8. *(a)* In 1987, the United Nations published a report on sustainable development, which included the following statement:

"Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

(i) In the UK, most electricity is generated in gas-fired power stations.
Give **two** reasons why the use of gas to generate electricity does not match the definition of sustainability. [2]

QWC [1]

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(ii) Suggest **one** method of generating electricity which would be sustainable and outline how it works. [2]

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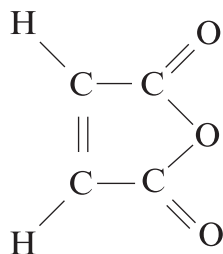
9. *(a)* The compound maleic anhydride (Z-butenedioic anhydride) is an important compound that is used in the production of polyester resins.

maleic anhydride

(i) Three compounds, **L**, **M** and **N**, can be used to produce maleic anhydride in the presence of oxygen. The same conditions are used in each method.

Compound	% Yield of maleic anhydride	Other product(s)
L	75	H_2O and CO_2
M	65	H_2O
N	75	H_2O

I Using the **information in the table only** suggest which compound, **L**, **M** or **N**, should be used to produce maleic anhydride. Explain your reasoning. [2]

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II Chemical manufacturers are interested in methods of production that have a minimum effect on the environment – 'Green Chemistry'.
Suggest **two** factors (not from information given in the table) that manufacturers should take into account when considering the production of maleic anhydride. [2]

1. ....

....

2. ....

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(c) Describe how industry is adapting to the challenges of *Green Chemistry*. Your answer should include reference to the

- overall aim of Green Chemistry,
- materials used or produced,
- energy used. [3]

QWC [1]

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Total [12]

II   Describe the practical steps used to obtain a titration value. You should start by measuring $25.00 \, cm^3$ of the potassium carbonate solution from the $250 \, cm^3$ stock solution, with the acid already in the burette.   [5]

QWC [1]

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(b)   In another experiment Penny obtained white crystals of potassium carbonate, K_2CO_3, from the wood ash.

(i)   Show that the percentage by mass of potassium in K_2CO_3 is 56.6.   [2]

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....

(ii)   Some of Penny's crystals were analysed for potassium by flame emission spectroscopy. The results showed that the percentage of potassium present was 44.9%.
Penny suggested that the crystals of potassium carbonate might be a hydrate, $K_2CO_3.2H_2O$.

Explain why the percentage of potassium in the hydrate is lower than the value stated in (i).   [1]

....

....

(c)   Potassium compounds are usually obtained from mineral deposits of potassium chloride rather than from wood ash.

Suggest **one** environmental disadvantage of using wood ash to obtain potassium compounds.   [1]

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Total [16]

Section B Total [70]

8. *(a)* During the last 200 years, the average temperature of the Earth has risen. One hypothesis put forward by many scientists is that this is due to increased concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

The table below shows the concentration of carbon dioxide in the atmosphere at 50 year intervals since 1800.

	Year				
	1800	1850	1900	1950	2000
Concentration of carbon dioxide in the atmosphere / % by volume	0.0282	0.0288	0.0297	0.0310	0.0368

The following graph based on data from NASA research, shows the annual global temperature relative to the average temperature between 1951 and 1980.

Global Temperature
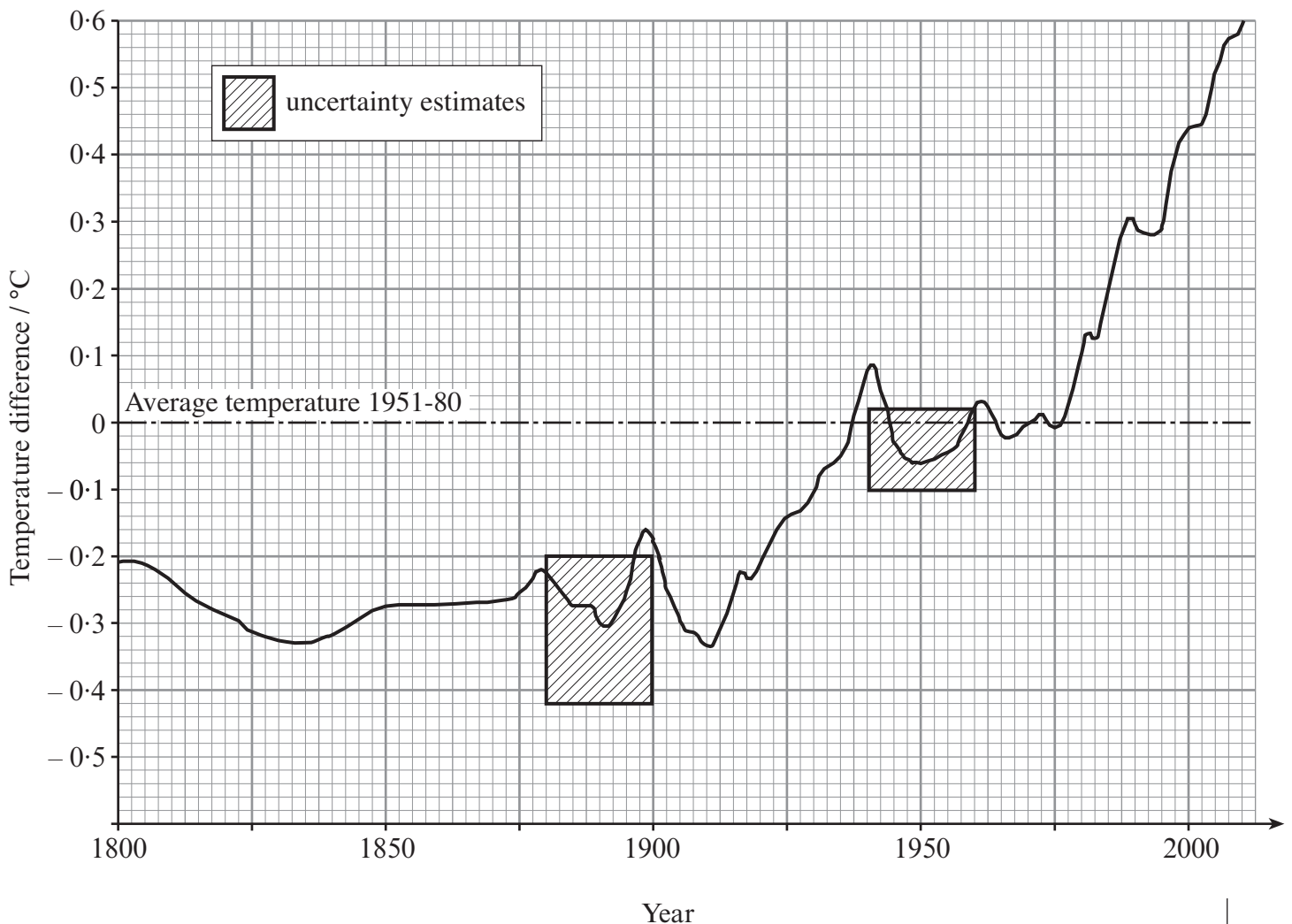
(i) Explain how these two sets of data led many scientists to this hypothesis.   [2]
                                                                          QWC [1]

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(ii) Suggest why the data does not convince all scientists that this hypothesis is true.[1]

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(iii) Suggest **two** reasons why the uncertainty is greater in the period 1880-1900 than
       the period 1940-1960.   [2]

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(iv) Give **two** reasons for the changing amounts of carbon dioxide in the atmosphere
      after 1900.   [2]

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Turn over.

(d) The most important chemical reactions in terms of tonnage used are the combustion of coal and hydrocarbons to produce energy. There are major problems arising from these combustion reactions. Describe **one** such problem and discuss what can be done about it. [2]

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Total [15]

Section B Total [70]

Turn over.

(b) The Fischer-Tropsch process uses a heterogeneous catalyst containing iron.

(i) State what is meant by the term *heterogeneous* in this context. [1]

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....

(ii) Explain how a catalyst increases the rate of a chemical reaction. [2]

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(iii) Chemical manufacturers consider catalysts to be a key part of production methods that have the minimum possible effect on the environment ('Green Chemistry'). Give **one** reason why the use of catalysts reduces the effect on the environment.[1]

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(iv) An alternative method of increasing the rate of a chemical reaction is to increase the temperature. Explain why temperature affects the rate of a chemical reaction. [3]
QWC [1]

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Turn over.

9. The metal lead was one of the first in common use and even as far back as two thousand years ago, tens of thousands of tonnes of the metal were being produced every year in the Roman Empire. It is still in common use today, although many of its former uses have declined due to the toxic nature of the element.

(a) Lead is commonly extracted from lead(II) sulfide, PbS. Initially this ore is heated in a limited supply of air to produce lead(II) oxide, PbO, giving off sulfur dioxide gas, SO_2.

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$

If 20 kg of lead(II) sulfide were heated in air, calculate the mass of lead(II) oxide formed. [3]

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Mass of lead(II) oxide formed = ... kg

(b) Metallic lead can then be obtained from lead(II) oxide by one of two methods:

Method 1: Reduction with a fresh supply of lead(II) sulfide in the absence of air

$$2PbO + PbS \longrightarrow 3Pb + SO_2$$

Method 2: Reduction by carbon monoxide in a blast furnace

$$PbO + CO \longrightarrow Pb + CO_2$$

(i) Both methods for producing lead release waste gases. Give an environmental problem associated with each of these gases. [2]

Sulfur dioxide, SO_2 ....

....

Carbon dioxide, CO_2 ....

....

(ii) The atom economy for producing lead by method 1 is 90.7 %.

I. Calculate the atom economy for producing lead by method 2. [2]

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II.   Atom economy is one factor used in 'Green Chemistry' to assess the advantages and disadvantages of different routes to produce the same product. State, giving a reason, which of the two alternative methods would be considered to have the more advantageous atom economy.   [1]

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(c)   Lead has a wide range of isotopes, some of which are stable and others that are radioactive. Radioactive lead-212 decays to eventually form the stable isotope ^{208}Pb. This process involves the decay of ^{212}Pb into ^{212}Bi followed by two alternative routes that both lead to ^{208}Pb, as shown in the scheme below.
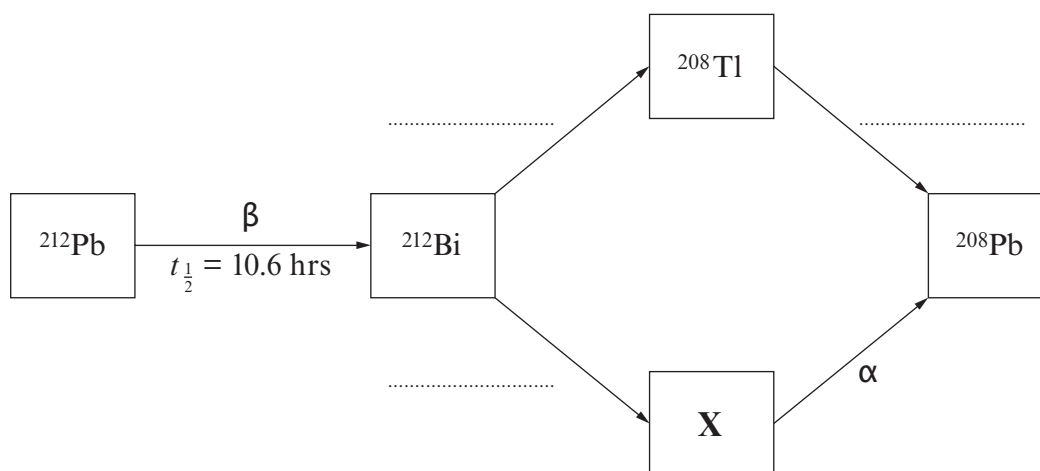
(i)   Give the correct symbol and mass number of the isotope indicated by **X** on the scheme above.   [2]

Symbol ....   *Mass Number* ....

(ii)   Two arrows have been labelled with α and β.
Label the remaining **three** arrows to indicate the nature of the radioactive decay occurring in each step.   [2]

(1091-01)   **Turn over.**

8. *(a)* The vast majority of motor vehicles worldwide are powered by petrol or diesel which come from crude oil. Give **two** reasons why we cannot rely indefinitely on oil as a source of transport fuel. [2]

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(b) Many vehicle manufacturers around the world have made the development of alternative fuels a priority. One such fuel being studied is hydrogen.

Its main advantage is that the only waste product is water, however hydrogen does not occur naturally on Earth. It is produced by passing an electric current through water.

(i) A leading car manufacturer said,
"Cars powered by hydrogen will be pollution-free".
Give **two** reasons why this is not necessarily true. [2]
QWC [1]

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(ii) A spokesperson for a safety group said,
"Hydrogen can burn explosively. It must not be used in cars unless it is 100% safe".
State, giving a reason, whether you agree with this. [1]

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14

(iii) Study the short account below, which gives more detail about this process.

The process to make phenol is carried out in the gas phase and uses a solid zeolite catalyst. The operating temperature is around 400 °C.

$$C_6H_6 \ + \ N_2O \ \longrightarrow \ C_6H_5OH \ + \ N_2 \qquad \Delta H = \ -286 \, kJ \, mol^{-1}$$

The reactants are the hydrocarbon benzene and nitrogen(I) oxide, which is a potent greenhouse gas. The nitrogen(I) oxide is obtained from another process, where it is produced as an undesirable side product.

Use the account and the equation to comment on the environmental and *Green Chemistry* advantages of this process. A reference to the yield is not required. [4]
QWC [1]

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Total [14]

(d) Ethanoic acid, CH_3COOH, is one of the most familiar compounds used as a flavouring and preservative for food. Originally ethanoic acid was produced by oxidation of ethanol by bacteria in the presence of air (route **A** below). Today there are many other possible routes and three of these are shown as routes **B**, **C** and **D** below.

Route	Carbon-containing starting materials	Conditions	Overall equation	Atom economy
A	ethanol		$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$	76.9%
B	methanol, carbon monoxide	150°C, 30 atm	$CH_3OH + CO \rightleftharpoons CH_3COOH$	100.0%
C	butane	150°C, 55 atm	$2C_4H_{10} + 5O_2 \rightarrow 4CH_3COOH + 2H_2O$	87.0%
D	sugars		$C_6H_{12}O_6 \rightarrow 3CH_3COOH$	

(i) State the atom economy of route **D** for production of ethanoic acid. [1]

....

(ii) Route **B** is the route most commonly used for producing ethanoic acid today for both financial and *Green Chemistry* reasons. Apply the principles of *Green Chemistry* to the information above to give **two** reasons why route **B** is favoured over route **C**. [2]

1. ....

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2. ....

....

(iii) Route **B** uses a homogeneous catalyst. State what effect the catalyst will have on the position of this equilibrium. [1]

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Total [17]

Section B Total [70]

(e)   Many catalysts are very expensive but their use does allow the chemical industry to operate more profitably. Explain why the use of catalysts provides economic and environmental benefits. [3]

QWC [1]

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Total [18]

(d) The students then used the apparatus from *(b)* to find the enthalpy change of combustion of higher relative molecular mass alcohols. They found that as the number of carbon atoms increased the value of the enthalpy change of combustion became more negative.

(i) Write the equation for the reaction which represents the enthalpy change of combustion of propanol, C_3H_7OH. [1]

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(ii) In terms of bond strengths, explain why enthalpy changes of combustion are negative. [1]

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(iii) Explain why the enthalpy change of combustion of propanol is more negative than that of ethanol. [1]

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(e) Recent research has been carried out to find economic and environmentally friendly uses for waste straw and wood chippings.

The process of gasification involves the material being partly combusted at a temperature of about 700 °C to give a mixture consisting mainly of hydrogen and carbon monoxide but also some carbon dioxide.

Another approach has been to use enzyme catalysed reactions to change the waste material into glucose and then to ethanol.

Comment on the economic and environmental factors involved in both of these processes. [4]
QWC [2]

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Total [17]