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.

<table>
<thead>
<tr>
<th>carbonates</th>
<th>dissolved</th>
<th>evaporated</th>
<th>melted</th>
<th>nitrates</th>
<th>sulfates</th>
</tr>
</thead>
</table>

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.

\[
\text{carbon dioxide} + \text{_______________} \rightarrow \text{glucose} + \text{_______________}
\]

(1)
(d) Draw one line from each gas to the approximate percentage of the gas in the Earth’s atmosphere today.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Approximate percentage of gas in the Earth's atmosphere today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Oxygen</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>&gt;90</td>
</tr>
</tbody>
</table>

(e) Carbon dioxide is a greenhouse gas.

Why does increasing the amount of carbon dioxide change the global climate?

___________________________________________________________________
(f) How can countries reduce carbon dioxide emissions?

Tick one box.

- only burn methane
- use renewable energy supplies
- use waste plastic bags as fuel

(1)

(g) Give one reason why it is difficult for countries to reduce emissions of carbon dioxide.

___________________________________________________________________
___________________________________________________________________

(1)

(Total 10 marks)

A student investigated the substances produced when fuels burn.

The figure below shows the apparatus the student used.

(a) The complete combustion of a hydrocarbon produces carbon dioxide and one other substance.

Look at the figure above. What would the student see in tube A?

___________________________________________________________________
___________________________________________________________________

(1)
(b) When the student burned the fuel she saw soot in the funnel.

Explain why soot forms.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) The student burned another fuel which contained impurities.

The substance in tube B is water containing universal indicator.

The indicator turned red.

Which gas made the indicator turn red?

Tick one box.

Ammonia

Carbon monoxide

Nitrogen

Sulfur dioxide

(1)

(Total 4 marks)

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.

___________________________________________________________________
___________________________________________________________________

(1)
(b) Carbon dioxide is a greenhouse gas.

Describe the greenhouse effect.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4)
(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](concentration of carbon dioxide)

![Graph B](global average surface temperature)

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)
 Millions of years ago the Earth’s atmosphere was probably like the atmosphere of Mars today.

(a) The table below shows percentages of the main gases in the atmospheres of Earth and Mars today.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage in atmosphere of Mars today</th>
<th>Percentage in atmosphere of Earth today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>95.00</td>
<td>0.04</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>3.50</td>
<td>78.00</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.50</td>
<td>21.00</td>
</tr>
</tbody>
</table>

For each gas in the table, suggest a reason for the change in the percentage of the gas in Earth’s atmosphere.

Carbon dioxide ______________________________________________________

___________________________________________________________________

Nitrogen ___________________________________________________________

___________________________________________________________________

Oxygen ____________________________________________________________

___________________________________________________________________
(b) The figure below shows how the concentration of carbon dioxide in the Earth's atmosphere changed between 1900 and 2000.

One of the causes of the increase in carbon dioxide between 1900 and 2000 is increased use of fossil fuels.

Suggest when use of fossil fuels began to increase.

Use data from the figure above to explain your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) What is the percentage increase in carbon dioxide levels between 1970 and 2000?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Increase = _______________ %

(3)
(d) Explain how the changes shown in the figure above can have harmful effects on the environment.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4)
(Total 12 marks)

Oxides of nitrogen are produced when fuels are burnt.

(a) Write a balanced symbol equation for the production of nitrogen dioxide (NO₂) from nitrogen and oxygen.

___________________________________________________________________

(2)
(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.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Percentage decrease = __________________ %

(3)

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

___________________________________________________________________
___________________________________________________________________

(1)  
(Total 6 marks)
6  In the last 200 years the concentration of carbon dioxide in the Earth’s atmosphere has risen.
Explain how a rise in carbon dioxide concentration in the atmosphere can decrease biodiversity.

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

(Total 6 marks)

7  Electricity in the UK is generated in many ways.

The figure below shows an undersea turbine.

The undersea turbine uses tidal energy to generate electricity.

(a) What is the original source of energy for tidal power schemes?

_______________________________________________________________________

(1)
(b) **Explain two advantages of using undersea tidal turbines to generate electricity rather than burning fossil fuels.**

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________

(4)

(c) Some power stations burn wood instead of fossil fuels to generate electricity.

A coal-burning power station burns 6 million tonnes of coal per year.

Coal has an average energy value of 29.25 MJ per kg.

Wood chip from willow trees has an energy value of 13 MJ per kg.

A hectare of agricultural land can produce 9 tonnes of dry willow wood per year.

If this power station burned dry willow wood instead of coal, how much agricultural land would be needed to grow the willow?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Amount of land needed = _______________ hectares

(3)
(d) The table below shows the carbon dioxide emissions of four fuels used to generate electricity.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Direct CO₂ emissions in kg per MWh</th>
<th>Lifecycle CO₂ emissions in kg per MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>460</td>
<td>540</td>
</tr>
<tr>
<td>Natural gas</td>
<td>185</td>
<td>215</td>
</tr>
<tr>
<td>Oil</td>
<td>264</td>
<td>313</td>
</tr>
<tr>
<td>Wood</td>
<td>2100</td>
<td>58</td>
</tr>
</tbody>
</table>

Direct CO₂ emissions are the amounts of carbon dioxide released when the fuel is burned.

Lifecycle CO₂ emissions is the total amount of carbon dioxide released during all stages from fuel extraction to when the fuel has been used.

Use the data from the table above to explain why wood is considered to be a low carbon dioxide emitting fuel.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(2)

This question is about copper.

(a) Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

\[ \text{Cu}_2\text{S}(s) + \text{O}_2(g) \rightarrow 2 \text{Cu}(s) + \text{SO}_2(g) \]

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(2)
Copper atoms are oxidised at the positive electrode to $\text{Cu}^{2+}$ ions, as shown in the half equation.

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

(i) How does the half equation show that copper atoms are oxidised?

(ii) The $\text{Cu}^{2+}$ ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

Write a balanced half equation for the reaction at the negative electrode.

(iii) Suggest a suitable electrolyte for the electrolysis.
(c) Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________

(4)

(d) Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil.

Describe how copper compounds are extracted by phytomining.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
(e) A compound in a copper ore has the following percentage composition by mass:

55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.

Relative atomic masses \( (A_r) \): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Empirical formula = ______________________________

(4)

(Total 16 marks)

Methane (CH\(_4\)) is used as a fuel.

(a) The displayed structure of methane is:

```
  H
 /|
 H — C — H
 /|
  H
```

Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)
(b) Why is methane a compound?

Tick (√) one box.

- Methane contains atoms of two elements, combined chemically.
- Methane is not in the periodic table.
- Methane is a mixture of two different elements.

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

• the activation energy
• the enthalpy change, $\Delta H$.

(ii) Complete and balance the symbol equation for the complete combustion of methane.

\[ \text{CH}_4 + \_\_\_\_\rightarrow \text{CO}_2 + \_\_\_\_ \]
(iii) Explain why the **incomplete** combustion of methane is dangerous.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(3)
Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:

\[
\begin{align*}
\text{H}_3\text{C}=\text{H} + \text{Cl}-\text{Cl} & \rightarrow \text{H}_3\text{C}-\text{Cl} + \text{H}-\text{Cl}
\end{align*}
\]

Some bond dissociation energies are given in the table.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond dissociation energy in kJ per mole</th>
</tr>
</thead>
<tbody>
<tr>
<td>C−H</td>
<td>413</td>
</tr>
<tr>
<td>C−Cl</td>
<td>327</td>
</tr>
<tr>
<td>Cl−Cl</td>
<td>243</td>
</tr>
<tr>
<td>H−Cl</td>
<td>432</td>
</tr>
</tbody>
</table>

(i) Show that the enthalpy change, \(\Delta H\), for this reaction is \(-103\) kJ per mole.
(ii) Methane also reacts with bromine in the presence of sunlight.

\[
\begin{align*}
\text{H} & \quad \text{Br} \\
\text{H} - \text{C} - \text{H} + \text{Br} - \text{Br} & \rightarrow \text{H} - \text{C} - \text{Br} + \text{H} - \text{Br} \\
\end{align*}
\]

This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, \( \Delta H \), is \(-45\) kJ per mole.

What is a possible reason for this?

Tick (✓) one box.

- CH\(_3\)Br has a lower boiling point than CH\(_3\)Cl
- The C–Br bond is weaker than the C–Cl bond.
- The H–Cl bond is weaker than the H–Br bond.
- Chlorine is more reactive than bromine.

(1)

Crude oil is a fossil fuel.

(a) To make crude oil more useful it is separated into fractions.

Use the correct word from the box to complete each sentence.

<table>
<thead>
<tr>
<th>boiling</th>
<th>compound</th>
<th>decomposition</th>
<th>distillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>filtration</td>
<td>mixture</td>
<td>molecule</td>
<td></td>
</tr>
</tbody>
</table>

(i) Crude oil is a _________________________ of different substances.

(ii) The substances in crude oil have different _________________________ points.

(iii) Crude oil is separated by fractional _________________________ .

(Total 15 marks)
Petrol is one of the fractions produced from crude oil.

Car engines use a mixture of petrol and air.

The diagram shows some of the gases produced.

(i) What type of reaction happens to petrol in a car engine?

Tick (✓) one box.

- combustion
- decomposition
- neutralisation

(ii) Petrol contains octane \( \text{C}_8\text{H}_{18} \).

Complete the word equation for the reaction of octane with oxygen.

\[ \text{octane} + \text{______________} \rightarrow \text{______________} + \text{______________} \]

(iii) Cars use sulfur-free petrol as a fuel.

Describe why sulfur should be removed from petrol.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
(c) Some fractions from crude oil contain large hydrocarbon molecules.

These molecules can be cracked to produce smaller, more useful molecules.

An equation for cracking decane is:

\[
\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_3\text{H}_8 + \text{C}_2\text{H}_4 + \text{C}_5\text{H}_{10}
\]

decane propane ethene pentene

(i) Why is propane useful?

Tick (✓) one box.

- Propane is a polymer.
- Propane is an alloy.
- Propane is a fuel.

(ii) Draw bonds to complete the displayed structure of ethene.

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H}
\end{array}
\]

(iii) What is the colour change when bromine water reacts with ethene?

Tick (✓) one box.

- Orange to colourless
- Orange to green
- Orange to red

(1)
(iv) Complete the sentence.

Pentene is useful because many pentene molecules can join together
to form ________________________ .

This question is about life, the Earth and its atmosphere.

(a) There are many theories about how life was formed on Earth.

Suggest one reason why there are many theories.

___________________________________________________________________
___________________________________________________________________

___________________________________________________________________

(1)
In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

This Earth and its atmosphere today are not like the early Earth and its atmosphere.

Describe and explain how the surface of the early Earth and its atmosphere have changed to form the surface of the Earth and its atmosphere today.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(6)
(Total 7 marks)
Sulfur is a non-metal.

Sulfur burns in the air to produce sulfur dioxide, $SO_2$.

(a) Why is it important that sulfur dioxide is not released into the atmosphere?

Tick (✔) one box.

- Sulfur dioxide causes acid rain.
- Sulfur dioxide causes global dimming.
- Sulfur dioxide causes global warming.

(b) Sulfur dioxide dissolves in water.

What colour is universal indicator in a solution of sulfur dioxide?

Give a reason for your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(c) Sulfur dioxide is a gas at room temperature.

The bonding in sulfur dioxide is covalent.

Explain, in terms of its structure and bonding, why sulfur dioxide has a low boiling point.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

___________________________________________________________________
Sulfur dioxide is produced when fossil fuels are burned.

It is important that sulfur dioxide is not released into the atmosphere.

Three of the methods used to remove sulfur dioxide from gases produced when fossil fuels are burned are:

- wet gas desulfurisation (W)
- dry gas desulfurisation (D)
- seawater gas desulfurisation (S).

Information about the three methods is given in the bar chart and in Table 1 and Table 2.

![Bar chart showing percentage of sulfur dioxide removed from waste gases]

**Table 1**

<table>
<thead>
<tr>
<th>Method</th>
<th>Material used</th>
<th>How material is obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Calcium carbonate, CaCO$_3$</td>
<td>Quarrying</td>
</tr>
<tr>
<td>D</td>
<td>Calcium oxide, CaO</td>
<td>Thermal decomposition of calcium carbonate: CaCO$_3$ → CaO + CO$_2$</td>
</tr>
<tr>
<td>S</td>
<td>Seawater</td>
<td>From the sea</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Method</th>
<th>What is done with waste material</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Solid waste is sold for use in buildings. Carbon dioxide is released into the atmosphere.</td>
</tr>
<tr>
<td>D</td>
<td>Solid waste is sent to landfill.</td>
</tr>
<tr>
<td>S</td>
<td>Liquid waste is returned to the sea.</td>
</tr>
</tbody>
</table>
Evaluate the three methods of removing sulfur dioxide from waste gases.

Compare the three methods and give a justified conclusion.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Diagram 1 shows the apparatus used to electrolyse magnesium sulfate solution.

Diagram 1

Gases were given off at both electrodes.
(a) The gas collected at the anode was oxygen.

Draw one line from the test for oxygen to the correct result.

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place a glowing splint in the tube of the gas</td>
<td>The splint relights</td>
</tr>
<tr>
<td></td>
<td>The splint goes out</td>
</tr>
<tr>
<td></td>
<td>There is a squeaky pop</td>
</tr>
</tbody>
</table>

(b) (i) The gas collected at the cathode was hydrogen.

Describe how to test the gas to show that it is hydrogen.

Test

________________________________________________________________________________________

________________________________________________________________________________________

Result

________________________________________________________________________________________

________________________________________________________________________________________

(ii) Why is hydrogen, and not magnesium, produced at the cathode?

________________________________________________________________________________________

________________________________________________________________________________________

(c) A student wanted to use electrolysis to silver plate a metal spoon.

(i) Give one reason why metal spoons are sometimes silver plated.

________________________________________________________________________________________

________________________________________________________________________________________
Diagram 2 shows the apparatus the student used. The student did not set the apparatus up correctly.

### Diagram 2

- **d.c. power supply**
- **Copper sulfate solution**
- **Pure silver**
- **Metal spoon**

The student found that the metal spoon eroded and a thin layer of copper formed on the pure silver electrode.

Suggest two changes that the student must make to his apparatus to be able to silver plate the metal spoon. Give a reason for each change.

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

(4)

(iii) Why is it difficult to electroplate plastic spoons?

________________________________________________________________________________________

(1)

(Total 10 marks)
Fossil fuels contain carbon.

(a) The figure below represents a carbon atom.

Draw a ring around the correct answer to complete each sentence.

(i) The name of the particle with a positive charge is

- an electron.
- a neutron.
- a proton.

(ii) The centre of the atom is called the

- energy level.
- molecule.
- nucleus.

(iii) Use the Chemistry Data Sheet to help you to answer this question.

Use the correct number from the box to complete each sentence.

| 4 | 6 | 8 | 10 | 12 |

The mass number of this carbon atom is

In the periodic table, carbon is in Group

1

Page 31 of 109
Coal is a fossil fuel.

A piece of coal contains:

- 80% carbon
- 9% oxygen
- 1% sulfur
- 5% hydrogen.

The rest of the coal is other elements.

(i) What is the percentage of other elements in this piece of coal?

________________ %

(ii) Coal burns in air to produce carbon dioxide, sulfur dioxide and water.

Draw one line from each product to the type of pollution caused by each product.

<table>
<thead>
<tr>
<th>Product</th>
<th>Type of pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>Acid rain</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Global dimming</td>
</tr>
<tr>
<td>Water</td>
<td>Global warming</td>
</tr>
<tr>
<td></td>
<td>No pollution</td>
</tr>
</tbody>
</table>

(Total 8 marks)
Some theories suggest that the Earth’s early atmosphere was the same as Mars’ atmosphere today.

The table below shows the percentage of four gases in the atmosphere of Mars today and the atmosphere of Earth today.

<table>
<thead>
<tr>
<th>Gases</th>
<th>The atmosphere of Mars today</th>
<th>Earth today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>95.00%</td>
<td>0.04%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>3.50%</td>
<td>78.00%</td>
</tr>
<tr>
<td>Argon</td>
<td>1.00%</td>
<td>0.96%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.50%</td>
<td>21.00%</td>
</tr>
</tbody>
</table>

(a) Which one of the gases in the table is a noble gas?

___________________________________________________________________

(1)

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

(i) Noble gases are in Group 0, 1, 7

(ii) Noble gases are slightly reactive, unreactive, very reactive.

(1)

(c) The percentage of carbon dioxide in the Earth’s early atmosphere was 95.00%. It is 0.04% in the Earth’s atmosphere today.

(i) Calculate the decrease in the percentage of carbon dioxide in the Earth’s atmosphere.

___________________________________________________________________

___________________________________________________________________

Decrease in percentage = _______________%

(1)
(ii) Give **two** reasons for this decrease.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

(2)
(Total 6 marks)

Fossil fuels contain carbon and hydrogen.

(a) (i) Use the Chemistry Data Sheet to help you to answer this question.

Complete the figure below to show the electronic structure of a carbon atom.

![Carbon Atom Diagram]

(ii) Complete the word equation for the oxidation of hydrogen.

hydrogen + oxygen → ____________________________

(1)
(b) Coal is a fossil fuel.

Coal contains the elements hydrogen, sulfur, oxygen and carbon.

Name two products of burning coal that have an impact on the environment.

What impact does each of the products you named have on the environment?

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4) (Total 6 marks)
Scientists study the atmosphere on planets and moons in the Solar System to understand how the Earth’s atmosphere has changed.

(a) Millions of years ago the Earth’s atmosphere was probably just like that of Mars today.

The table shows data about the atmosphere of Mars and Earth today.

<table>
<thead>
<tr>
<th>Mars today</th>
<th>Earth today</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>3%</td>
</tr>
<tr>
<td>oxygen</td>
<td>trace</td>
</tr>
<tr>
<td>water</td>
<td>trace</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>95%</td>
</tr>
<tr>
<td>Average surface temperature</td>
<td>−23°C</td>
</tr>
</tbody>
</table>

The percentages of some gases in the Earth’s atmosphere of millions of years ago have changed to the percentages in the Earth’s atmosphere today.

For two of these gases describe how the percentages have changed and suggest what caused this change.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)
(b) Titan is the largest moon of the planet Saturn.
Titan has an atmosphere that contains mainly nitrogen.
Methane is the other main gas.

<table>
<thead>
<tr>
<th>Main gases in Titan's atmosphere</th>
<th>Percentage (%)</th>
<th>Boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>95</td>
<td>−196</td>
</tr>
<tr>
<td>Methane</td>
<td>5</td>
<td>−164</td>
</tr>
<tr>
<td>Average surface temperature</td>
<td>−178°C</td>
<td></td>
</tr>
</tbody>
</table>

When it rains on Titan, it rains methane!

Use the information above and your knowledge and understanding to explain why.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) Ultraviolet radiation from the Sun produces simple alkenes, such as ethene (C\(_2\)H\(_4\)) and propene (C\(_3\)H\(_6\)) from methane in Titan’s atmosphere.

State the general formula for alkenes.

___________________________________________________________________

(1)
(Total 5 marks)

Saturated hydrocarbons, for example methane and octane, are often used as fuels.

(a) Methane can be represented as:

\[
\text{H} \quad \text{H} \quad \text{H}
\]

\[
\text{H} \quad \text{C} \quad \text{H}
\]

\[
\text{H}
\]

(i) The formula of methane is _________________________________ .

(1)
(ii) Draw a ring around the correct answer to complete the sentence.

In a saturated hydrocarbon molecule all of the bonds are _____________________________.

- double.
- ionic.
- single.

(1)

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

The homologous series that contains methane and octane is called the _____________________________.

- alcohols.
- alkanes.
- alkenes.

(1)

(b) (i) The complete combustion of petrol produces carbon dioxide, water vapour and sulfur dioxide.

Name three elements petrol must contain.

1. ____________________________________________________________
2. ____________________________________________________________
3. ____________________________________________________________

(3)

(ii) The exhaust gases from cars can contain oxides of nitrogen.

Complete the sentence.

Nitrogen in the oxides of nitrogen comes from _____________________________.

(1)

(iii) The sulfur dioxide and oxides of nitrogen from cars cause an environmental problem.

Name the problem and describe one effect of the problem.

Name of problem _________________________________________________________

Effect of problem _________________________________________________________

______________________________________________________________

(2)

(c) When a fuel burns without enough oxygen, there is incomplete combustion.

One gaseous product of incomplete combustion is carbon monoxide.

Name one solid product of incomplete combustion.

______________________________________________________________

(1)
A student investigated how well different hydrocarbon fuels would heat up 100 g of water. Her hypothesis was:

**The more carbon atoms there are in a molecule of any fuel, the better the fuel is.**

The apparatus the student used is shown in the diagram.

She burned each hydrocarbon fuel for 2 minutes.

Her results are shown in the table.

<table>
<thead>
<tr>
<th>Name of hydrocarbon fuel</th>
<th>Number of carbon atoms in a molecule of hydrocarbon fuel</th>
<th>Temperature change of water in °C after 2 minutes</th>
<th>Temperature change per g of fuel burned</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pentane</td>
<td>5</td>
<td>30</td>
<td>60</td>
<td>no smoke</td>
</tr>
<tr>
<td>Hexane</td>
<td>6</td>
<td>40</td>
<td>57</td>
<td>very small amount of smoke</td>
</tr>
<tr>
<td>Octane</td>
<td>8</td>
<td>55</td>
<td>55</td>
<td>small amount of smoke</td>
</tr>
<tr>
<td>Decane</td>
<td>10</td>
<td>57</td>
<td>52</td>
<td>large amount of smoke</td>
</tr>
<tr>
<td>Dodecane</td>
<td>12</td>
<td>60</td>
<td>43</td>
<td>very large amount of smoke</td>
</tr>
</tbody>
</table>

The student investigated only hydrocarbons.

Look carefully at her results.

How well do the student’s results support her hypothesis?

**The more carbon atoms there are in a molecule of any fuel, the better the fuel is.**
(e) A 0.050 mol sample of a hydrocarbon was burned in excess oxygen.

The products were 3.60 g of water and 6.60 g of carbon dioxide.

(i) Calculate the number of moles of carbon dioxide produced.

Relative atomic masses: C = 12; O = 16.

Moles of carbon dioxide = __________________

(ii) When the hydrocarbon was burned 0.20 mol of water were produced.

How many moles of hydrogen atoms are there in 0.20 mol of water?

Moles of hydrogen atoms = __________________
(iii) The amount of hydrocarbon burned was 0.050 mol.

Use this information and your answers to parts (e) (i) and (e) (ii) to calculate the molecular formula of the hydrocarbon.

If you could not answer parts (e) (i) or (e) (ii) use the values of 0.20 moles carbon dioxide and 0.50 moles hydrogen. These are not the answers to parts (e) (i) and (e) (ii).

Formula = ________________________________

(Total 19 marks)

Crude oil is a mixture of many different chemical compounds.

(a) Fuels, such as petrol (gasoline), can be produced from crude oil.

(i) Fuels react with oxygen to release energy.

Name the type of reaction that releases energy from a fuel.

______________________________________________________________

(1)

(ii) Fuels react with oxygen to produce carbon dioxide.

The reaction of a fuel with oxygen can produce a different oxide of carbon.

Name this different oxide of carbon and explain why it is produced.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

(2)
Describe and explain how petrol is separated from the mixture of hydrocarbons in crude oil.

Use the diagram and your knowledge to answer this question.
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.

\[
\begin{align*}
\text{CH}_4 + 2\text{O}_2 & \rightarrow 2 \text{ ..........} + \text{ CO}_2 \\
\text{CaCO}_3 & \rightarrow \text{ ..........} + \text{ CO}_2
\end{align*}
\]

(ii) Hydrocarbons and calcium carbonate contain \textit{locked up} carbon dioxide.

What is \textit{locked up} carbon dioxide?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(2)
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.

(ii) Give two reasons why the percentage of carbon dioxide has changed.
Graph 2 shows how the percentage of carbon dioxide in the atmosphere changed in the last 250 years.

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

Explain your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2) (Total 10 marks)
A camping stove uses propane gas.

(a) A student did an experiment to find the energy released when propane is burned.

The student:

• put 500 g water into a beaker
• measured the temperature of the water
• heated the water by burning propane for 1 minute
• measured the temperature of the water again.

The student found the temperature change was 20 °C.

The student can calculate the energy released, in joules (J), using the equation:

energy released (J) = \text{mass of water (g)} \times 4.2 \times \text{temperature change (°C)}

(i) Use the student's result to calculate the energy released in joules (J).

__________________________________________________________________________________

__________________________________________________________________________________

Energy released = _________________________ J

(2)
(ii) State **two** safety precautions that the student should take during the experiment.

1. ____________________________________________________________
   ____________________________________________________________

2. ____________________________________________________________
   ____________________________________________________________

(2)

(iii) Tick (✓) **two** boxes which describe how the student could make his result more accurate.

<table>
<thead>
<tr>
<th>Tick (✓)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stir the water before measuring the temperature.</td>
</tr>
<tr>
<td></td>
<td>Heat the water until it boils.</td>
</tr>
<tr>
<td></td>
<td>Place a lid on the beaker.</td>
</tr>
<tr>
<td></td>
<td>Use a larger beaker for the water.</td>
</tr>
</tbody>
</table>

(2)
(b) The change in energy when propane is burned can be shown in an energy level diagram.

Draw **one** line from each description to the correct letter.

<table>
<thead>
<tr>
<th>Description</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>products</td>
<td>P</td>
</tr>
<tr>
<td>activation energy</td>
<td>Q</td>
</tr>
<tr>
<td>energy released by the reaction</td>
<td>R</td>
</tr>
<tr>
<td>energy released by the reaction</td>
<td>S</td>
</tr>
</tbody>
</table>
Propane and hydrogen are both used as fuels.

Some information about propane and hydrogen is given in the table.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Resource</th>
<th>Products formed when fuel burned</th>
</tr>
</thead>
<tbody>
<tr>
<td>propane</td>
<td>crude oil</td>
<td>carbon dioxide and water</td>
</tr>
<tr>
<td>hydrogen</td>
<td>water</td>
<td>water</td>
</tr>
</tbody>
</table>

Use the information in the table to suggest two disadvantages that propane has as a fuel compared to hydrogen.

1. _________________________________________________________________
   _____________________________________________________________________

2. _________________________________________________________________
   _____________________________________________________________________

(Total 11 marks)

A mixture of petrol and air is burned in a car engine.

Petrol is a mixture of alkanes. Air is a mixture of gases.

The tables give information about the composition of petrol and the composition of air.

<table>
<thead>
<tr>
<th>Petrol</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alkane</strong></td>
<td><strong>Gas</strong></td>
</tr>
<tr>
<td>hexane</td>
<td>nitrogen</td>
</tr>
<tr>
<td>heptane</td>
<td>oxygen</td>
</tr>
<tr>
<td>octane</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>nonane</td>
<td>Small amounts of other gases</td>
</tr>
<tr>
<td>decane</td>
<td>and water vapour</td>
</tr>
<tr>
<td></td>
<td><strong>Percentage (%)</strong></td>
</tr>
<tr>
<td></td>
<td>nitrogen 78</td>
</tr>
<tr>
<td></td>
<td>oxygen 21</td>
</tr>
<tr>
<td></td>
<td>carbon dioxide 0.035</td>
</tr>
</tbody>
</table>

(a) Use the information above to answer these questions.

(i) Give the formula for heptane

______________________________________________________________

(1)
(ii) Complete the general formula of alkanes.
\[ C_n H \]

\(^{(1)}\)

(b) Alkanes in petrol burn in air.
The equations represent two reactions of hexane burning in air.

**Reaction 1** \[ 2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O \]

**Reaction 2** \[ 2C_6H_{14} + 13O_2 \rightarrow 12CO + 14H_2O \]

**Reaction 2** produces a different carbon compound to **Reaction 1**.

(i) Name the carbon compound produced in **Reaction 2**.

____________________________________________________________________________________

\(^{(1)}\)

(ii) Give a reason why the carbon compounds produced are different.

____________________________________________________________________________________

____________________________________________________________________________________

\(^{(1)}\)

(c) The table shows the percentages of some gases in the exhaust from a petrol engine.

<table>
<thead>
<tr>
<th>Name of gas</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen</td>
<td>68</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>15</td>
</tr>
<tr>
<td>carbon monoxide</td>
<td>1.0</td>
</tr>
<tr>
<td>oxygen</td>
<td>0.75</td>
</tr>
<tr>
<td>nitrogen oxides</td>
<td>0.24</td>
</tr>
<tr>
<td>hydrocarbons</td>
<td>0.005</td>
</tr>
<tr>
<td>sulfur dioxide</td>
<td>0.005</td>
</tr>
<tr>
<td>other gases</td>
<td></td>
</tr>
</tbody>
</table>

(i) What is the percentage of the other gases in the table?

____________________________________________________________________________________

\(^{(1)}\)

(ii) What is the name of the compound that makes up most of the other gases?

____________________________________________________________________________________
(iii) Give a reason why sulfur dioxide is produced in a petrol engine.

________________________________________________________________________
________________________________________________________________________

(1)

(iv) State how nitrogen oxides are produced in a petrol engine.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(d) Many scientists are concerned about the carbon dioxide released from burning fossil fuels such as petrol.

Explain why.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(Total 11 marks)
About 3000 million years ago carbon dioxide was one of the main gases in the Earth’s early atmosphere.

About 400 million years ago plants and trees grew on most of the land. When the plants and trees died they were covered by sand and slowly decayed to form coal.

Today coal is burned in power stations to release the energy needed by industry.

(a) The bar chart shows the percentage of some of the elements in this coal.

(i) This coal contains 85% carbon. Draw the bar for carbon on the chart.
(ii) Coal is burned in the atmosphere to release energy. Two of the products of burning coal are shown.

Draw one line from each product to its environmental impact.

<table>
<thead>
<tr>
<th>Product</th>
<th>Environmental impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur dioxide</td>
<td>Acid rain</td>
</tr>
<tr>
<td>Carbon particles</td>
<td>Global dimming</td>
</tr>
<tr>
<td></td>
<td>Global warming</td>
</tr>
</tbody>
</table>

(b) Use the information above and your knowledge and understanding to answer these questions.

(i) How did the formation of coal decrease the amount of carbon dioxide in the Earth’s early atmosphere?

________________________________________________________________________
________________________________________________________________________

(1)

(ii) How does burning coal affect the amount of carbon dioxide in the Earth’s atmosphere?
Explain your answer.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)

(Total 6 marks)
Petroleum diesel is a fuel made from crude oil.
Biodiesel is a fuel made from vegetable oils.
To make biodiesel, large areas of land are needed to grow crops from which the vegetable oils are extracted.
Large areas of forest are cleared by burning the trees to provide more land for growing these crops.

(a) Use this information and your knowledge and understanding to answer these questions.

(i) Carbon neutral means that there is no increase in the amount of carbon dioxide in the atmosphere.

Suggest why adverts claim that using biodiesel is carbon neutral.
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

(2)
(ii) Explain why clearing large areas of forest has an environmental impact on the atmosphere.

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(2)

(b) Why is there an increasing demand for biodiesel?

______________________________________________________________

______________________________________________________________

(1)

(c) Suggest why producing biodiesel from crops:

(i) causes ethical concerns

______________________________________________________________
______________________________________________________________

(1)

(ii) causes economic concerns.

______________________________________________________________

______________________________________________________________

(1)

(Total 7 marks)
About 3000 million years ago, carbon dioxide was one of the main gases in the Earth’s atmosphere.

About 400 million years ago, plants and trees grew on most of the land. When the plants and trees died they were covered by sand and slowly decayed to form coal.

(a) Describe and explain how the composition of the Earth’s atmosphere was changed by the formation of coal.

(b) Today, coal is burned in power stations to release the energy needed by industry. Carbon dioxide, water and sulfur dioxide are produced when this coal is burned.

Name three elements that are in this coal.

(c) In some power stations coal is mixed with calcium carbonate (limestone). The mixture is crushed before it is burned.

(i) Many chemical reactions happen when this mixture is burned. The chemical equation represents one of these reactions.

Balance the chemical equation.

\[2\text{CaCO}_3(\text{s}) + 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \ldots \ldots \ldots + \text{CaSO}_4(\text{s}) + \text{CO}_2(\text{g})\]
(ii) Explain how the use of calcium carbonate in the mixture:

increases atmospheric pollution

______________________________
______________________________
______________________________
______________________________

 decreases atmospheric pollution.

______________________________
______________________________
______________________________
______________________________

(4)

(Total 10 marks)

The bar chart shows some of the gases in the atmospheres of Earth today and Mars today.

![Bar Chart]

(a) Complete the bar chart to show the percentage of nitrogen in the Earth’s atmosphere today.

(1)

(b) Some scientists suggest that the Earth’s early atmosphere was like the atmosphere of Mars today.

(i) There is not much oxygen in the atmosphere of Mars.

Suggest why.

______________________________
______________________________
______________________________
______________________________

(1)
(ii) The percentage of argon in the Earth’s atmosphere today is the same as it was in the Earth’s early atmosphere.

Suggest why.

______________________________________________________________
______________________________________________________________

(1)

(c) Compared with the percentage of carbon dioxide in the Earth’s early atmosphere there is not much carbon dioxide in the Earth’s atmosphere today.

Give one reason for this change.

______________________________________________________________
______________________________________________________________

(1)

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

Some theories suggest that the Earth’s early atmosphere was

- burning fossil fuels.
- made by the formation of oceans.
- the eruption of volcanoes.

(1)

(Total 5 marks)
There are two main types of diesel fuel used for cars:

- biodiesel, made from vegetable oils
- petroleum diesel, made from crude oil.

(a) A scientist compared the viscosity of biodiesel with petroleum diesel at different temperatures. The scientist measured the time for the same volume of diesel to flow through a small hole in a cup. The scientist’s results are plotted on the grid.

(i) Draw a line of best fit for the biodiesel results.

(ii) What conclusions can the scientist make about the viscosity of biodiesel compared with the viscosity of petroleum diesel at different temperatures?

(iii) Biodiesel may be less suitable than petroleum diesel as a fuel for cars. Use these results to suggest one reason why.
(b) Biodiesel can be mixed with petroleum diesel to make a fuel for cars. In a car engine, the diesel fuel burns in air. The waste products leave the car engine through the car exhaust system. The bar chart compares the relative amounts of waste products made when three different types of diesel fuel burn in a car engine.

Nitrogen oxides and sulfur dioxide cause a similar environmental impact.

(i) What environmental impact do particulates from car exhaust systems cause?

(ii) What is the percentage reduction in particulates when using B100 instead of petroleum diesel?

Key: Petroleum diesel  B20 (20% biodiesel)  B100 (100% biodiesel)
(iii) Replacing petroleum diesel with biodiesel increases one type of environmental pollution.

Use the bar chart and the information given to explain why.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

(2)

(iv) A carbon neutral fuel does not add extra carbon dioxide to the atmosphere.

Is biodiesel a carbon neutral fuel?

Use the bar chart and your knowledge to explain your answer.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

(2)

(Total 10 marks)

The Earth has a layered structure and is surrounded by an atmosphere.

(a) The diagram shows the layers of the Earth.

Complete the labels on the diagram.

The diagram shows the layers of the Earth.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

(2)
(b) The data in the table shows the percentages of the gases in the Earth's atmosphere.

<table>
<thead>
<tr>
<th>Name of gas</th>
<th>Percentage (%) of gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>78</td>
</tr>
<tr>
<td>Oxygen</td>
<td>21</td>
</tr>
<tr>
<td>Other gases</td>
<td>1</td>
</tr>
</tbody>
</table>

Present the data in the table on the grid below.
Millions of years ago a large meteorite hit the Earth. The meteorite heated limestone in the Earth’s crust to a very high temperature. The heat caused calcium carbonate in the limestone to release large amounts of carbon dioxide.

Draw a ring round the correct answer to complete each sentence.

(i) Carbon dioxide was released because the calcium carbonate was ________

- decomposed.
- evaporated.
- reduced.

(ii) More carbon dioxide in the Earth’s atmosphere causes ________

- acid rain.
- global dimming.
- global warming.

(Total 7 marks)
The Earth has a layered structure and is surrounded by an atmosphere.

(a) Scientists believe that the Earth’s atmosphere was formed by volcanoes releasing gases. This early atmosphere was about 95 % carbon dioxide. The composition of the Earth’s atmosphere is always changing.

(i) The Earth’s atmosphere today contains about 0.035 % carbon dioxide.

What happened to most of the carbon dioxide that was in the Earth’s early atmosphere?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(ii) About 60 million years ago a large meteorite hit the Earth. This meteorite heated limestone in the Earth’s crust causing the release of large amounts of carbon dioxide.

Explain how carbon dioxide is released from limestone.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

(2)
The graph shows the percentage of carbon dioxide in the Earth's atmosphere over the last 50 years.

Explain, as fully as you can, why we should be concerned about the information displayed on this graph.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(3)
Scientists believe that all the continents of the Earth were once joined together. The huge ‘supercontinent’ was called Pangaea.

In 1915, Alfred Wegener had an idea that the change shown in the diagram was caused by continental drift. Most scientists could not accept his idea.

(i) Suggest why most scientists in 1915 could not accept Wegener’s idea of continental drift.

____________________________________________________________________________________

____________________________________________________________________________________

(1)
To help you with this question, the information and diagram from the beginning of the question are reproduced here.

The Earth has a layered structure and is surrounded by an atmosphere.

(ii) Use this information and your knowledge and understanding to explain how continents move.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
(Total 11 marks)

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.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(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.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(5)
(Total 7 marks)
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?

___________________________________________________________________

(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?

___________________________________________________________________

(1)

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

___________________________________________________________________

___________________________________________________________________

(1)
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’.

Crude oil is a mixture of hydrocarbons. Most of these hydrocarbons are alkanes.

(a) The general formula of an alkane is $C_nH_{2n+2}$

Complete the structural formula for the alkane that has six carbon atoms in its molecules.
(b) The boiling points of alkanes are linked to the number of carbon atoms in their molecules.

(i) Describe the link between the number of carbon atoms in an alkane molecule and its boiling point.

______________________________________________________________
______________________________________________________________

(ii) Suggest two reasons why all of the alkanes in the bar chart are better fuels than the alkane with the formula $C_{30}H_{62}$

1. ____________________________________________________________
   ____________________________________________________________

2. ____________________________________________________________
   ____________________________________________________________

(1)
During the last 200 million years the carbon cycle has maintained the percentage of carbon dioxide in the atmosphere at about 0.03%. Over the last 100 years the percentage of carbon dioxide in the atmosphere has increased to about 0.04%. Most of this increase is caused by burning fossil fuels to heat buildings, to generate electricity and to power our transport. Fossil fuels contain carbon that has been locked up for millions of years.

(i) Burning fossil fuels, such as petrol, releases this locked up carbon. Balance the chemical equation for the combustion of one of the alkanes in petrol.

\[ 2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow \underline{\text{CO}_2} + \underline{\text{H}_2\text{O}} \]

(ii) Where did the carbon that is locked up in fossil fuels come from?

______________________________________________________________

______________________________________________________________

(iii) The burning of fossil fuels has caused the percentage of carbon dioxide in the atmosphere to increase to above 0.03%. Explain why.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

(2)

(Total 8 marks)
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.
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?

(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.
In the future more coal-fired and fewer oil-fired power stations will be used to generate electricity. When coal and oil are burned they produce the same types of emissions which can cause environmental problems.

(a) Emissions from the chimney can cause acid rain, global dimming and global warming. Draw one straight line from each possible environmental problem to the emission that causes it.

<table>
<thead>
<tr>
<th>Possible environmental problem</th>
<th>Emission that causes it</th>
</tr>
</thead>
<tbody>
<tr>
<td>acid rain</td>
<td>carbon particles</td>
</tr>
<tr>
<td>global warming</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>global dimming</td>
<td>sulfur dioxide</td>
</tr>
<tr>
<td></td>
<td>water vapour</td>
</tr>
</tbody>
</table>

(b) Draw a ring around the correct word in the box to complete each sentence.

(i) Incomplete combustion of coal or oil is caused by too little oxygen.

(1)
(ii) A gas formed by the incomplete combustion of coal or oil is

\text{carbon monoxide.}

\text{hydrogen.}

\text{oxygen.}

(c) The table shows the world production for both coal and oil in 2000.

The world production figures after 2000 are predicted.

<table>
<thead>
<tr>
<th>Year</th>
<th>World production of coal (billions of tonnes per year)</th>
<th>World production of oil (billions of barrels per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>3.5</td>
<td>12.5</td>
</tr>
<tr>
<td>2050</td>
<td>4.5</td>
<td>5.6</td>
</tr>
<tr>
<td>2100</td>
<td>5.0</td>
<td>1.7</td>
</tr>
<tr>
<td>2150</td>
<td>5.5</td>
<td>0.5</td>
</tr>
<tr>
<td>2200</td>
<td>6.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(i) How is the world production of oil predicted to change from 2000 to 2200?

________________________________________________________________________

________________________________________________________________________

(1)

(ii) Suggest \textbf{two} reasons why the world production of coal is predicted to increase.

1. ______________________________________________________________________

________________________________________________________________________

2. ______________________________________________________________________

________________________________________________________________________

(2)

(Total 8 marks)
Mark schemes

(a) dissolved
   in this order
   carbonates

(b) Photosynthesis

(c) water
   In this order
   oxygen
   both needed for the mark

(d) Gas
    Approximate percentage of gas
    in the Earth's atmosphere today
    
    | Gas          | <1  | 5   |
    |--------------|-----|-----|
    | Carbon dioxide | 10  |     |
    | Nitrogen      | 20  | 50  |
    | Oxygen        | 80  | >90 |

Extra lines from Gas negate the mark

(e) increases global temperatures

(f) use renewable energy supplies

(g) correct reason, eg:
    • renewable technology underdeveloped
    • disagreement between countries


(a) Colourless liquid / condensation / water

(b) incomplete combustion of the fuel
   because not enough oxygen
(c) Sulfur dioxide

(a) sediment / limestone formation from carbonates

(b) short wavelength radiation

passes through atmosphere to Earth’s surface

Earth’s surface radiates different wavelengths

which are absorbed by greenhouse gases to produce temperature increase

allow CH₄, H₂O or CO₂

(c) 13.8 %

allow values in the range 13.0 to 15.0

(d) 15.08 (°C)

allow values in the range 15.05 – 15.10

(e) correlation between CO₂ levels and temperature

despite short-term variations of temperature

supported by values from graph which show correlation

cannot determine causality from this data or possible causality as increasing use of fossil fuels since 1900 has caused accelerated temperature increase

(a) carbon dioxide (decreased) one from:

1 mark for one reason for each gas

• photosynthesis
• formation of (sedimentary) rocks
• formation of fossil fuels
• dissolved in oceans

ignore respiration

(b) nitrogen (increased) one from:

• volcanoes / volcanic activity
• ammonia reacted with oxygen
oxygen (increase):

• photosynthesis

(b) 1960

because the rise became much steeper

(c) $362 - 320 = 42$ (ppm)

\[42 \div 320 \times 100\]

\[= 13(\%)\]

(d) Level 2 (3–4 marks):
A detailed and coherent explanation of how the rise in carbon dioxide levels affect the environment.

Level 1 (1–2 marks):
Simple relevant statements are made about the effects of rise in carbon dioxide levels on the environment. The account is incomplete or inaccurate and lacks coherence.

0 marks:
No relevant content.

Indicative content

consequences of rise in carbon dioxide levels
• carbon dioxide is a greenhouse gas
• it stops infrared radiation escaping from the Earth
• warming up the atmosphere
• rise in level warms atmosphere up more
• so leads to global warming
• leading to climate change

effects on environment:
• extreme weather fluctuations
• rise in sea levels
• effects on human habitats
• effects on animal habitats
• decrease in biodiversity
• effects on food producing capacity.
5 (a) \[ N_2 + 2O_2 \rightarrow 2NO_2 \]

- correct formulae for reactants 1
- correct balancing 1

(b) \[ 2.96 - 0.98 \]

- correct values read from graph 1

\[ 1.98 \div 2.96 \times 100 \]

- allow ecf from readings from graph 1

\[ = 66.9(\%) \]

- allow 66.9 shown without working for the 3 calculation marks 1
- incorrect number of sig. figs max 2 marks

(c) less acid rain or fewer respiratory problems in humans

- allow improved air quality 1

---

6 Level 3 (5–6 marks):
A full explanation is given that is coherent and logically structured, linking effect of increase in carbon dioxide to climate change and effects on biodiversity.

Level 2 (3–4 marks):
An attempt is made to link the effects of rising carbon dioxide levels to climate change and biodiversity. The logic may be inconsistent at times but builds towards a coherent explanation.

Level 1 (1–2 marks):
Discrete relevant points made. The logic may be unclear and attempts at reasoning may not be consistent.

0 marks:
No relevant content.

Indicative content
- rise in carbon dioxide increases atmospheric temperature / causes global warming
- global warming causes extreme weather patterns
- such as rise in sea levels
- increased or decreased rainfall
- frequency of storms / droughts
- rise in sea levels means habitats will change due to flooding
- rise in sea levels could increase salt in soil
- increased rainfall will increase water levels
- severity of storms / droughts could affect photosynthesis
- consequences of changes are loss of or damage to habitats
- which will affect animal and plant distributions
- by increasing migration or species dying off
- which decreases biodiversity
(a) gravity (of moon and sun)

(b) any two from:

1 mark for statement, 1 mark for correctly linked reason

- tidal energy is renewable (1)
- so won’t run out like fossil fuels (1)

or

- doesn’t emit carbon dioxide
- so won’t contribute to global warming / climate change

or

- doesn’t emit oxides of sulfur or nitrogen
- so doesn’t cause acid rain

or

- doesn’t use fossil fuels
- so less impact on environment of extraction / transport

or

- doesn’t produce particulates
- so less effect on health / environment

Max. 4

(c) coal consumption per year = $29.25 \times 1000 \times 6 \text{ million} = 175\,500\,000\,000 \text{ MJ}$

1 hectare of willow will produce $9 \times 13 \times 1000 = 117\,000 \text{ MJ per year}$

so need $175\,500\,000\,000 \div 117\,000 = 1\,500\,000 \text{ (hectares)}$

allow 1\,500\,000 with no working shown for 3 marks

(d) although has higher direct emissions than other fuels

it has much lower lifetime emissions

[10]

(a) because sulfur dioxide causes acid rain

which kills fish / aquatic life or dissolves / damages statues / stonework or kills / stunts growth of trees

if no other mark awarded then award 1 mark for sulfur dioxide is toxic or causes breathing difficulties.

(b) (i) electrons are lost
(ii) \[ \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \]
allow \[ \text{Cu}^{2+} \rightarrow \text{Cu} - 2e^- \]
ignore state symbols

(iii) copper sulfate
allow any ionic copper compound

(c) (lattice of) positive ions
delocalised electrons
accept sea of electrons
(electrostatic) attraction between the positive ions and the electrons

electrons can move through the metal / structure or can flow
allow electrons can carry charge through the metal / structure
if wrong bonding named or described or attraction between oppositely charged ions then do not award M1 or M3 – MAX 2

(d) (copper compounds are absorbed / taken up by) plants
allow crops

which are burned

the ash contains the copper compounds
do not award M3 if the ash contains copper (metal)

(e) | / \(A_r\) | 55.6 / 63.5 | 16.4 / 56 | 28.0 / 32 |
---|---|---|---|
moles | 0.876 | 0.293 | 0.875 |
ratio | 3 | 1 | 3 |
formula | \(\text{Cu}_3\text{FeS}_3\) |

award 4 marks for \(\text{Cu}_3\text{FeS}_3\) with some correct working
award 3 marks for \(\text{Cu}_3\text{FeS}_3\) with no working
if the answer is not \(\text{Cu}_3\text{FeS}_3\) award up to 3 marks for correct steps from the table apply ecf
if the student has inverted the fractions award 3 marks for an answer of \(\text{CuFe}_3\text{S}\)
(a) circle round any one (or more) of the covalent bonds
any correct indication of the bond – the line between letters

(b) Methane contains atoms of two elements, combined chemically

(c) (i) activation energy labelled from level of reagents to highest point of curve
ignore arrowheads

enthalpy change labelled from reagents to products

\[
\text{Energy} \quad \begin{array}{c}
\text{Activation energy} \\
\downarrow \\
\text{Enthalpy change } \Delta H
\end{array}
\]

arrowhead must go from reagents to products only

(ii) \(2 \text{O}_2\)

\(2 \text{H}_2\text{O}\)
if not fully correct, award 1 mark for all formulae correct.
ignore state symbols

(iii) carbon monoxide is made

this combines with the blood / haemoglobin or prevents oxygen being carried in the blood / round body or kills you or is toxic or poisonous
dependent on first marking point

(iv) energy is taken in / required to break bonds
accept bond breaking is endothermic

energy is given out when bonds are made
accept bond making is exothermic

the energy given out is greater than the energy taken in
this mark only awarded if both of previous marks awarded
(d) (i) energy to break bonds = 1895

\[\text{calculation with no explanation max = 2}\]

energy from making bonds = 1998

\[1895 - 1998 = (-103)\]

or

energy to break bonds = 656
energy from making bonds = 759

\[656 - 759 = (-103)\]

allow:

\[\text{bonds broken - bonds made =} \]

\[413 + 243 - 327 - 432 = -103 \text{ for 3 marks.}\]

(ii) The C — Br bond is weaker than the C — Cl bond

(a) (i) mixture (of different substances)

(ii) boiling (points)

(iii) distillation

(b) (i) combustion

(ii) (reactant)

oxygen

\[\text{allow correct formulae}\]

(products)

\[\text{products in any order}\]

carbon dioxide

\[\text{allow carbon or carbon monoxide}\]

and

water

\[\text{allow water vapour or steam or hydrogen oxide}\]

(iii) (burning sulfur) produces sulfur dioxide / \(\text{S0}_2\)

\[\text{allow it / sulfur reacts with oxygen ignore sulfur oxide}\]

causes acid rain
(c) (i) propane is a fuel

(ii) double bond drawn between carbon atoms
    *do not allow any other bonds or symbols*

(iii) orange to colourless

(iv) poly(pentene)
    *allow polymer(s)*

(a) any one from:
    • not enough evidence or proof
        *allow no evidence or no proof*
    • (life and the Earth were created) billions of years ago
        *allow a long time ago*
        *ignore different beliefs or no one was there.*
(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a ‘best–fit’ approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
Statements based on diagrams

Level 2 (3–4 marks)
Description of how one change occurred

Level 3 (5–6 marks)
Descriptions of how at least two changes occurred

Examples of chemistry points made in the response could include:

Main changes
• oxygen increased because plants / algae developed and used carbon dioxide for photosynthesis / growth producing oxygen; carbon dioxide decreased because of this
• carbon dioxide decreased because oceans formed and dissolved / absorbed carbon dioxide; carbon dioxide became locked up in sedimentary / carbonate rocks and / or fossil fuels
• oceans formed because the Earth / water vapour cooled and water vapour in the atmosphere condensed
• continents formed because the Earth cooled forming a supercontinent / Pangaea which formed the separate continents
• volcanoes reduced because the Earth cooled forming a crust.

Other changes
• nitrogen has formed because ammonia in the Earth’s early atmosphere reacted with oxygen / denitrifying bacteria.

(a) Sulfur dioxide causes acid rain.

(b) red / orange / yellow
   *do not accept any other colours*

   because sulfur dioxide (when in solution) is an acid

(c) (there are) weak forces (of attraction)
   *do not accept any reference to covalent bonds breaking*

   between the molecules
   *do not accept any other particles*
(d) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
A relevant comment is made about the data.

Level 2 (3 – 4 marks)
Relevant comparisons have been made, and an attempt made at a conclusion.

Level 3 (5 – 6 marks)
Relevant, detailed comparisons made and a justified conclusion given.

examples of the points made in the response

effectiveness

• W removes the most sulfur dioxide
• D removes the least sulfur dioxide

material used

• Both W and D use calcium carbonate
• Calcium carbonate is obtained by quarrying which will create scars on landscape / destroy habitats
• D requires thermal decomposition, this requires energy
• D produces carbon dioxide which may cause global warming / climate change
• S uses sea water, this is readily available / cheap

waste materials

• W product can be sold / is useful
• W makes carbon dioxide which may cause global warming / climate change
• D waste fill landfill sites
• S returned to sea / may pollute sea / easy to dispose of
(a) | Test | Result |
---|---|---|
| Place a glowing splint in the tube of the gas | The splint relights |
| | | There is a squeaky pop |

more than one line from test negates the mark

(b) (i) place a lighted splint at the mouth of the tube

there is a squeaky pop

dependent on correct test

(ii) hydrogen is less reactive than magnesium

accept converse

accept magnesium is too reactive

(c) (i) any one from:

• to improve appearance or make it look nice
• to prevent corrosion
• to make it more durable
• cheaper than solid silver

(ii) solution must be silver nitrate or contain silver ions

otherwise copper will be deposited or silver will not be deposited

spoon must be the negative electrode / cathode

because silver ions have a positive charge or go to negative electrode or are discharged at the negative electrode.

(iii) because (plastic is an) insulator or does not conduct electricity

accept does not contain mobile electrons

(a) (i) a proton
(ii) nucleus

(iii) 12

order must be correct
4

(b) (i) 5 / five (%)

(ii) Carbon dioxide > global warming

Sulfur dioxide > acid rain

Water > no pollution

(a) argon / Ar

(b) (i) 0

(ii) unreactive

(c) (i) 94.96(%)  

(ii) any two from:

- plants or photosynthesis
- absorbed in oceans / seas
  
  allow oceans store or take in or dissolve carbon dioxide
- locked up in (sedimentary) rocks
- locked up in fossil fuels

2

[6]

15

16 (a) (i) 2,4 drawn (as dots / crosses / e⁻)
(ii) Water (vapour) / steam
   
   allow hydrogen oxide / $H_2O$
   do not accept hydroxide

(b) any two pairs from:

  carbon dioxide (1)
  
  causes global warming (1)
  
  allow greenhouse effect / climate change / sea level rise / melting of polar ice caps

  or

  carbon (particles) / soot (1)
  
  allow particulates

  causes global dimming (1)
  
  allow blocks out sunlight / smog / prevents plant growth / causes breathing difficulties

  or

  carbon monoxide (1)
  
  is toxic (1)

  or

  sulfur dioxide (1)
  
  causes acid rain (1)
  
  allow kills plants / erosion / acidifies water
(a) any two from:

asks for cause therefore no marks for just describing the change
must link reason to a correct change in a gas

carbon dioxide has decreased due to:
accept idea of ‘used’ to indicate a decrease
• plants / microorganisms / bacteria / vegetation / trees
• photosynthesis
  ignore respiration
• ‘locked up’ in (sedimentary) rocks / carbonates / fossil fuels
• dissolved in oceans
  ignore volcanoes

oxxygen has increased due to:
accept idea of ‘given out / produced’
• plants / bacteria / microorganisms / vegetation / trees
• photosynthesis
  ignore respiration

nitrogen increased due to:
accept idea of ‘given out / produced’
• ammonia reacted with oxygen
• bacteria / microorganisms
  ignore (increase in) use of fossil fuels / deforestation

(b) (because methane’s) boiling point is greater than the average / surface temperature
or Titan’s (average / surface) temperature is below methane’s boiling point
  ignore references to nitrogen or water

any methane that evaporates will condense
accept boils for evaporates
accept cooling and produce rain for condensing

(c) $C_nH_{2n}$

18 (a) (i) $CH_4$

allow $H_4C$
do not allow lower-case h
do not allow superscript
(ii) single

(iii) alkanes

(b) (i) carbon / C
   any order
   hydrogen / H
   allow phonetic spelling
   sulfur / sulphur / S

(ii) air / atmosphere

(iii) acid rain
   damages trees / plants or kills aquatic organisms or damages buildings / statues or causes respiratory problems
   allow harmful to living things

(c) carbon / C
   accept soot / particulates / charcoal

(d) any four from:
   • (supports hypothesis) because when the fuel contained more carbon the temperature of the water went up more / faster (in 2 minutes)
   • (does not support hypothesis as) temperature change per gram decreases as the number of carbons increases
   • (does not support hypothesis) because the more carbon in the fuel the more smoke or the dirtier / sootier it is
   • only tested hydrocarbons / alkanes / fuels with between 5 and 12 carbon atoms
   • valid, justified, conclusion
     accept converse statements

(e) (i) 0.15
     correct answer with or without working gains 2 marks
     if answer incorrect, M, carbon dioxide = 44 gains 1 mark
     allow 0.236 / 0.24 / 0.2357142 (ecf from \( M \)) for 1 mark

(ii) 0.4(0)
(iii) $C_3H_8$

*correct formula with or without working scores 2 marks*

$0.15 / 0.05 = 3$

*allow ecf from (e)(i)*

and

$0.4 / 0.05 = 8$ (1)

*allow ecf from (e)(ii)*

*allow 1 mark for correct empirical formula from their values*

If use ‘fall-back-values:

$0.50 / 0.05 = 10$

and

$0.20 / 0.05 = 4$

1 mark

$C_4H_{10}$

1 mark

*if just find ratio of $C$ to $H$ using fall-back values, get $C_2H_5$ allow 1 mark*

---

(a) (i) exothermic

*accept combustion*

*allow burning or oxidation or redox*

(ii) carbon monoxide / $CO$ (is produced)

*allow monoxide (is produced) ignore carbon oxide*

because there is incomplete / partial combustion (of the fuel)

*accept because there is insufficient oxygen / air (to burn the fuel)*

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks

No relevant content.

**Level 1 (1-2 marks)**

There is a statement that crude oil is heated or that substances are cooled. However there is little detail and any description may be confused or inaccurate.
Level 2 (3-4 marks)
There is some description of heating / evaporating crude oil and either fractions have different boiling points or there is an indication of a temperature difference in the column.

Level 3 (5-6 marks)
There is a reasonable explanation of how petrol is or fractions are separated from crude oil using evaporating and condensing.

If cracking is given as a preliminary or subsequent process to fractional distillation then ignore.

However, if cracking / catalyst is given as part of the process, maximum is level 2.

Examples of chemistry points made in the response could include:

- Some / most of the hydrocarbons (or petrol) evaporate / form vapours or gases
- When some of / a fraction of the hydrocarbons (or petrol) cool to their boiling point they condense
- Hydrocarbons (or petrol) that have (relatively) low boiling points and are collected near the top of the fractionating column or hydrocarbons with (relatively) high boiling points are collected near the bottom of the fractionating column
- The process is fractional distillation
- Heat the crude oil / mixture of hydrocarbons or crude oil / mixture is heated to about 350°C
- Some of the hydrocarbons remain as liquids
- Liquids flow to the bottom of the fractionating column
- Vapours / gases rise up the fractionating column
- Vapours / gases cool as they rise up the fractionating column
- The condensed fraction (or petrol) separates from the vapours / gases and flows out through a pipe
- Some of the hydrocarbons remain as vapours / gases
- Some vapours / gases rise out of the top of the fractionating column
- There is a temperature gradient in the fractionating column or the fractionating column is cool at the top and hot at the bottom

20  (a)   (i)   \( \text{H}_2\text{O} \)

*must be formula*
CaO

must be formula

(ii) carbon dioxide from the air / (Earth’s early) atmosphere

it = carbon (dioxide)
accept carbon dioxide from millions of years ago

formed (sedimentary) rocks or fossil fuels
ignore trapped / stored

(b) (i) decreases rapidly at first

it = carbon (dioxide)
then slowly or levels off
allow both marks if the description is correct using either ‘rapidly’ or ‘slowly’
allow correct use of figures for either marking point
if no other mark awarded, allow CO₂ decreased for 1 mark

(ii) any two from:

it = carbon (dioxide)
accept photosynthesis
• used by plants
• dissolved in oceans
• ‘locked up’ in fossil fuels or formed fossil fuels
• ‘locked up’ in rocks or formed rocks

(c) (yes)

it = percentage of carbon (dioxide)
ignore yes or no
because the percentage of carbon dioxide is increasing
which causes global warming (to increase)
allow (carbon dioxide) causes greenhouse effect/climate change
or

(no)

because the percentage of carbon dioxide is low (1)
compared to millions of years ago (1)

allow global warming can be caused by other factors (e.g. Sun / water vapour / methane)

(a) (i) 42 000

correct answer gains 2 marks with or without working
allow 42 \text{kJ}

if answer incorrect : correct substitution 500 \times 4.2 \times 20 gains 1 mark

(ii) any two from:

• eye protection
• lab coat
• heat-proof mat
• (heat-proof) gloves
• (long) hair tied back
• stand up
• secure the beaker

(iii) Stir the water before measuring the temperature.

Place a lid on the beaker.

(b) the products → S

the activation energy → Q

the energy released by the reaction → P

(c) carbon dioxide produced

\text{it = propane}

allow converse arguments

allow greenhouse gas / global warming / atmospheric pollution

(crude oil / propane) non-renewable
allow crude oil running out

(a) (i) C$_7$H$_{16}$
mark answer line first
answer may be given in the table

(ii) C$_n$H$_{2n+2}$

(b) (i) carbon monoxide
do not accept carbon oxide
do not accept water
ignore CO

(ii) because of partial / incomplete combustion (in reaction 2) or complete combustion (in reaction 1)
allow because there is less / insufficient oxygen (in reaction 2) or sufficient oxygen (in reaction 1) allow different amounts of oxygen used (in the reactions) or $19O_2$ (in reaction 1) and $13O_2$ (in reaction 2)
ignore air

(c) (i) 15 (%)
ignore units

(ii) water (vapour)/steam
allow $H_2O$ / $OH_2$ / hydrogen oxide

(iii) sulfur in petrol / crude oil (reacts with oxygen)
it = sulfur dioxide

(ii) because nitrogen and oxygen (are in the air and) react
allow nitrogen and oxygen burn
accept nitrogen + oxygen $\rightarrow$ nitrogen oxide or symbol equation
ignore air

at high temperature (inside a petrol engine)
allow heat / hot (engine)

(d) because carbon dioxide / it causes global warming or
allow because carbon dioxide / it causes greenhouse effect / climate change
because carbon dioxide / it has an impact on oceans
because this carbon dioxide / carbon / it was ‘locked up’ (in fossil fuels) or
because the percentage/amount of carbon dioxide / it in the atmosphere is increasing

(a) (i) bar drawn between 84 and 86

(ii) sulfur dioxide linked to acid rain

carbon particles linked to global dimming

(b) (i) any one from:
- plants / trees absorb (carbon dioxide)
- coal ‘locks up’ (carbon dioxide)

(ii) it increases the amount (of CO₂)

because carbon in coal (forms carbon dioxide)

accept because carbon / coal burns / reacts with oxygen (to produce CO₂)

(a) (i) use of carbon throughout = max 1

burning biodiesel releases CO₂

ignore burning trees

CO₂ is absorbed / used by the crops/plants (used to produce the biodiesel)

allow CO₂ absorbed / used by trees

(ii) allow use of carbon for carbon dioxide throughout

increases CO₂ / greenhouse effect

accept causes global warming

OR

allow causes climate change

less CO₂ is absorbed (from atmosphere)

ignore other correct effects
because burning trees releases CO₂
   accept fewer trees to absorb CO₂
   or crops / plants do not absorb as much CO₂ as trees

OR
because there is less photosynthesis
   ignore habitats / biodiversity
   if no other mark awarded global dimming because of smoke /
   particles gains 1 mark

(b) any one from:
   ignore carbon neutral / cost / less harmful / environmentally friendly
   • crude oil / fossil fuel is running out / non-renewable
     allow biodiesel is renewable / sustainable
   • demand for fuels / energy is increasing
     ignore demand for biodiesel is increasing
   • new legislation / protocols

(c) (i) uses crops / land that could be used for food
   allow destroys habitats or reduces biodiversity
   ignore cost

(ii) increases the cost of food / land
   ignore cost of machinery / process
   ignore cheaper to produce biodiesel

(a) carbon dioxide decreased (by plants / trees)
   allow plants / trees absorbed carbon dioxide

oxygen increased (by plants / trees)
   allow plants / trees released oxygen
   if neither of these marks awarded
   allow plants / trees
   photosynthesise for 1 mark

because coal ‘locks up’ / traps / stores carbon dioxide / carbon
   allow trees ‘locked up’ carbon dioxide / carbon
(b) carbon / C
hydrogen / H
sulfur / S
all 3 correct 2 marks
1 or 2 correct 1 mark
allow H₂
ignore oxygen

(c) (i) 2 2
balancing must be correct
do not accept changed formulae

(ii) increases atmospheric pollution
carbon dioxide / CO₂ released
from the (thermal) decomposition of calcium carbonate or accept causes global warming or CO₂ is a greenhouse gas
description of this decomposition or equation
ignore sulfur dioxide and effects in this part
decreases atmospheric pollution
sulfur dioxide / SO₂ is removed
accept less acid rain produced
by reaction with calcium oxide or calcium carbonate
accept neutralisation or forms calcium sulfate

(a) bar drawn correctly 78 – 80 (%)
(d) the eruption of volcanoes

(a) (i) a reasonable attempt at a smooth curve

allow a curve which is close to but does not necessarily touch all points

(ii) any two from:

allow thicker / thinner / runny for viscous

- biodiesel is more *viscous* than petroleum diesel at all / lower temperatures

- biodiesel – as the temperature increases the viscosity decreases or vice versa

- petroleum diesel – the viscosity does not change
  
  if no other mark awarded

  allow 1 mark for any correct conclusion based on time or rate of flow

(iii) does not flow as easily (through pipes / engine)

allow could form a solid / block pipes / engine at low temperatures

or

needs a high temperature to flow

allow more difficult to vaporise / ignite

ignore burning

ignore references to viscosity

(b) (i) global dimming

allow correct description

(ii) 56 (%)  

(iii) (increases) acid rain

because there is *more* nitrogen oxide(s)

ignore sulfur dioxide

if no other mark awarded

allow 1 mark for nitrogen oxide(s) given
(iv) answer yes or no does not gain credit because the marks are for an explanation
ignore references to petroleum diesel
allow carbon for carbon dioxide

no because carbon dioxide (26%) is released / produced

this will not all be absorbed by photosynthesis / growing plants for biodiesel
accept growing plants / farming uses machinery / fossil fuels
releases carbon dioxide

OR

yes because although carbon dioxide (26%) is released / produced (1)

this was absorbed by photosynthesis / growing plants (for biodiesel) (1)
allow this will be absorbed by photosynthesis / growing plants for biodiesel

(a) crust
ignore Earth’s

core
ignore inner and/or outer

(b) bar chart
all heights are correct
accept correctly plotted points

all labels are correct for nitrogen, oxygen and other / argon

(c) (i) decomposed

(ii) global warming
(a) (i) any two from:

- used by plants  
  *allow specific plants and algae*

- used for photosynthesis  
  *ignore oxygen released / respiration*

- absorbed / dissolved in oceans  
  *ignore oceans formed*

- locked up in fossil fuels / limestone / sedimentary rocks

(ii) calcium carbonate / CaCO$_3$

  decomposed / thermal decomposition
  *do not allow reaction with oxygen*
  accept quicklime / calcium oxide produced
  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ gains 2 marks

(b) increasing (CO$_2$ or global warming)

  more rapid increase recently

  carbon dioxide causes global warming
  *accept greenhouse gas or climate change / sea level rising or ice caps melting*
  *do not accept ozone layer or acid rain or global dimming*

(c) (i) any one from:

- Wegener had no evidence / proof  
  *accept movement too slow to measure*

- other scientists had different ideas / views  
  *accept continents / plates fixed or land bridge*

- did not respect Wegener as a scientist / geologist
(ii) any three from:

- plates (move)
  * ignore continents
- heat energy / radioactivity (causes)
- convection currents
- in mantle

3

(a) carbon / diesel / it reacts / burns in oxygen / air

limited supply (of oxygen / air)
* accept incomplete combustion

\[ 2C + O_2 \rightarrow 2CO \text{ or} \]
\[ C + CO_2 \rightarrow 2CO \text{ gains 2 marks} \]

1

(b) any four from:

* accept converse statements for fossil diesel.
  * ignore cost / ease of manufacture / usage issues

for biodiesel:

- less global dimming (because fewer carbon particles)
- less acid rain (because less sulfur dioxide)
  * if neither point awarded, fewer carbon particles and less sulfur dioxide = 1 mark
- renewable resource / sustainable
  * accept fossil fuel / diesel supplies are limited
- use waste vegetable oils / fats
- vegetables / plants absorbed carbon dioxide / carbon neutral
  * accept fossil fuel / diesel releases locked up carbon / is not carbon neutral
- uses land which could be used to produce food
- third world countries can produce bio diesel
- biodegrades easily
- more NOx released

4

justified conclusion

1

[7]
(a) sulfur dioxide / SO₂
   
   allow sulfur oxide

(b) global dimming

(c) oxygen / O₂

(d) (oil is a) limited resource / finite / non-renewable
   
   accept running out of oil or wood is sustainable
   accept (burning oil) increases amount of carbon dioxide in the atmosphere / global warming or releases locked up carbon / global dimming / acid rain
   accept the oil (may become) too expensive

(e) carbon dioxide produced (from burning wood)
   
   ignore global warming

   carbon dioxide used by plants / trees or for photosynthesis
   
   if no other mark awarded
   allow carbon emissions used by plants / trees or for photosynthesis
   for 1 mark

(a) complete diagram with 2 carbon atoms and 5 hydrogen atoms each C–C and each C–H linked by a single line (bond)

(b) (i) the greater the number of (carbon) atoms (in an alkane molecule) the greater its boiling point or vice versa
   
   allow as the (carbon) chain gets longer the boiling point increases
   ignore melting points
   do not accept reference to greater number of molecules
(ii) \( \text{they} = \text{hydrocarbons from the graph} \)
\( \text{it} = C_{30}H_{62} \)
any two from:
- low boiling point / volatile
  accept they are gases or liquids
- low viscosity
- high flammability
  accept easier to burn / ignite
- small molecules
  accept short chains
  ignore number of carbon atoms
- burn completely
  ignore speed of burning

(c) (i) \( 16 (\text{CO}_2) + 18 (\text{H}_2\text{O}) \)

(ii) (carbon dioxide in the Earth’s early) atmosphere
  accept from volcanoes (millions of years ago)
  or from dead plants / animals
  allow dead sea creatures
  ignore shells

(iii) increase in burning / use of fossil fuels

locked up carbon (carbon dioxide) is released
  allow carbon / carbon dioxide from millions of years ago is released
  accept extra carbon dioxide is not ‘absorbed’ (by the carbon cycle)
Arguments for biodiesel

max three from:

• sustainable / renewable
• (carbon neutral) absorbs CO₂ when growing / during photosynthesis
• burning biodiesel produces low amounts particulates / carbon monoxide
  allow burning biodiesel produces little / low amount of global dimming
  ignore sulfur dioxide
• can use waste vegetable oils / fats (from food industry) or can use waste plant material
• can be used to conserve crude oil (instead of / mixed with petroleum diesel)
• produced by a low energy / temperature process
  accept produced by a low tech process
• biodegrades (easily)
  ignore engine effects

Arguments against biodiesel

max three from:

• creates food shortages
  accept price of food increases
• deforestation to plant more crops leads to loss of habitat / biodiversity or deforestation leads to a reduction in absorption of CO₂
  allow burning trees increases CO₂
  allow deforestation increases global warming
• burning biodiesel produces high amounts of nitrogen oxides
  allow increases acid rain
• crops takes time to grow
  allow crops can fail
• vast areas of land needed to grow crops

conclusion supported by the argument presented, which must give added value to the points for and against given above
(a) (thought to cause) global warming / green house (effect) / climate change

global warming → carbon dioxide

global dimming → carbon particles

(b) any three from:

• replant trees / renewable / sustainable
  ignore reusable

• carbon (dioxide) used by trees / photosynthesis
  accept trees absorb carbon (dioxide) as they grow
  ignore respiration

• it is a (continuous / carbon) cycle
  accept burning wood is carbon neutral

  or
  carbon (dioxide) goes back into the air
  for the second and third bullet points: accept trees use carbon
dioxide which is released when (trees / wood are / is) burnt for 2
marks

• no new carbon (dioxide) is produced
  or
  no locked up carbon (dioxide) is released

  or
  the carbon (dioxide) was absorbed millions of years ago

(a) acid rain → sulfur dioxide

(b) (i) oxygen

(ii) carbon monoxide

(c) (i) decreasing
  accept running out / none left
(ii) any two from:

\[ \text{it = coal} \]

- world needs (more) energy
  accept population is increasing
  allow (greater) demand for coal / fuels / energy

- plentiful supply
  accept readily available
  allow coal will 'last longer'

- (many) countries have coal

- easy to find / extract

- oil / gas is running out
  accept need to use less oil / gas
  accept need to use it to replace oil / gas

- cheap or cheaper than oil

\[ ^2 \]