off.

- The impure bromine is then purified by distillation and dried.

Half a tonne of chlorine is required for each tonne of bromine manufactured. Bromine is used in the manufacture of the fuel additive tetraethyllead (IV) (TEL), although to a decreasing extent. Bromine compounds are also used in photography (AgBr), medicines (KBr) and herbicides as well as in the manufacture of flame-retardant materials.

Figure 10.13 The Dead Sea is a particularly rich source of salts, including bromides from which bromine is extracted.

Magnesium

Magnesium can also be extracted from sea water. The sea water is first treated with calcium hydroxide, and magnesium hydroxide is precipitated and filtered off

magnesium ions + hydroxide ions → magnesium hydroxide

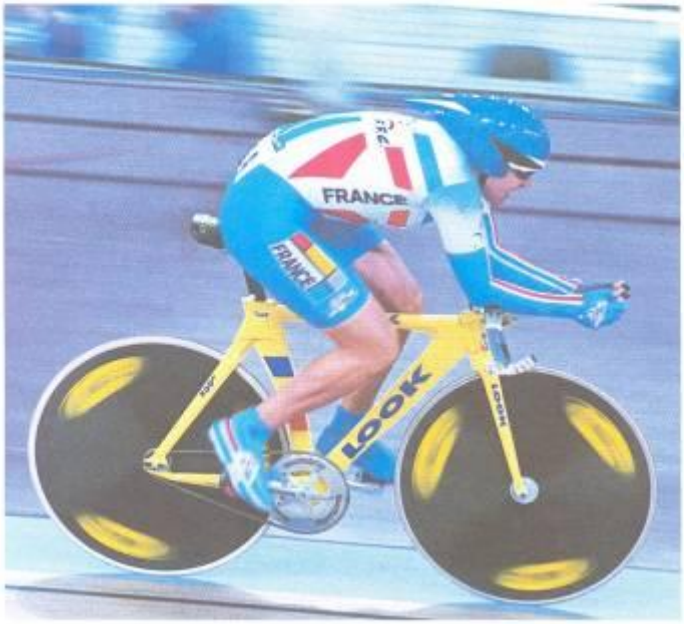
$$Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$$

The magnesium hydroxide is then dissolved in hydrochloric acid and the resulting solution is evaporated to produce magnesium chloride. This is then fused, at about 700 °C, with additives to lower its melting point and is electrolysed with a graphite anode and a steel cathode. The magnesium produced is liberated at the cathode and is 99.9% pure. Around 250000 tonnes are produced worldwide each year.

magnesium ions + electrons → magnesium

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

Magnesium is used in alloys which are used in the space and aviation industries, and in racing cycles (Figure 10.14a). Compounds of magnesium ($Mg(OH)_2$ and $MgSO_4.7H_2O$) are also used in medicines, for example indigestion remedies (Figure 10.14b), and in toothpastes.



a Magnesium (as the element) is used in alloys to build space shuttles and racing cycles.

b As a compound it is used in the manufacture of indigestion remedies and toothpaste.

Figure 10.14

Sodium chloride

As you might guess, salt is the most abundant resource in sea water. There is about 25 g of sodium chloride per dm^3 of sea water. It is extracted in several areas of the world by evaporation, for example in France, Saudi Arabia and Australia.

The sea water is kept in shallow ponds until all the water has been evaporated by the heat of the Sun. The salt is then harvested.

Sodium chloride is used to flavour food, in the manufacture of sodium carbonate and sodium hydrogencarbonate and as the raw material for the chloralkali industry (Chapter 6).

Questions

1. Use the information in the text and any other information you can obtain from other sources to construct a flow diagram to show the processes involved in the extraction of bromine from sea water.

2. In the extraction of magnesium from sea water, the magnesium hydroxide precipitate is treated with dilute hydrochloric acid. Write both a word and a balanced chemical equation to describe this reaction. In addition, write an electrode equation to show the production of chlorine gas at the anode.

The water cycle

Figure 10.15 illustrates the water cycle, which shows how water circulates around the Earth. The driving force behind the water cycle is the heat of the Sun.

- Heat from the Sun causes evaporation from oceans, seas and lakes. Water vapour is also formed from the evaporation of water from leaves (transpiration), through respiration and through combustion. The water vapour rises and cools, and condenses to form tiny droplets of water. These droplets form clouds.

- The clouds are moved along by air currents. As they cool, the tiny droplets join to form larger droplets, which fall as rain when they reach a certain size.

- The water that falls as rain runs into streams and rivers and then on into lakes, seas and oceans.

Question

1. Construct a simplified version of the water cycle using 'key words' in boxes and the 'processes involved' over linking arrows.

Pollution

The two major resources considered in this chapter, water and air, are essential to our way of life and our very existence. However, we are continually guilty of polluting these resources. We now look at the effects of the various sources of pollution and the methods used to control or eliminate them.

Water pollution

Water is very good at dissolving substances. It is, therefore, very unusual to find really pure water on this planet. As water falls through the atmosphere and down on to and through the surface of the Earth, it dissolves a tremendous variety of substances. Chemical fertilisers washed off surrounding land will add nitrate ions (NO_3) and phosphate ions (PO_4^{3-}) to the water, owing to the use of artificial fertilisers such as ammonium nitrate and ammonium phosphate. It may also contain human waste as well as insoluble impurities such as grit and bacteria and oil and lead 'dust' (to a decreasing extent) from the exhaust fumes of lorries and cars (Figure 10.16).

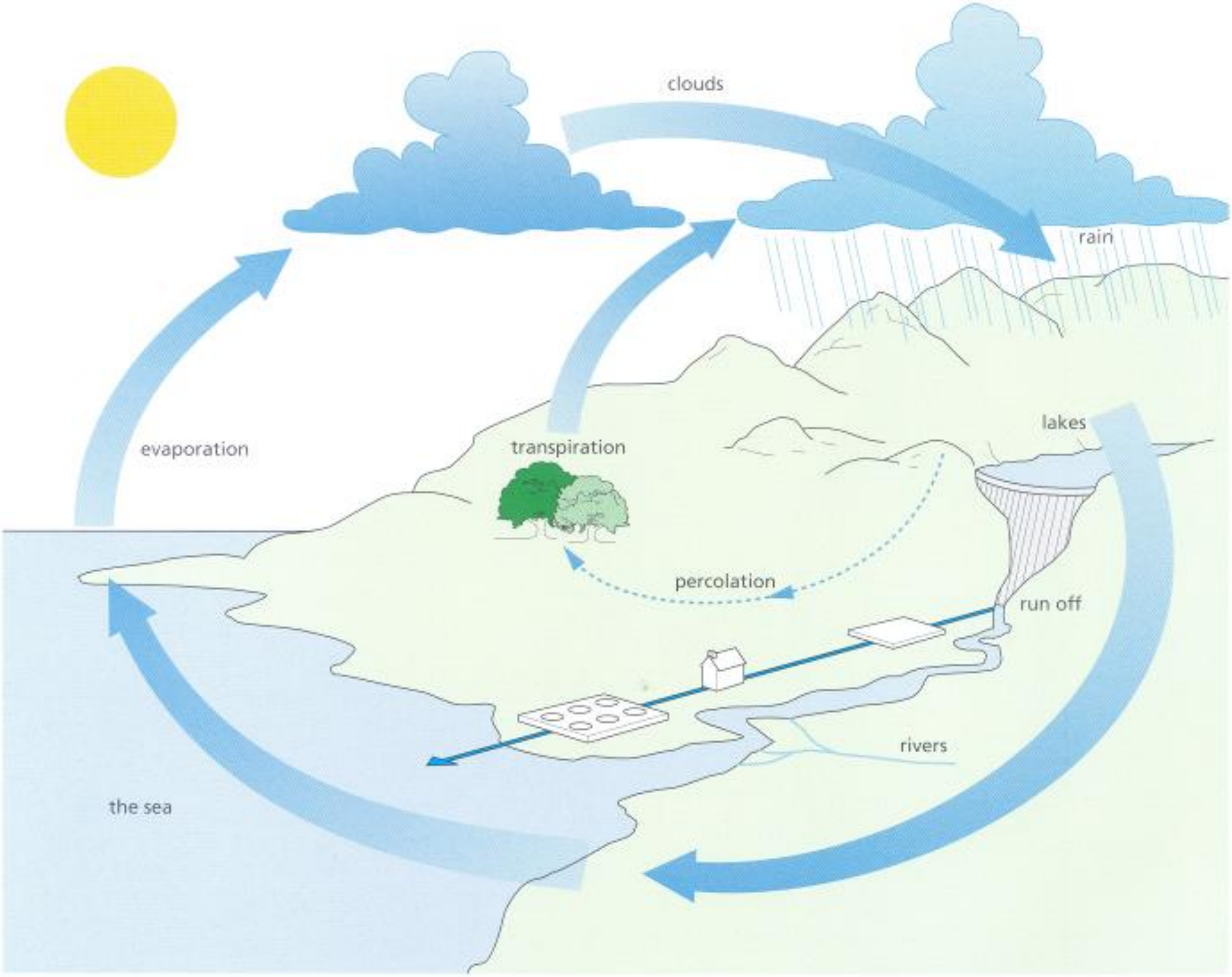


Figure 10.15 The water cycle.


Figure 10.16 A badly polluted river.

All these artificial as well as natural impurities must be removed from the water before it can be used. Recent European Union (EU) regulations have imposed strict guidelines on the amounts of various substances allowed in drinking water (Figure 10.17).

Figure 10.17 A water treatment works.

Most drinking water in the UK is obtained from lakes and rivers where the pollution levels are low. Undesirable materials removed from water include:

- colloidal clay (clay particles in the water)
- bacteria
- chemicals which cause the water to be coloured and foul tasting
- acids, which are neutralised.

The process of water treatment involves both filtration and chlorination and is summarised in Figure 10.18.

1. Impure water is first passed through screens to filter out floating debris.

2. Aluminium sulphate is added to coagulate small particles of clay so that they form larger clumps, which settle more rapidly.

3. Filtration through coarse sand traps larger, insoluble particles. The sand also contains specially grown microbes which remove some of

the bacteria.

4. A sedimentation tank has chemicals known as flocculants, for example aluminium sulphate, added to it to make the smaller particles (which remain in the water as colloidal clay) stick together and sink to the bottom of the tank.

5. These particles are removed by further filtration through fine sand. Sometimes a carbon slurry is used to remove unwanted tastes and odours and a lime slurry is used to adjust the acidity.

6. Finally, a little chlorine gas is added, which kills any remaining bacteria. This sterilises the water. Excess chlorine can be removed by the addition of sulphur dioxide gas. The addition of chlorine gas makes the water more acidic and so appropriate amounts of sodium hydroxide solution are added.

Fluoride is added to water in some local supplies if there is insufficient occurring naturally, as it helps to prevent tooth decay.

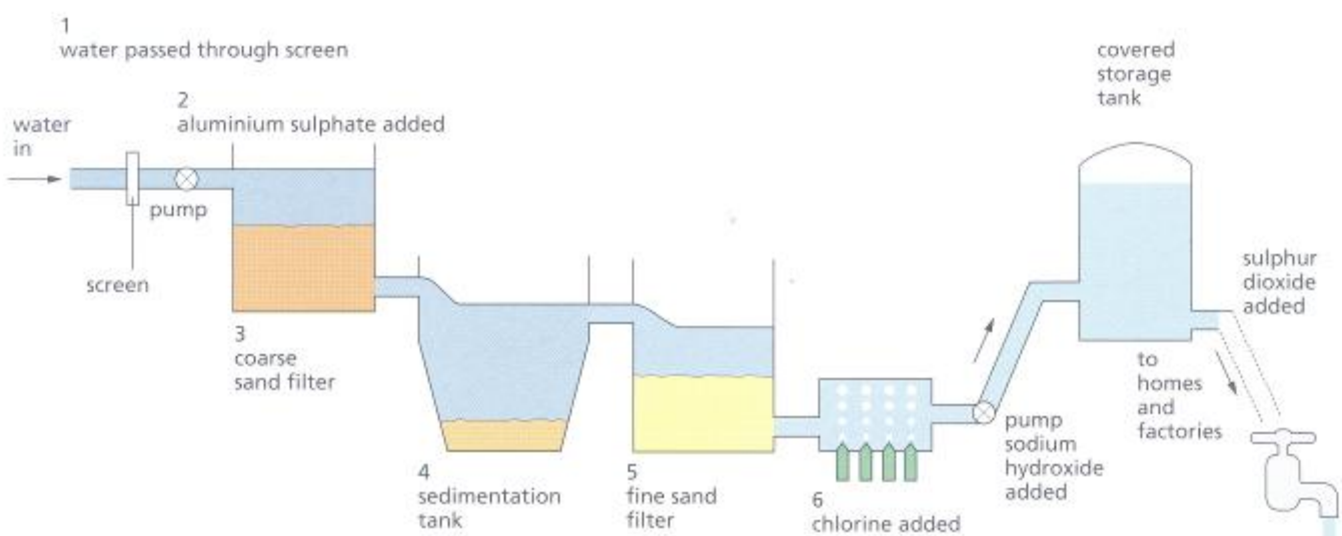


Figure 10.18 The processes involved in water treatment.

The 'iron problem'

If the acidity level of the treated water is not con-trolled then problems occur due to the precipitation of iron(m) hydroxide. These include:

- vegetables turning brown
- tea having an inky appearance and a bitter taste
- clothes showing rusty stains after washing.

Sewage treatment

After we have used water it must be treated again before it can be returned to rivers, lakes and seas. This multi-stage process known as sewage treatment is shown in Figure 10.19.

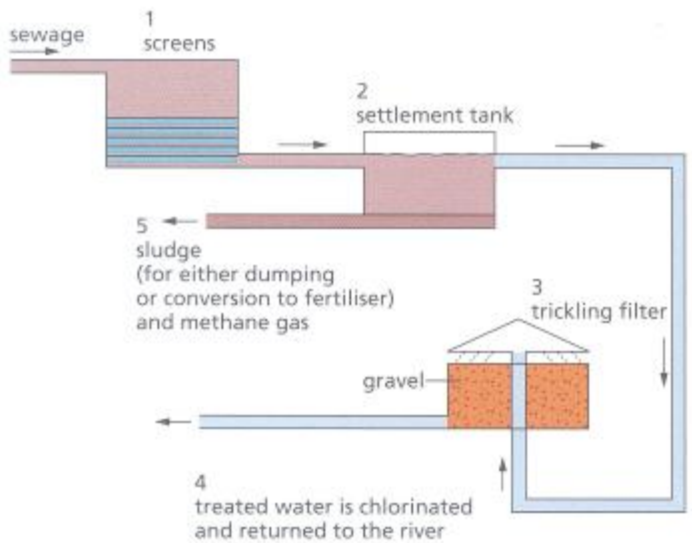


Figure 10.19 The processes involved in sewage treatment.

Used water, sewage, contains waste products such as human waste and washing-up debris as well as every-thing else that we put down a drain or sink. The processes that are involved are as follows.

1. Large screens remove large pieces of rubbish.

2. Sand and grit are separated on large sedimentation tanks. The process is speeded up by adding aluminium sulphate, which helps the solids to coagulate into larger particles that separate more rapidly. The sand and grit often contain large amounts of useful chemicals which, by the action of selected microbes, can be used as fertilisers.

3. The impure water is then removed and sent to a trickling filter, where it is allowed to drain through gravel on which microbes have been

deposited. These kill off any remaining bacteria in the water by aerobic processes. This stage is known as biological filtration.

4. The treated water is then chlorinated and returned to a river, after checking.

5. Anaerobic bacteria digest what remains from the other stages. Methane gas is produced, which can be used as a fuel.

Atmospheric pollution

Air pollution is all around us. Concentrations of gases in the atmosphere such as carbon monoxide, sulphur dioxide and nitrogen oxides are increasing with the increasing population. As the population rises there is a consequent increase in the need for energy, industries and motor vehicles. These gases are produced primarily from the combustion of the fossil fuels coal, oil and gas, but they are also produced by the smoking of cigarettes.

Motor vehicles are responsible for much of the air pollution in large towns and cities. They produce four particularly harmful pollutants:

- carbon monoxide
- sulphur dioxide
- hydrocarbons
- oxides of nitrogen.

Concern about pollution due to cars has led to the introduction of strict regulations by the EU and now all new cars must have a device known as a catalytic converter fitted to eliminate the production of some of these gases.

The catalytic converter acts as a device to speed up reactions which involve the pollutant gases, converting them to less harmful products, such as nitrogen and carbon dioxide. It should be noted that catalytic converters can only be used with unleaded petrol as the lead 'poisons' the catalyst, preventing it from catalysing the reactions. For a further discussion of catalytic converters see Chapter 11.

Another method that has been introduced to reduce the amount of pollutants is that of the 'lean burn' engine. Although this type of engine reduces the amounts of carbon monoxide and oxides of nitrogen produced, it actually increases the amount of hydro-carbons in the exhaust gases.

A further method of regulating pollutant gases is to convert petrol burning engines to LPG (liquid petroleum gas) engines, whilst retaining the ability to burn petrol. These cars are known as dual-fuel cars. Much research has also been carried out to produce efficient electric motors that can be fitted in place of the petrol engine in a car. This development is moving forward at a pace.

Power stations are a major source of sulphur dioxide, a pollutant formed by the combustion of coal, oil and gas, which contain small amounts of sulphur.

$$\text{sulphur} + \text{oxygen} \rightarrow \text{sulphur dioxide}$$

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

This sulphur dioxide gas dissolves in rainwater to form the weak acid, sulphurous acid (H_2SO_3).

$$\text{sulphur dioxide} + \text{water} \rightarrow \text{sulphurous acid}$$

$$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$$

Figure 10.20 Sulphur dioxide is a major pollutant produced by industry.

A further reaction occurs in which the sulphurous acid is oxidised to sulphuric acid.

Solutions of these acids are the principal contributors to acid rain. For a further discussion of acid rain, see Chapter 16.

Units called flue gas desulphurisation (FGD) units are being fitted to some power stations to prevent the emission of sulphur dioxide gas. Here, the sulphur dioxide gas is removed from the waste gases by passing it through calcium hydroxide slurry. This not only removes the sulphur dioxide but also creates calcium sulphate, which can be sold to produce plasterboard. The FGD units are very expensive and therefore the sale of the calcium sulphate is an important economic part of the process.

Questions

1. Make a list of four major water pollutants and explain where they come from. What damage can these pollutants do?

2. Write a balanced chemical equation to represent the reaction which takes place between sulphur dioxide and calcium hydroxide slurry in the FGD unit of a power station.

3. In the treatment of water for public use, state the purpose of the addition of:

a. aluminium sulphate
b. chlorine
c. sodium hydroxide
d. sulphur dioxide.

4. Many industries use water as a coolant. Suggest the sorts of problems that may be created by this 'thermal pollution'.

Checklist

After studying Chapter 10 you should know and understand the following terms.

Fractional distillation of air The process to extract individual gases from the air. Air is a major raw material. The mixture of gases is separated by first liquefying the mixture at low temperature and high pressure. The temperature is then allowed to rise and the gases collected as they boil off. The gases so produced have many and varied uses.

Mesosphere A section of the atmosphere above the stratosphere in which the temperature falls with increasing height.

Ozone (trioxygen) A colourless gas produced in the stratosphere by the action of high-energy ultraviolet radiation on oxygen gas, producing oxygen atoms. These oxygen atoms then react with further oxygen molecules to produce ozone. Its presence in the stratosphere acts as a screen (ozone layer) against dangerous ultraviolet radiation.

Pollution The modification of the environment caused by human influence. It often renders the environment harmful and unpleasant to life. Water pollution is caused by many substances, such as those found in fertilisers and in industrial effluent. Atmospheric pollution is caused by gases such as sulphur dioxide, carbon monoxide and nitrogen oxides being released into the atmosphere by a variety of industries and also by the burning of fossil fuels.

Primary atmosphere The original thick layer of gases, mainly hydrogen and helium, that surrounded the Earth's core soon after the planet was formed 4500 million years ago.

Sea water as a resource Sea water is a major resource. By evaporation (desalination) we can produce water for drinking or irrigation. Also, bromine, magnesium and salt are extracted in large quantities from sea water.

Secondary atmosphere A layer of a mixture of gases created by early volcanic activity. The mixture that formed this atmosphere included ammonia, nitrogen, methane, carbon monoxide, carbon dioxide and sulphur dioxide gases.

Stratosphere A layer of the atmosphere above the troposphere in which the temperature increases with increasing height.

Troposphere A layer of the atmosphere closest to the Earth which contains about 75% of the mass of the atmosphere. The composition of dry air is relatively constant in this layer of the atmosphere.

Water cycle This cycle shows how water circulates around the Earth. The driving force behind the water cycle is the Sun.

Atmosphere and oceans

Additional questions

1. The apparatus shown in Figure 10.5, was used to estimate the proportion of oxygen in the atmosphere. A volume of dry air (200 cm^3) was passed backwards and forwards over heated copper until no further change in volume took place. The apparatus was then allowed to cool down to room temperature and the final volume reading was then taken. Some typical results are shown below.

Volume of gas before = 200 cm^3
Volume of gas after = 157cm^3

During the experiment the copper slowly turned black.

a. Why was the apparatus allowed to cool back to room temperature before the final volume reading was taken?

b. (i) Using the information given above, calculate the volume reduction which has taken place.

(ii) Calculate the percentage reduction in volume.

c. Explain briefly why there is a change in volume.

d. What observation given above supports your explanation in c? Write a balanced chemical equation for any reaction which has occurred.

e. Give the name of the main residual gas at the end of the experiment.

f. Would you expect the copper to have increased or decreased in mass during the experiment? Explain your answer.

2. Explain the following.

a. Air is a mixture of elements and compounds.

b. The percentage of carbon dioxide in the atmosphere does not significantly vary from 0.03%.

c. When liquid air has its temperature slowly raised from -270°C, helium is the first gas to boil off.

d. Power stations are thought to be a major cause of acid rain.

3. Air is a raw material from which several useful substances can be separated. They are separated in the following process.

Dry and 'carbon dioxide free' air is cooled under pressure. Most of the gases liquefy as the temperature falls below -200°C. The liquid mixture is separated by fractional distillation. The boiling points of the gases left in the air after removal of water vapour and carbon dioxide are given in the table below:

Gas	**Boiling point/°C**
Argon	-186
Helium	-269
Krypton	-157
Neon	-246
Nitrogen	-196
Oxygen	-183
Xenon	-108

a. Why is the air dried and carbon dioxide removed before it is liquefied?

b. Which of the gases will not become liquid at -200°C?

c. Which of the substances in the liquid mixture will be the first to change from liquid to gas as the temperature is slowly increased?

d. Give a use for each of the gases shown in the table.

e. Use the data given in Table 10.1 to calculate the volume of each of the gases found in 1 dm^3 of air.

4. Explain what is meant by the term 'pollution' with reference to air and water.

a. (i) Name an air pollutant produced by the burning of coal.

(ii) Name a different air pollutant produced by the combustion of petrol in a car engine.

b. Some of our drinking water is obtained by purifying river water.

(i) Would distillation or filtration produce the purest water from river water? Give a reason for your answer.

(ii) Which process, distillation or filtration, is actually used to produce drinking water from river water? Comment on your answer in comparison to your answer in c.(i).

c. Power stations produce warm water. This causes thermal pollution as this warm water is pumped into nearby rivers.

(i) Why do power stations produce such large quantities of warm water?

(ii) What effect does this warm water have on aquatic life?

5. In the final stage of the extraction of magnesium from sea water, molten magnesium chloride is electrolysed. Substances are added to bring the working temperature of the electrolysis cell down to 700°C.

a. Write equations to represent the reactions taking place at the cathode and anode. State clearly whether oxidation or reduction is taking place.

b. Why are substances added to the molten magnesium chloride before electrolysis takes place?

c. The industrial production of magnesium by electrolysis uses a current of 14 000 amps. Calculate the time required to produce 50 kg of magnesium from molten magnesium chloride.

(1 faraday = 96500 coulombs; A_r: Mg = 24)

d. A large proportion of the magnesium produced (43%) is used to make alloys.

(i) Why has it such a use in the production of magnesium alloys?

(ii) The world production of magnesium is approximately 240000 tonnes. Calculate the number of tonnes used in the production of magnesium alloys.

6. The developed countries produce about 230000 tonnes of bromine per year: 80% of this production is from sea water.

a. Calculate the amount of bromine obtained in developed countries from sea water.

b. Sea water contains 0.07g of bromine per dm^3. Using your answer to a, calculate the volume of sea water required to obtain that amount of bromine.

c. The main reaction in the extraction process is that involving displacement of bromine using chlorine gas.

(i) Write an ionic equation for this reaction.

(ii) Explain why you could not use iodine instead of chlorine in the displacement reaction.

d. Chlorine and bromine are hazardous substances. Describe some of the precautions that have to be taken to ensure the safety of members of the workforce who deal with these two substances.

7. France obtains some of its sodium chloride by evaporation of sea water.

a. If France produces 1.1 million tonnes of salt per year by this method and sea water contains 25g of sodium chloride per dm^3, calculate the volume of sea water required to produce the annual salt production.

b. Give four important uses of sodium chloride.

c. Sodium chloride is an ionic substance.

(i) Draw a diagram to show the bonding which takes place within sodium chloride.

(ii) What are the properties of ionic substances such as sodium chloride?

8. In plants, during photosynthesis, carbon dioxide and water are converted into carbohydrates such as glucose ($C_6H_{12}O_6$), and oxygen is released.

a. Write a balanced chemical equation for the reaction taking place during photosynthesis.

b. What conditions are essential for this reaction to take place?

c. Why are animals unable to photosynthesise?

d. Which process occurs if we reverse photosynthesis?

e. Some of the oxygen released during photosynthesis is broken up by ultraviolet radiation. Some of the oxygen atoms produced combine with further oxygen molecules to produce an important allotrope of oxygen.

(i) Name and give the formula of this allotrope of oxygen.

(ii) Write a balanced chemical equation for the reaction in which this allotrope is produced.

(iii) Why is this allotrope of oxygen so important to us?