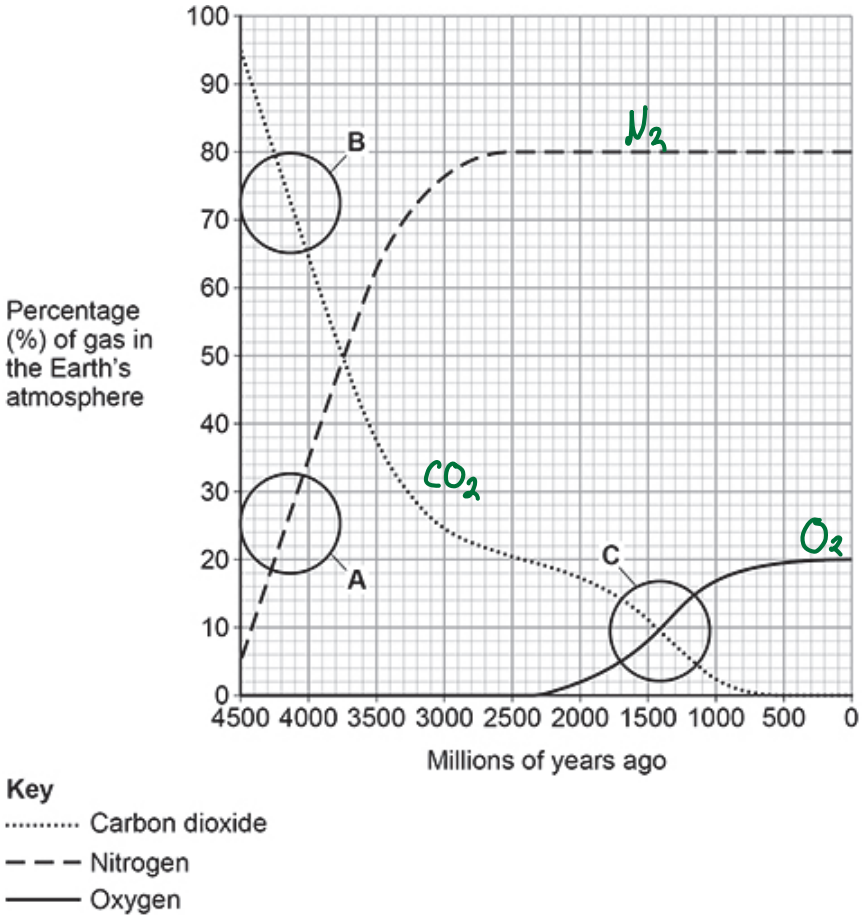
**All questions are for both separate science and combined science students**

## Q1.

This question is about the chemistry of the Earth's atmosphere.

The figure below shows how the percentages of gases in the Earth's atmosphere may have changed since the atmosphere was formed.




(a) Explain the change in the percentage of gas in the region labelled **A** on the figure above.

A shows that the percentage of Nitrogen increased. This is because of intense volcanic activity.

**(2)**

(b) Explain the change in the percentage of gas in the region labelled **B** on the figure above.

B shows that the percentage of Carbon dioxide decreased.
This is because carbon dioxide dissolved in oceans or formed carbonate precipitates

**(2)**

(c) Compare the changes in the percentages of gases in the region labelled **C** on the figure above.

C shows the percentage of carbon dioxide decreased and the percentage of oxygen increased, both occur at the same time and at a similar rate.

**(2)**

(d) What process caused the changes in the percentages of gases in the region labelled **C** on the figure above?

Photosynthesis
(interconversion of $CO_2$ and $O_2$)

**(1)**

(e) Natural gas is a fossil fuel.

Describe how deposits of natural gas were formed.

Plankton (marine organisms) died and were covered by sediments (anaerobic conditions) and subject to high pressure, over millions of years.

**(3)**

**(Total 10 marks)**

**Questions are for both separate science and combined science students unless indicated in the question**

## Q1.

This question is about burning fuels in central heating boilers.

In the future, gas central heating boilers may burn hydrogen rather than natural gas.

The table below shows information about these fuels when 1 $dm^3$ of the fuel is burned in a central heating boiler.

| | Fuel | |
|---|---|---|
| | **Hydrogen** | **Natural gas** |
| Energy released in kJ | 11.9 | 37.1 |
| Mass of carbon dioxide produced in grams | 0.00 | 1.83 |
| Mass of water vapour produced in grams | 0.75 | 1.50 |
| Mass of oxides of nitrogen produced in grams | $6.6 \times 10^{-4}$ | $4.9 \times 10^{-4}$ |

Hydrocarbon

(a) Explain how oxides of nitrogen are produced when burning fuels.

Nitrogen and oxygen from the air react together under high temperature conditions.

**(2)**

(b) Explain **one** positive impact on the environment of burning hydrogen rather than natural gas as a fuel.

Use the table above.

From the table above, burning hydrogen does not produce any carbon dioxide.
So one positive impact would be less climate change.

**(2)**

(c) Explain **one** negative impact on the environment of burning hydrogen rather than natural gas as a fuel.

Use the table above.

Slightly more oxides of nitrogen will be produced
This will produce increased acid rain
(or respiratory problems)

**(2)**

(d) Air is 20% oxygen.

1 mole gas = 24 $dm^3$ at RTP

Calculate the volume of air needed to provide enough oxygen to react with 3.50 $dm^3$ of hydrogen gas. **(chemistry only) (HT only)**

The equation for the reaction is

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

2 : 1

2 moles of $H_2$ require 1 mole of $O_2$
3.5 $dm^3$ " " " $\frac{3.5}{2}$ " " " = 1.75 $dm^3$
BUT air is only 20% $O_2$
Volume of air = 1.75 $dm^3$ × $\frac{100}{20}$ = 8.75 $dm^3$

Volume of air = 8.75 $dm^3$

**(3)**

(e) Central heating boilers can also burn kerosene.

Kerosene is produced from crude oil in a fractionating column using fractional distillation.

In the first step, crude oil is heated and hydrocarbon vapours are formed.

Explain how kerosene is produced from these hydrocarbon vapours.

The fractionating column is heated at the base and has a temperature gradient, the column is cooler toward the top.
Kerosene vapours condense at the level in the column corresponding to kerosenes boiling point range.

**(3)**

**(Total 12 marks)**

**Q2.**

This question is about greenhouse gases and climate change.

Carbon dioxide and methane are greenhouse gases.

(a) Which of the following is also a greenhouse gas?

Tick (✓) **one** box.

| | |
|---|---|
| Chlorine | ☐ |
| Nitrogen | ☐ |
| Oxygen | ☐ |
| Water vapour | ✓ |

**(1)**

In the past 50 years, there has been an increase in:

- the world population
- the concentration of carbon dioxide in the atmosphere
- the concentration of methane in the atmosphere
- the mean temperature of the atmosphere at the Earth's surface.

Most scientists think this information can be used to explain climate change.

(b) Explain why the increase in world population may have caused the increase in the concentration of carbon dioxide in the atmosphere.

An increased population requires more energy, so more fossil fuels are burned.

**(2)**

(c) Explain why the increase in world population may have caused the increase in the concentration of methane in the atmosphere.

An increased population requires more food, so more methane-producing food production.

**(2)**

(d) Describe **two** potential effects of the increase in the mean temperature of the atmosphere at the Earth's surface.

1 Melting ice

2 Increased sea levels

**(2)**

(e) The mean temperature of the atmosphere at the Earth's surface has increased.

Most scientists think that this has been caused by an increase in the concentration of greenhouse gases in the atmosphere.

Give **one** reason why some scientists do **not** accept this theory.

There may be other reasons for the changes in the mean temperature.

**(1)**

**(Total 8 marks)**

**Q2.**

This question is about the fractions obtained from crude oil.

(a) Crude oil is separated into fractions by fractional distillation.

The fractions obtained from crude oil include:

- lubricating oil
- naphtha
- petroleum gases.

**Table 1** shows the boiling point range of these fractions.

**Table 1**

| Fraction | Boiling point range in °C |
|---|---|
| Lubricating oil | 300–350 |
| Naphtha | 90–200 |
| Petroleum gases | < 25 |

Explain how these fractions are obtained from crude oil by fractional distillation.

Crude oil is heated to vaporise the hydrocarbons. The fractionating column is heated at the base and has a temperature gradient, the column is cooler toward the top.
Gases condense at different levels, so lubricating oil condenses below naptha and petroleum gases do not condense, because of their different boiling points

**(4)**

(b) Fractions from crude oil can be processed to produce feedstock for the petrochemical industry.

Which **two** are useful materials produced from this feedstock?

Tick (✓) **two** boxes.

| | |
|---|---|
| Alloys | ☐ |
| Ceramics | ☐ |
| Detergents | ☑ |
| Fertilisers | ☐ |
| Solvents | ☑ |

**(2)**

Another fraction obtained from crude oil is petrol.

(c) Petrol contains a hydrocarbon with the formula $C_9H_{20}$

Complete the equation for the complete combustion of $C_9H_{20}$

You should balance the equation.

$C_9H_{20} + \underline{14\ O_2} \rightarrow \underline{9\ CO_2} + \underline{10\ H_2O}$

28 O

**(2)**

(d) Petrol obtained from crude oil contains sulfur impurities.

Explain why sulfur impurities are removed before petrol is burned in car engines.

When sulfur impurities are burned, they produce sulfur dioxide ($SO_2$) which causes acid rain and respiratory problems.

**(2)**

(e) **Table 2** shows information about two more fractions obtained from crude oil.

**Table 2**

| Fraction | Range of number of carbon atoms in each molecule |
|---|---|
| Kerosene | 11–15 |
| Heavy fuel oil | 20–40 |

A student predicted that heavy fuel oil is more viscous than kerosene.

The student's prediction was correct.

Justify the student's prediction.

As molecular size increases, viscosity increases and heavy fuel oil has larger molecules than Kerosene.

**(2)**

The heavy fuel oil fraction can be processed to produce smaller hydrocarbon molecules.

(f) Name the process which produces smaller hydrocarbon molecules from heavy fuel oil.

Give the conditions used in this process.

Name of process Cracking

Conditions High temperature
Steam or catalyst.

**(3)**

(g) Hydrocarbon molecules containing seven and eight carbon atoms can be produced when heavy fuel oil is processed.

Which pair of hydrocarbon molecules would **both** turn bromine water colourless?

Tick (✓) **one** box.

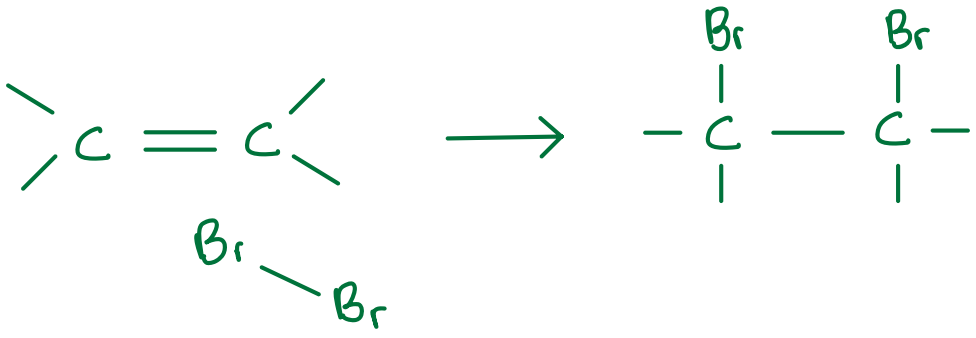
Must contain a double bond C=C!

Alkenes $C_nH_{2n}$

- $C_7H_{14}$ and $C_8H_{16}$ ✓
- $C_7H_{14}$ and $C_8H_{18}$
- $C_7H_{16}$ and $C_8H_{16}$
- $C_7H_{16}$ and $C_8H_{18}$

**(1)**

**(Total 16 marks)**



Alkenes

$C_nH_{2n}$