Trilogy Chemistry paper 2 Revision checklist
Chemistry of the atmosphere

The evolution of the atmosphere		
Give the approximate composition of Earth's atmosphere today		
Describe the likely composition of Earth's early atmosphere		
Describe and explain how Earth's atmosphere has changed – condensation, sedimentation, photosynthesis etc		
Name the two greenhouse gases and explain why their concentration in the atmosphere is increasing		
Explain the 'greenhouse effect' and how this is linked to climate change		
Describe some of the consequences of climate change		
Define 'carbon footprint' and give ways of reducing it		
Describe how carbon monoxide, soot, sulphur dioxide and nitrogen oxides are made		
Explain the environmental problems linked to soot, sulphur dioxide, nitrogen oxides and carbon monoxide		

History of Our atmosphere

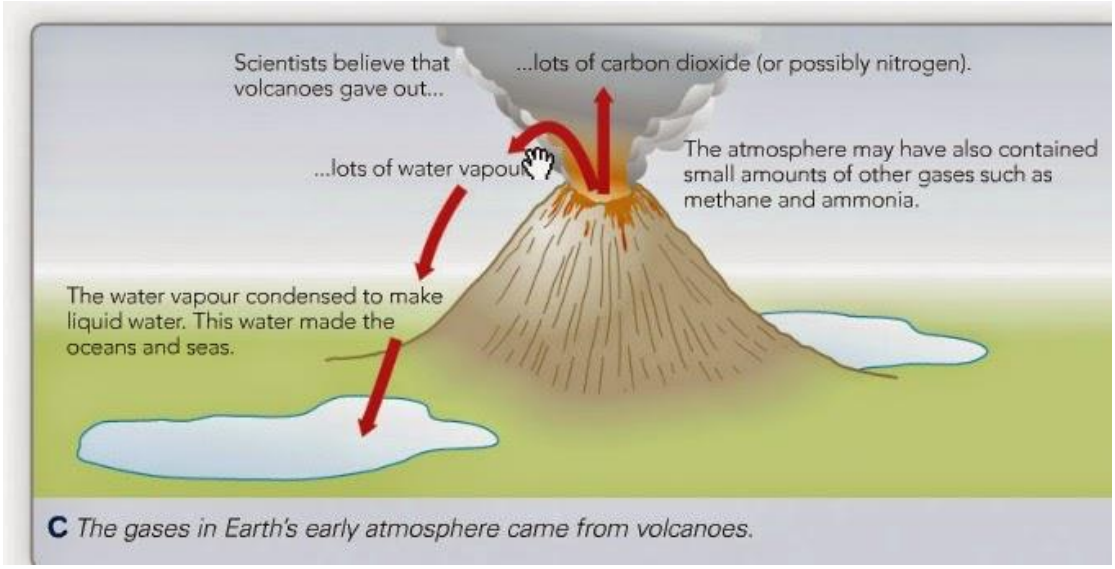
Scientists estimate that the Earth was formed 4.6 billion years ago (4,600,000,000) years. It is believed that for the first billion years, it was a very hot, turbulent place with volcanoes spewing gases into the atmosphere.

How can we suggest what the atmosphere was like without any direct evidence?

There are several theories as to what the early atmosphere was like which has been based on evidence from gas bubbles trapped in ancient rocks, they have also used data gathered from the atmospheres from other planets and moons in our solar system.

One theory suggests that the volcanoes released Carbon dioxide (CO_2), water vapour (H_20), and nitrogen N_2, and that these gases formed the early atmosphere.

As the Earth cooled, water vapour condensed and fell as rain, iit has also been suggested that icy comets fell to Earth adding to the Earth's early oceans.



C *The gases in Earth's early atmosphere came from volcanoes.*

Oxygen is a reactive element so very little if any would have been present in the early atmosphere.
Our nearest neighbours in the solar system have atmospheres which resembles Earth.

Oxygen in the atmosphere
Approximately 3.4 billion years ago,

The first simple living organisms appeared (similar to bacteria), they could use the breakdown of chemicals as a source of energy.

The first living things on Earth were one-celled organisms, known as **prokaryotes,** which came into existence between about 3.4 billion years ago.

Prokaryotes do not have a cell nucleus.

Cells with nuclei are known as **eukaryotic cells**, and organisms that have such cells, including human beings, are knows as **eukaryotes**.

When the Earth was first formed, it was extremely hot.
Eventually, it cooled enough for the crust to solidify. Volcanoes formed, pouring ammonia, methane, nitrogen and carbon dioxide into the atmosphere.

Organic molecules coalesced in the oceans to form these molecules, and eventually formed prokaryotic cells.

When the first prokaryotes lived, there was almost no free oxygen in the air. Therefore, they were **anaerobic** (didn't breathe oxygen).

They probably ingested amino acids and excreted carbon dioxide and methane.

There are two types of prokaryotes - **bacteria** and **archaea**.
Archaea may have been the earliest form of life on Earth.

They live in extreme environments such as hot springs and deep sea vents.

The conditions in these environments resemble conditions that existed early in the Earth's history.

About 2.7 Billion years ago, bacteria and other simple organisms such as algae evolved. The algae could use energy from the sun to make their own food by photosynthesis. Oxygen was produced as a by-product.

Oxygen levels rose steadily, more and more plants evolved, removing carbon dioxide and increasing the amount of oxygen in the atmosphere.

The first animals evolved which used this oxygen and the plants for food to respire.

Lots of organisms which had evolved in the early atmosphere could not tolerate the high oxygen levels and died out.

Changes in the Atmosphere Q's

Q1. This question is about gases in the Earth's atmosphere.

(a) The amount of carbon dioxide in the Earth's atmosphere decreased during the first billion years of the Earth's existence.

Complete the sentences. Use words from the box.

carbonates	**dissolved**	**evaporated**	**melted**	**nitrates**	**sulfates**

The amount of carbon dioxide in the Earth's atmosphere decreased

because

The carbon dioxide..... in the oceans.

Sediments were formed when ..... were produced.

Algae and plants use carbon dioxide and water to produce oxygen.

(2)

(b) What is the name of this process?

Tick **one** box.

Carbon capture ☐

Combustion ☐

Photosynthesis ☐

Polymerisation ☐

(1)

(c) Complete the word equation for this process.

carbon dioxide + ... → glucose + ...

(1)

(d) Draw **one** line from each gas to the approximate percentage of the gas in the Earth's atmosphere today.

Gas	**Approximate percentage of gas in the Earth's atmosphere today**
	<1
	5

Carbon dioxide	10
Nitrogen	20
	50
Oxygen	80
	>90

(3)

Q2. There is less carbon dioxide in the Earth's atmosphere now than there was in the Earth's early atmosphere.

(a) The amount of carbon dioxide in the Earth's early atmosphere decreased because it was used by plants and algae for photosynthesis, dissolved in the oceans and formed fossil fuels.

Give **one** other way that the amount of carbon dioxide in the Earth's early atmosphere decreased.

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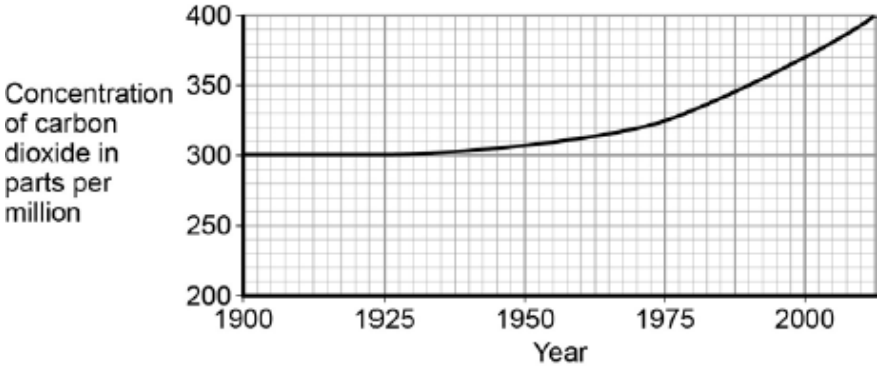
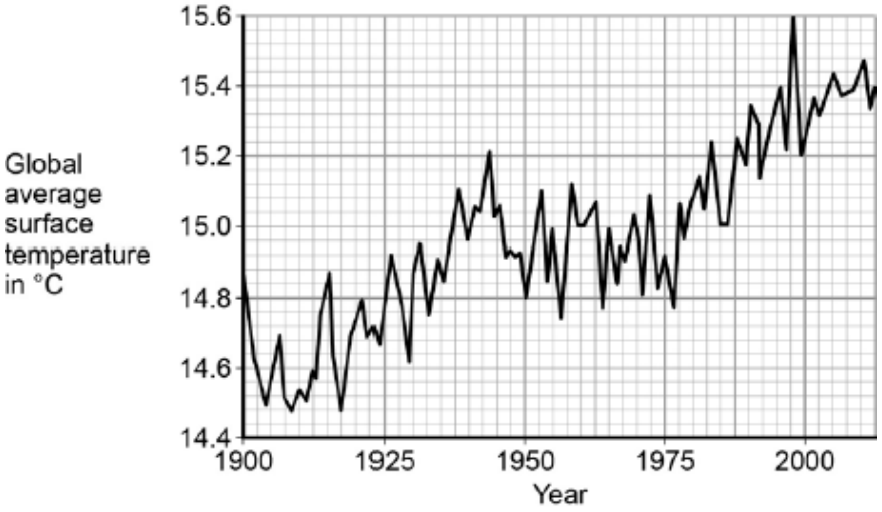
(1)

(c) The graphs in **Figure 1** show the concentration of carbon dioxide in the atmosphere and global average surface temperature since 1900.**Figure 1**

Graph A



Graph B



Calculate the percentage increase in the concentration of carbon dioxide from 1975 to 2000.

..... %

(1)

(d) What was the global average surface temperature in 1980?

Global average surface temperature =
..... °C

(1)

(e) A student stated: 'The graphs show that increasing the concentration of carbon dioxide in the atmosphere causes global temperature increases.'
Discuss why this statement is only partially true.

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.....(4)

Our evolving atmosphere

Where did all the carbon dioxide of the early atmosphere go?

The carbon dioxide has gone into living organisms and into the materials formed from living organisms.

Carbon dioxide is converted into glucose during photosynthesis. This can end up in new plant material. Some of this carbon can be transferred to animal tissue when they eat the plants. Some of which is contained within their skeletons and shells.

Over millions of years, the skeletons and shells of huge numbers of these marine organisms built up at the bottom of vast oceans. They became covered with layer upon layer of fine sediment. The pressure caused by the build up of all these layers formed sedimentary carbonate rocks such as limestone, a rock principally formed from calcium carbonate.

Some remains of ancient living things were crushed by large scale movements in the Earth. Over a long period of time, the pressure and heat formed fossil fuels, coal, oil and natural gas.

Coal

Coal is classed as a sedimentary rock. It was formed from thick deposits of plant materials. When plants died in swamps, they were buried, in the absence of oxygen, and compressed over millions of years

Crude oil and natural gas

These fossil fuels were formed from the remains of plankton deposited in mud on the sea bed. The remains were covered by sediments which became layers of rock when compressed over millions of years. The oil and gas deposits are trapped beneath these layers of rock.

Carbon dioxide also dissolved in the oceans, it reacted with metal oxides and formed insoluble carbonate compounds. These fell to the seabed as sediments helping to form more carbonate rocks.

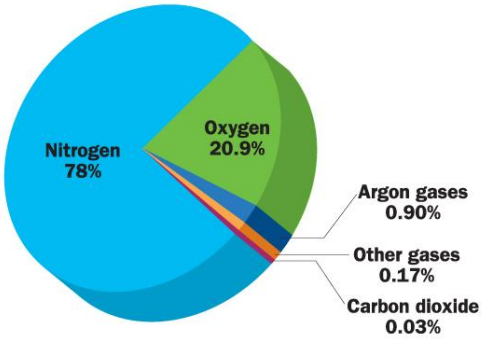
Over the **past 200 million years**, the level of carbon dioxide in the atmosphere has not changed much. **The carbon cycle** moves carbon between the oceans, rocks and the atmosphere.

In Earth's early history volcanoes produced nitrogen gas, Ammonia and methane may have also been produced.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

The nitrogen formed is unreactive so the levels of nitrogen gas in our atmosphere built up.



Nitrogen	Oxygen	Argon	Carbon dioxide	Other gases

Fill in the percentage proportions of gases in the atmosphere using the pie chart

Argon is the most abundant noble gas, Neon, Krypton and xenon together make up less than 0.1 % of dry clean air.

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Sediments were formed when ..... were produced.

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Tick **one** box.

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(1)

(c) Complete the word equation for this process.

carbon dioxide + ... → glucose + ...

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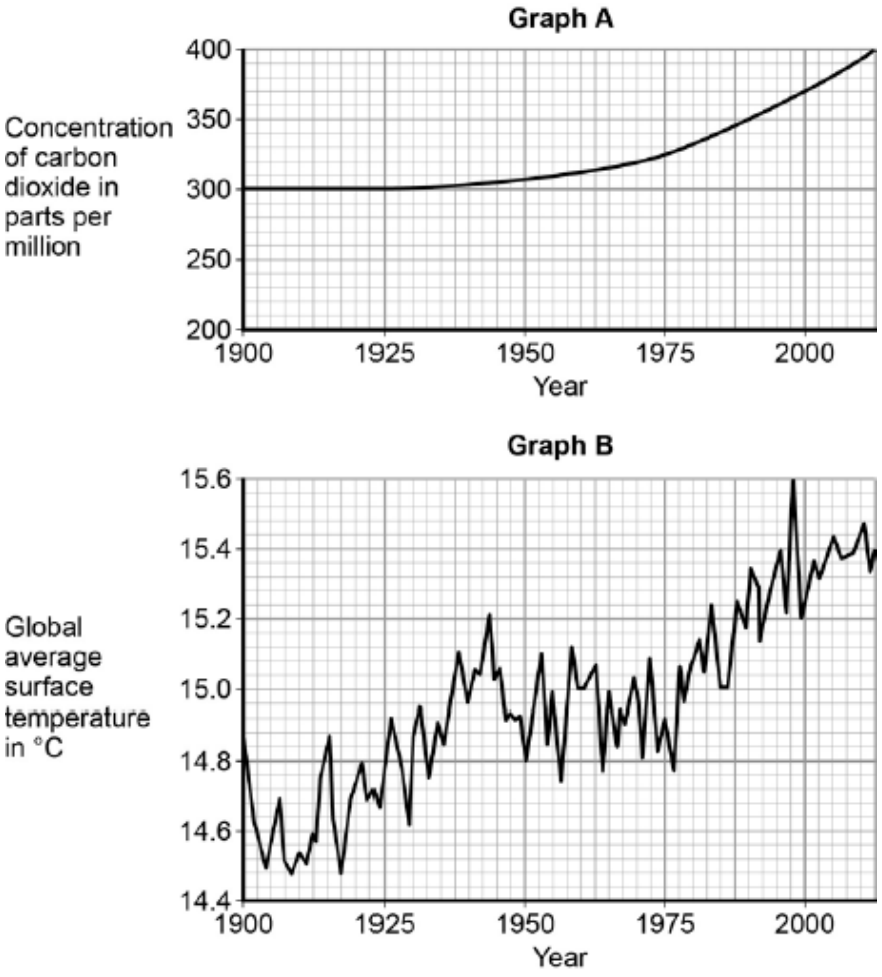

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.....(4)

Q1. The amount of carbon dioxide in the Earth's atmosphere has changed since the Earth was formed. The amount of carbon dioxide continues to change because of human activities.

(a) Cement is produced when a mixture of calcium carbonate and clay is heated in a rotary
kiln. The fuel mixture is a hydrocarbon and air.

Hydrocarbons react with oxygen to produce carbon dioxide.
Calcium carbonate decomposes to produce carbon dioxide.

(I) Complete each chemical equation by writing the formula of the other product.

$CH_4 + 2O_2 \longrightarrow 2$ ..... $+ CO_2$

$CaCO_3 \longrightarrow$ ..... $+ CO_2$

(2)

(ii) Hydrocarbons and calcium carbonate contain *locked up* carbon dioxide.

What is *locked up* carbon dioxide?

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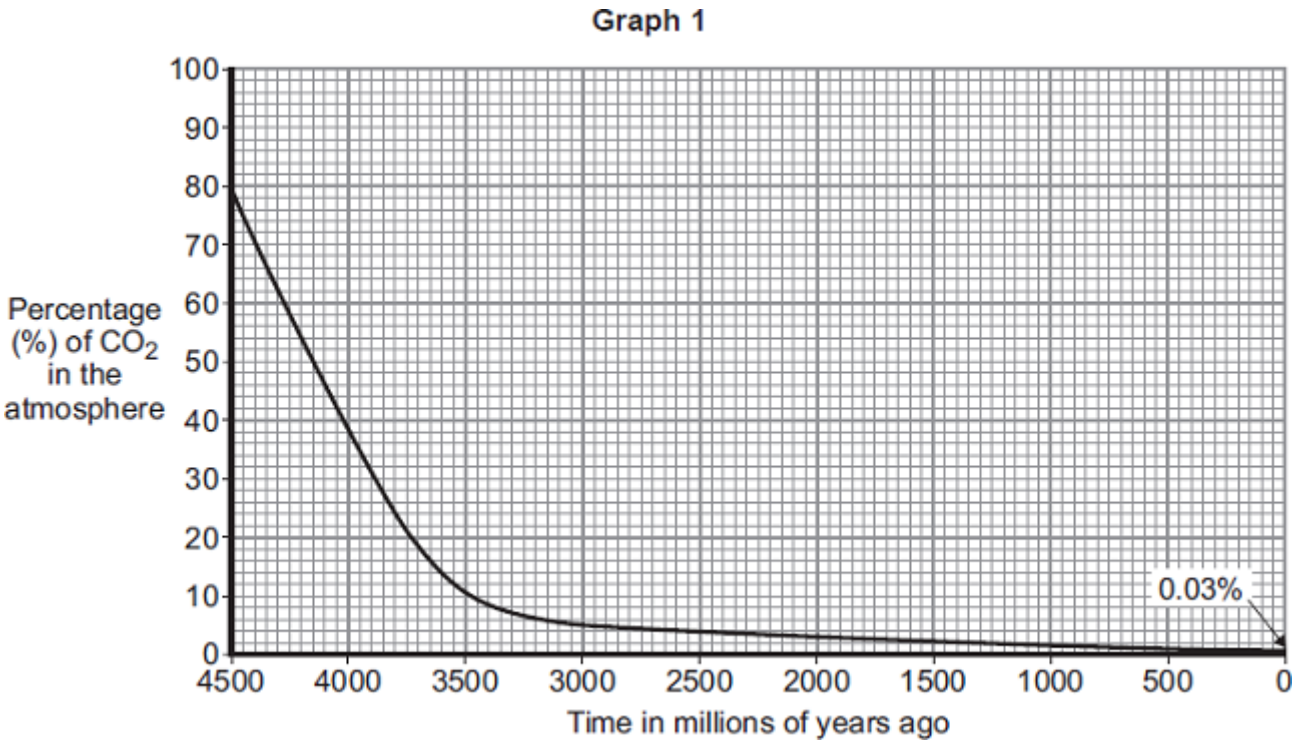
(2)

(b) **Graph 1** shows how the percentage of carbon dioxide in the atmosphere changed in the last 4500 million years.



Use information from **Graph 1** to answer these questions.

(i) Describe how the percentage of carbon dioxide has changed in the last 4500 million years.

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(2)

(ii) Give **two** reasons why the percentage of carbon dioxide has changed.

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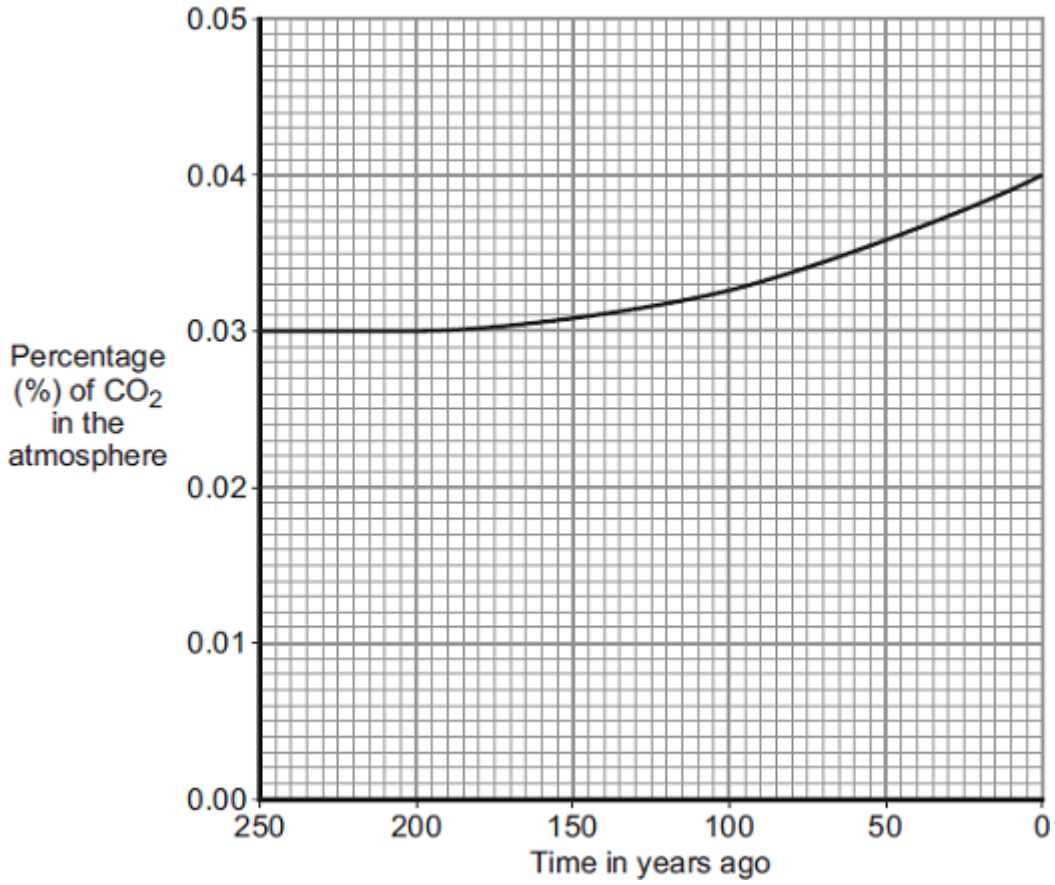
(2)

(c) **Graph 2** shows how the percentage of carbon dioxide in the atmosphere changed in the last 250 years.

Graph 2



Should we be concerned about this change in the percentage of carbon dioxide?

Explain your answer.

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(2)
(Tota 10 marks)

Q2. Many human activities result in carbon dioxide emissions.
Our carbon footprint is a measure of how much carbon dioxide we each cause to be produced.

(a) Why should we be concerned about our carbon footprint?

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(1)

(b) Most power stations in the UK burn coal.
Coal was formed from tree-like plants over millions of years.

Suggest why burning wood instead of coal would help to reduce our carbon footprint.

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(3)
(Total 4 marks)

Q3. (a) For the last 200 million years the amount of carbon dioxide in the atmosphere has remained almost the same.

Describe the natural processes which remove carbon dioxide from the atmosphere.

To gain full marks in this question you should write your ideas in good English.
Put them into a sensible order and use the correct scientific words.

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(4)

(b) The amount of carbon dioxide in the atmosphere has increased over the last one hundred years. Suggest **two** reasons why this has happened.

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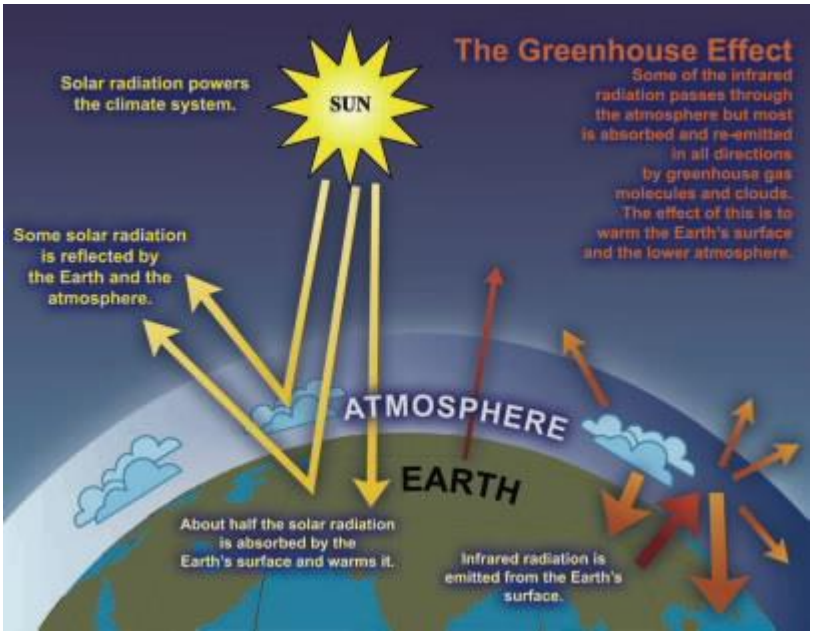
(2)

(Total 6 marks)

Greenhouse gases



30 % of the sun's radiation is reflected by the atmosphere and the Earth's surface. Some short wavelength radiation (e.g. UV) is absorbed and warms the earth. The Earth as it cools emits radiation of a longer wavelength (I.R. radiation.). This radiation does not pass through the greenhouse gases but it is absorbed. The bonds within these molecules vibrate more bend and stretch more vigorously, raising their temperature. So the energy radiated from the Earth's surface is essentially trapped in the atmosphere and the temperature raises. The greater the proportion of greenhouse gases in the air the more energy is absorbed.

What are the main greenhouse gases?

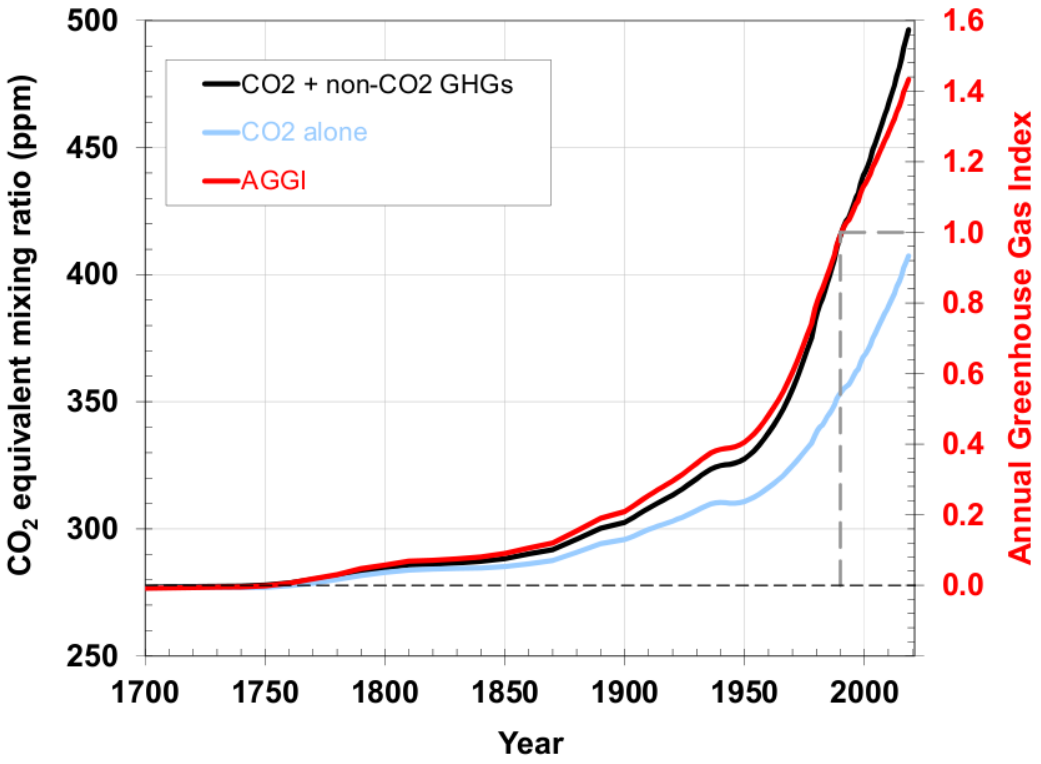
Carbon dioxide, methane and water are the main 'greenhouse gases'. The levels of carbon dioxide have greatly increased. More fossil fuels are being used than ever before, to make electricity, heat homes and run cars. All the carbon which has been locked up in these fossil fuels for millions of years is being released into the atmosphere.

Task: Balance the equation

$$C_3H_8 + O_2 \rightarrow CO_2 + H_20$$

Methane gets into the atmosphere from swamps and rice fields. Another source of methane is emissions from the growing number of grazing cattle, and from their

decomposing waste. The increasing human population produces more waste for landfill sites, which are another source of methane.



Task: Describe the change in the CO_2 equivalent mixing ratio in ppm over time

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Scientists use ice cores from Greenland's ice sheets to compare the atmospheric composition over a long period of time. Bubbles of gas trapped when the snow fell is contained within the core, the ice core is heated gently and the gas released is analysed. The current levels are greater than at any time in the last 440,000 years.

<u>Global climate change</u>

Climate change occurs when changes in Earth's climate system result in **new weather patterns** that remain in place **for an extended period of time**. This length of time can be as short as a few decades to as long as millions of years.

Consequences of rising levels of greenhouse gases

Rising sea levels as a result of melting ice caps and expansion of the warmer oceans. This may cause flooding of low lying land and increased coastal erosion.

Increasingly common extreme weather events like severe storms
Changes in temperature and the amount, timing and distribution of rainfall. This could Impact on the food-producing capacity of different regions

Changes to the distribution of wildlife species, decrease in biodiversity putting stress on ecosystems around the globe.

<u>Solutions to tackle the problem of global climate change</u>

The carbon footprint of a product, service or event is the total amount of carbon dioxide and other greenhouse gases emitted over its full life cycle.

Carbon capture and storage: Pumping carbon dioxide produced from burning fossil fuels used to generate electricity deep underground to be absorbed into porous rock. It has been estimated that the cost of electricity would rise by 10 %

Reducing Methane from cattle:
Reducing the number of cattle with more people having a plant based diet reduces methane emmisions. Plant based diets offer a greater efficiency than meat ones.

Carbon taxes: Government can tax cars which use a lot of petrol and diesel. Offer tax relief to companies that plant trees to offset the emissions

Use of biofuels: Biofuels absorb they same quantity of carbon dioxide when they are photosynthesising as released when they are being. They are described as being carbon neutral.

Problems of trying to reduce the global carbon footprint.

Lack of international co-operation on setting targets for the reduction of greenhouse gas emissions.
Restrictions will have cost implications in all manufacturing and transport industries

Restrictions could hinder the developing industries of poorer countries.

More individuals need to start to believe that their small contributions will have an effect. For example, recycling, using public transport, using less electricity will all reduce our use of fossil fuels and lower carbon dioxide emissions.

Q1. This information about diesel was printed in a magazine.

Almost all of the crops that we eat can be converted into fuel for cars.
Vegetable oils can be used as biodiesel. Diesel from crude oil is called fossil diesel.
When either biodiesel or fossil diesel burn they both produce similar amounts of carbon dioxide.
Both types of diesel produce carbon monoxide. However, biodiesel produces fewer carbon particles and less sulfur dioxide.

(a) Carbon monoxide can be produced when diesel burns in a car engine. Explain how.

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(2)

(b) Use the information at the start of this question and your knowledge and understanding to evaluate the use of biodiesel compared with fossil diesel as a fuel for cars.

Remember to give a conclusion to your evaluation.

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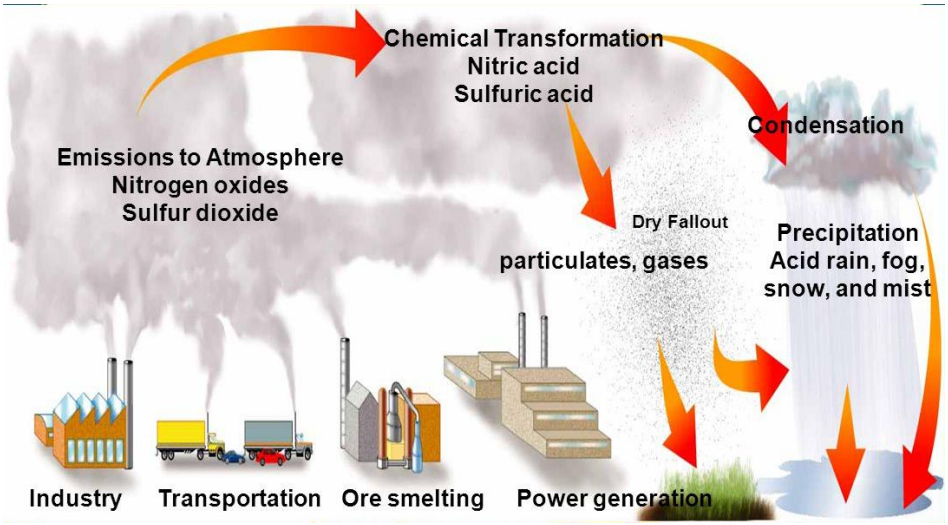
(5)
(Total 7 marks)

Atmospheric pollutants

Impurities in all fossil fuels when they burn can cause major problems. Sulfur for example forms Sulfur dioxide, an acidic gas which is toxic. The sulfur dioxide produced is a cause of acid rain, which damages trees, kills plants and animals in lakes. Acid rain can damage buildings especially those made of limestone and metal structures.

The sulfur impurities can be removed from a fuel before it is burnt, this happens in gas-fired power stations and also for the petrol and diesel used in cars.

In coal-fired power stations the sulfur dioxide in the flue or waste gases is removed by reacting it with basic calcium oxide or calcium hydroxide.



In a car engine when fuel is burnt, if there is not enough oxygen present incomplete combustion occurs. The carbon dioxide gas formed is toxic. Carbon monoxide takes up the sites on Haemoglobin that oxygen usually occupies. If a person continues to breathe it in they become drowsy lose consciousness and will die if not removed from the source of the gas.

In the high temperatures within a car's engine the usually unreactive gas nitrogen can form nitrogen oxides. These too are also toxic and can trigger asthma and also contribute to the formation of acid rain.

In diesel engines, the hydrocarbon molecules used for the fuel are larger. The molecules do not always burn completely and the exhaust gas can contain carbon particulates – carbon and unburnt hydrocarbons. These are believed to be responsible for global dimming (The particulates travel up into the upper atmosphere and reflect sunlight back into space). It is also believed that particulates can damage cells in the lungs and may even cause lung
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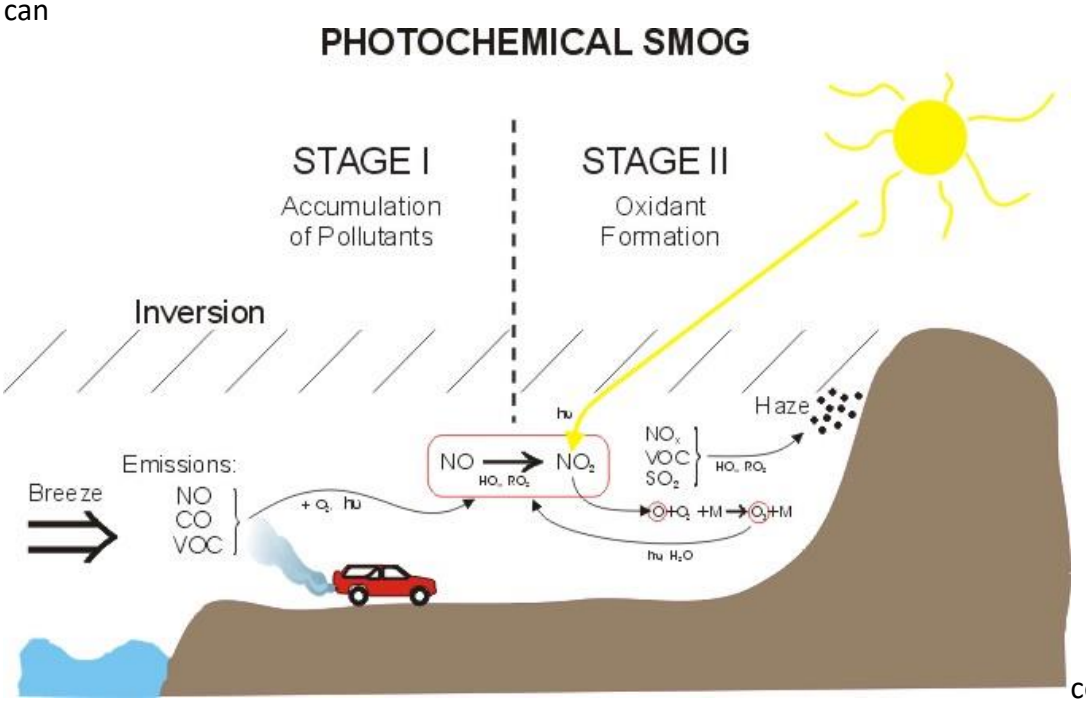

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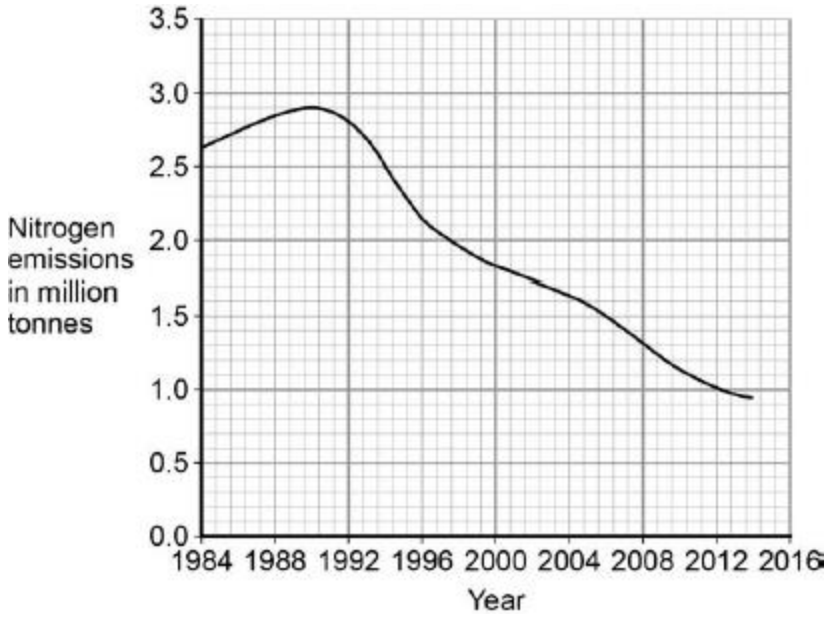
Q1. Oxides of nitrogen are produced when fuels are burnt.

(b) The figure below gives information about emissions of oxides of nitrogen in the UK.



Calculate the percentage decrease in emissions of oxides of nitrogen from 1990 to 2014.

Give your answer to three significant figures.

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Percentage decrease =
..... %

(3)

(c) Give **one** advantage of reducing the emissions of oxides of nitrogen.

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(1)

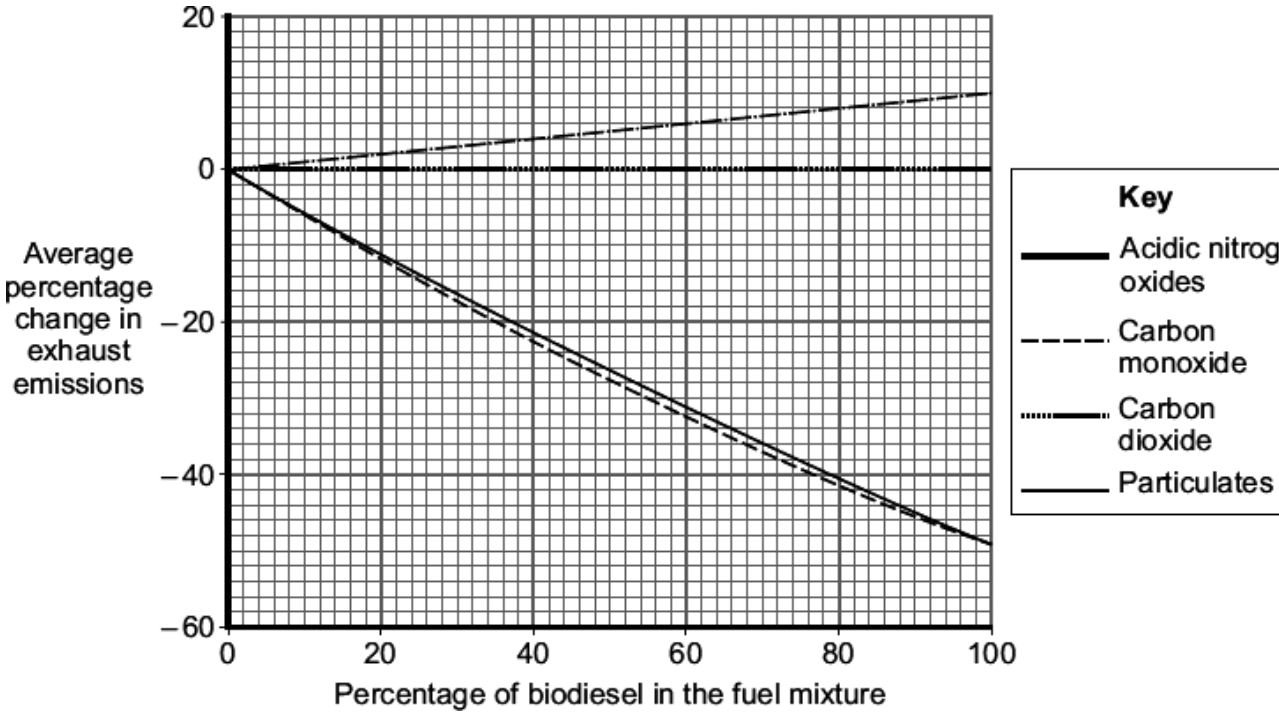
(Total 6 marks)

Q2. Petroleum diesel is produced from crude oil.

Most vehicles that use petroleum diesel as fuel can also use biodiesel or a mixture of these two fuels. In the UK (in 2010) there must be 5 % biodiesel in all petroleum diesel fuel.

Biodiesel is produced from plant oils such as soya. The crops used to produce biodiesel can also be used to feed humans. The benefit that biodiesel is 'carbon neutral' is outweighed by the increasing demand for crops. This increasing demand is causing forests to be burnt to provide land for crops to produce biodiesel. Only a huge fall in the price of petroleum diesel would halt the increasing use of biodiesel.

The graph shows the average percentage change in exhaust emissions from vehicles using different mixtures of petroleum diesel and biodiesel.



There is no difference in carbon dioxide emissions for all mixtures of petroleum diesel and biodiesel.

Use the information and your knowledge and understanding to evaluate the use of plant oils to produce biodiesel. Remember to give a conclusion to your evaluation.

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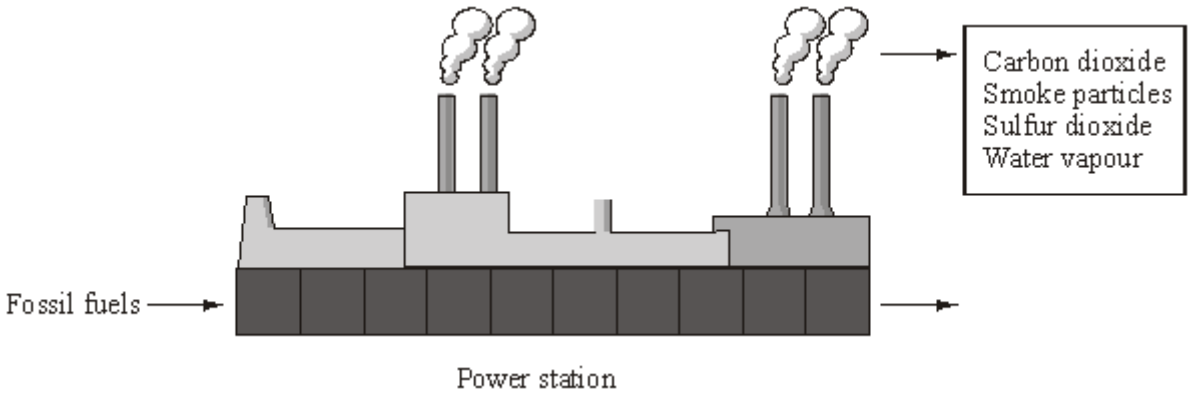
Q3. Most electricity in the UK is generated in power stations that burn fossil fuels. The diagram lists some of the substances released into the air when fossil fuels are burned.



(a) (i) Which **one** of the substances released into the air causes acid rain?

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(1)

(ii) In the sentence below, draw a ring around the correct answer.

The type of environmental pollution caused by

smoke particle is	global dimming global warming rising sea levels

(1)

(iii) Suggest how the burning of fossil fuels may cause climate change.

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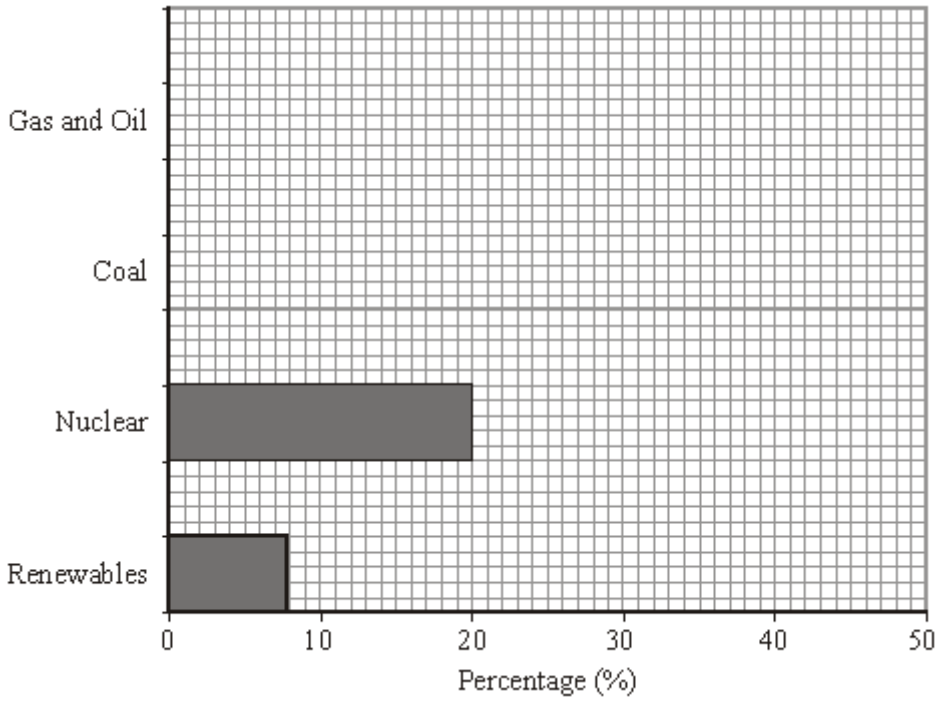
(2)

(b) The table shows the percentage of electricity generated by different energy sources.

Energy sources	Renewables	Nuclear	Coal	Gas and Oil
Percentage (%)	8	20	32	40

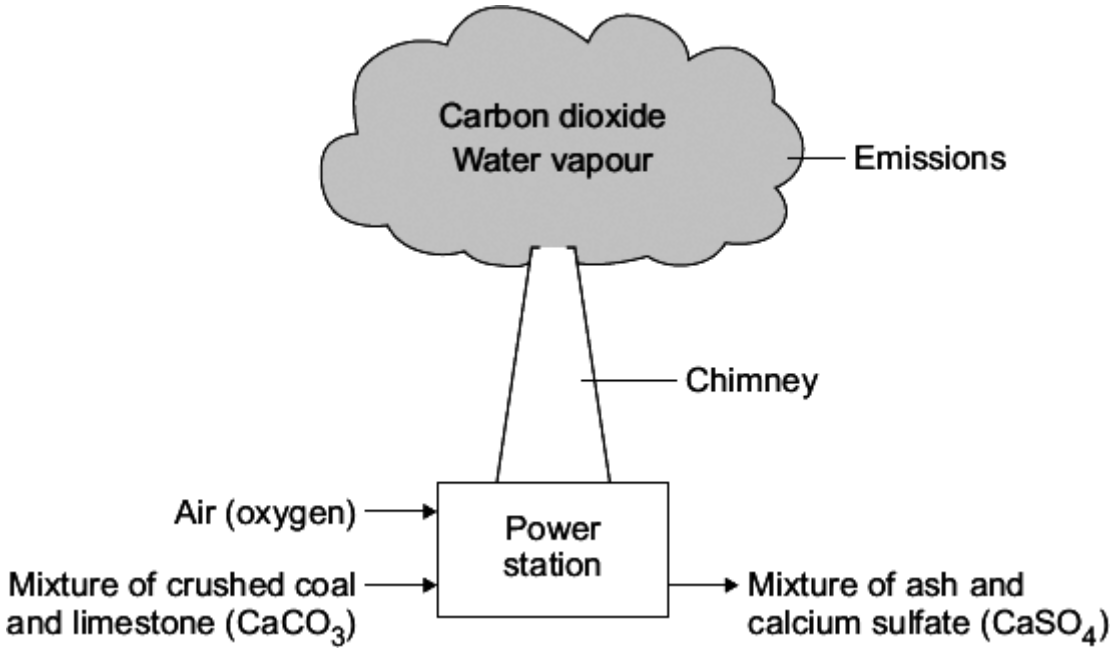
Complete the bar chart to show the percentage of electricity generated by coal and by gas and oil.



(2)

(Total 6 marks)

Q4. Most power stations burn coal to generate electricity. Burning coal gives off sulfur dioxide gas which can be removed from the waste gases by using limestone.
This prevents sulfur dioxide from entering the atmosphere and causing acid rain.
One disadvantage of using limestone in a power station is that it releases 'locked up carbon dioxide' into the atmosphere.



(a) How does the limestone used in a power station:

(i) release carbon dioxide

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(1)

(ii) remove sulfur dioxide?

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(1)

(b) The waste gases from the chimney are monitored. One toxic gas that should not be released is carbon monoxide.

Explain how carbon monoxide would be formed.

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(2)

(c) The use of limestone in a power station releases 'locked up carbon dioxide' into the atmosphere.

(i) Explain the meaning of 'locked up carbon dioxide'.

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(2)

(ii) Why does the release of this carbon dioxide cause an environmental problem?

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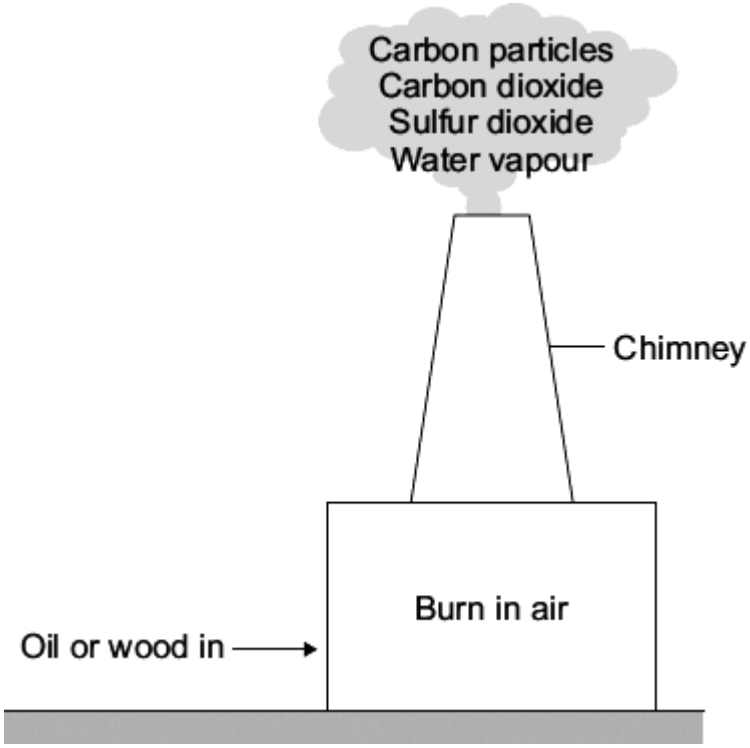
(1)

(Total 7 marks)

Q5. In the future:

- there will be fewer oil burning power stations
- there may be more wood burning power stations.



(a) Which **one** of the emissions from the chimney can cause acid rain?

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(1)

(b) Draw a ring around the correct answer to complete the sentence.

Carbon particles in the Earth's atmosphere cause

acid rain.
global dimming.
global warming.

(1)

(c) Which gas in the air is needed for oil or wood to burn?

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(1)

(d) Suggest why there will be **fewer** power stations burning oil in the future.

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(1)

(e) Some power stations burn wood.
The wood comes from trees grown in forests.

Suggest why burning wood in power stations is said to be 'carbon-neutral'.

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(2)
(Total 6 marks)