F322: Chains, Energy and Resources
2.4.1 Chemistry of the Air

1. NO is a radical and contributes towards ozone depletion in the stratosphere.

(i) What is a *radical*?

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[1]

(ii) One of the processes leading to the breakdown of ozone in the stratosphere can be represented by the following two equations.

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$$

$$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$$

What is the role of the NO in this process?

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[1]

(iii) Ozone in the stratosphere is broken down to make O_2 and O.

Describe and explain how the concentration of ozone in the stratosphere is maintained.

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[2]

(iv) Why is it important to life on the Earth's surface that the concentration of ozone in the stratosphere is maintained?

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[1]

[Total 5 marks]

2. There is much international concern that an increase in atmospheric concentrations of carbon dioxide and methane may lead to global warming and climate change.

Carbon dioxide and methane are both greenhouse gases.

(i) What type of radiation is absorbed by methane molecules and what effect does this radiation have on these molecules?

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[2]

(ii) Some scientists are more concerned about carbon dioxide as a greenhouse gas than methane.

Suggest why.

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[1]

[Total 3 marks]

3. Describe ways that research chemists are trying to minimise climate change resulting from global warming caused by the release of greenhouse gases.

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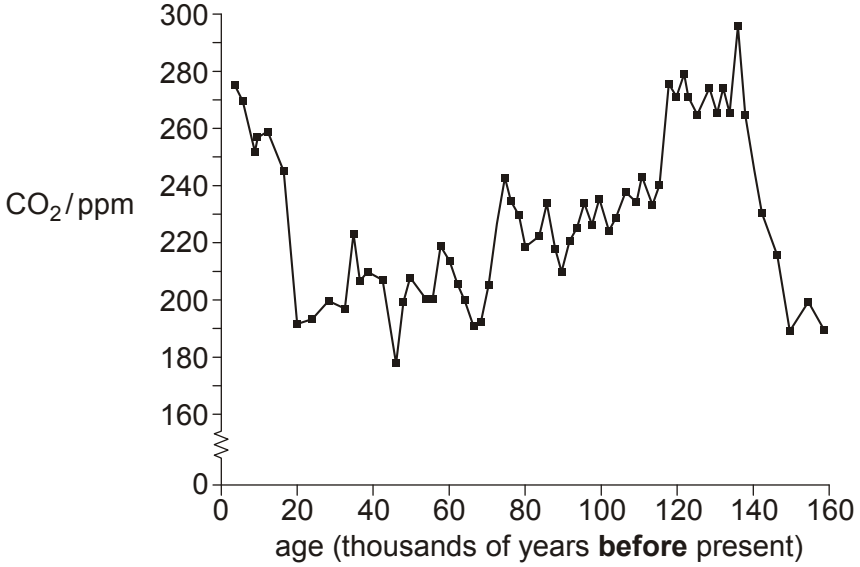
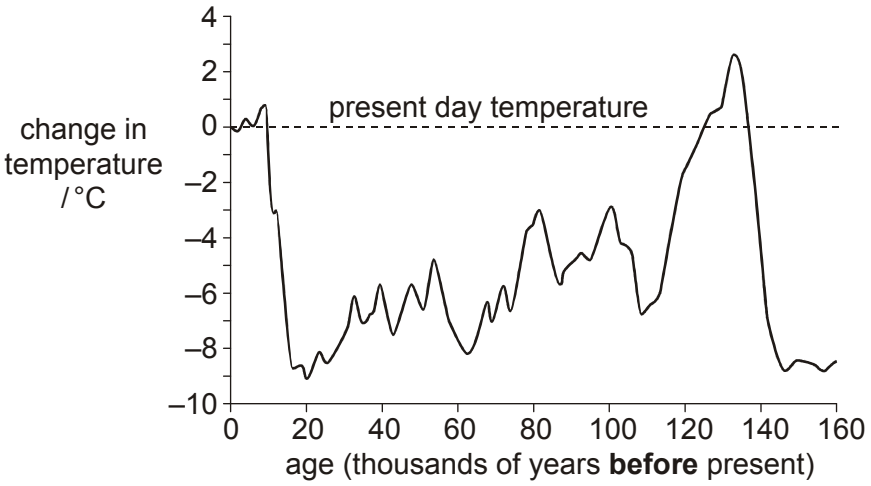
[Total 5 marks]

4. Research scientists working in the Antarctic have measured the concentration of carbon dioxide in the ice. This study has allowed the scientists to estimate the atmospheric concentration of carbon dioxide over many thousands of years.

The graphs below show these atmospheric concentrations and the corresponding average surface temperature.





Do the graphs provide reliable evidence that an increase in atmospheric carbon dioxide concentration will result in global warming?

Explain your answer.

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[Total 2 marks]

5. In cars fitted with a catalytic converter, two toxic gases, CO and NO, react together to form two non-toxic gases.

(i) Write an equation for the reaction between CO and NO in a catalytic converter.

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[1]

(ii) Outline the stages that take place in a catalytic converter to allow CO to react with NO.

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[3]

[Total 4 marks]

6. Some scientists believe that increased CO_2 levels arising from the combustion of hydrocarbons lead to global warming because CO_2 is a greenhouse gas. Carbon capture and storage, CCS, is being developed as a method for removing CO_2 produced by combustion.

(i) Different gases have different contributions to global warming.

State **two** factors that affect the contribution of a greenhouse gas to global warming.

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[2]

(ii) Outline two methods that could be developed to achieve carbon capture and storage, CCS.

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[2]

[Total 4 marks]

7. Catalysts are increasingly being used in chemical processes.

A catalyst speeds up a reaction without being consumed by the overall reaction.
A catalyst provides an alternative reaction route with a lower activation energy.

(i) Chlorine radicals, $Cl^{\bullet}$, catalyse some reactions.

Choose a reaction that you have studied that is catalysed by chlorine radicals.

Write down an equation for the overall reaction and show how chlorine radicals are **not** consumed by the overall reaction.

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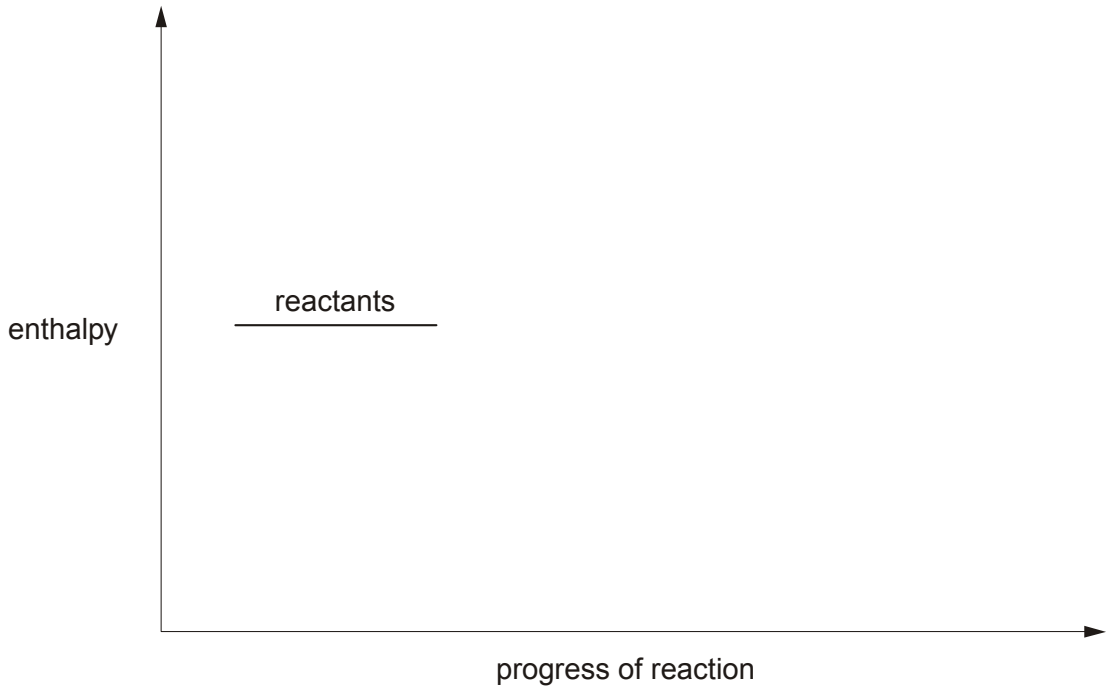
[3]

(ii) Using the axes below, sketch an enthalpy profile diagram for an exothermic reaction to show how a catalyst provides an alternative reaction route with a lower activation energy. Include on your diagram labels for:

- enthalpy change, ΔH;
- activation energy for the catalysed route, E_c;
- activation energy for the uncatalysed route, E_a.



[3]

[Total 6 marks]

8. Chlorofluoroalkanes, CFCs, were developed from fluoroalkanes and were used in aerosols and as refrigerants. Under the Montreal Protocol, CFCs are now largely banned because of their ozone-depleting properties. CFCs have now been replaced in many applications.

Suggest **two** reasons why there is still concern about ozone depletion.

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[Total 2 marks]

9. CFCs and carbon dioxide affect the Earth's atmosphere.

CFCs form chlorine radicals, C*l*, in the atmosphere. Chlorine radicals are one of the factors responsible for depleting the ozone layer in the stratosphere. The equations below represent two steps that occur during this process. Complete these equations and construct an overall equation for the reaction.

$Cl + O_3 \rightarrow ClO +$ .....

..... $+ O \rightarrow Cl + O_2$

.....overall equation

[Total 2 marks]

10. Concern about the consumption of fossil fuels and excessive emissions of carbon dioxide from cars has led to moves to cut down on car usage.

(i) Heptane, C_7H_{16}, is a component in petrol. Construct a balanced equation for the complete combustion of heptane.

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[2]

(ii) Gases such as CO_2 contribute towards the 'Greenhouse Effect'.

What happens to CO_2 molecules in this process?

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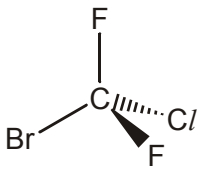
[2]

[Total 4 marks]

11.



Bromochlorodifluoromethane has been used as a flame retardant.

When exposed to high temperatures, one of the C–halogen bonds undergoes homolytic fission to produce free radicals.

Suggest, with a reason, which C–halogen bond is most likely to be broken.

The C–halogen bond most likely to be broken is ..... because .....

.....

.....

[Total 1 marks]

12. Many chemical reactions occur in the atmosphere.

Car engines produce carbon monoxide and nitrogen monoxide near to the Earth's surface.

Explain how carbon monoxide and nitrogen monoxide are formed in the car engine.

carbon monoxide .....

.....

nitrogen monoxide .....

.....

[Total 2 marks]

13. In the upper atmosphere, reactions occur involving chlorine free radicals, C*l*.

Equations for two such processes are given below.

$Cl + O_3 \rightarrow ClO + O_2$ **equation 1**

$ClO + ... \rightarrow Cl + O_2$ **equation 2**

(i) Complete **equation 2.**

[1]

(ii) Write the overall equation for the two processes shown in **equations 1 and 2.**

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[1]

(iii) Describe how the chlorine free radicals, C*l*, are formed in the upper atmosphere.

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[2]

(iv) State **one** undesirable result of ozone depletion in the upper atmosphere for life on Earth.

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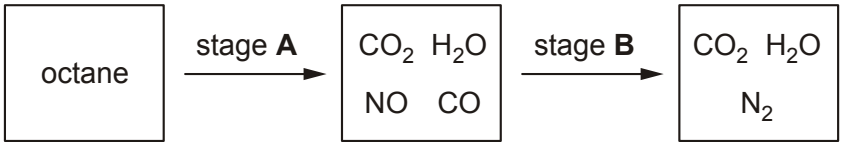
[1]

[Total 5 marks]

14. This question looks at some aspects of the use of petrol as a fuel for cars.

Petrol contains octane, C_8H_{18}. Two of the stages that occur when petrol, containing octane, is used in a car engine are shown below.



(a) Stage **A** includes the complete combustion of octane.

(i) Write the equation for this reaction.

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[2]

(ii) Suggest how NO is produced.

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[1]

(b) Stage **B** requires a catalyst.

(i) Name **two** metals generally present in the catalyst.

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[1]

(ii) The catalyst is a heterogeneous catalyst. Describe how it works.

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[3]

(iii) Using the substances shown above, write the equation for the reaction that occurs in stage **B**.

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[2]

(c) If stage **B** does not happen, further reactions occur and pollution levels rise.

Suggest **one** pollutant whose level in the atmosphere would rise.

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[1]

[Total 10 marks]

15. There are two types of catalysis, homogeneous and heterogeneous.

CFCs form chlorine free radicals, C*l*, in the atmosphere. Chlorine free radicals are one of the factors responsible for depleting the ozone layer in the stratosphere. This is an example of homogeneous catalysis.

(i) Equations 1 and 2 represent two possible steps that occur during this process. Complete these equations and construct an overall equation for the reaction.

$Cl + O_3 \rightarrow ClO +$ ..... equation 3.1

..... $+ O \rightarrow Cl + O_2$ equation 3.2

overall equation

[3]

(ii) Use the equations above to identify a catalyst in the reaction scheme.

Explain your answer.

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[2]

[Total 5 marks]

16. A catalytic converter contains a heterogeneous catalyst. One of the reactions catalysed is shown below.

$$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$$

State what is meant by a *heterogeneous* catalyst and outline the way that this type of catalyst works in a catalytic converter.

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[Total 4 marks]