Questions

Q1.

This is a question about alkanes.

Alkanes are obtained by processing crude oil.

(i) Explain why different alkanes in crude oil can be separated by fractional distillation.

(2)

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(ii) Complete the equation for the cracking of octane to produce ethene and only one other organic compound. State symbols are not required.

(1)

C_8H_{18} → .... + ...

(iii) Write the equation for the reforming of hexane into cyclohexane, using **displayed** formulae for the organic compounds. State symbols are not required.

(1)

(Total for question = 4 marks)

Q2.

This question is about alkanes and their reactions.

A student researched the reaction of propane with bromine and found that the reaction could be used to make 1-bromopropane.

$$C_3H_8(g) + Br_2(l) \rightarrow C_3H_7Br(l) + HBr(g)$$

(i) The first step of the reaction involves

(1)

- ☐ **A** heterolytic bond fission to form free radicals
- ☐ **B** heterolytic bond fission to form ions
- ☐ **C** homolytic bond fission to form free radicals
- ☐ **D** homolytic bond fission to form ions

(ii) Calculate the atom economy by mass for the formation of 1-bromopropane in the reaction in (i).

(2)

(iii) A source from the internet gave the percentage yield for this reaction as 31.0%.

The best explanation for the low percentage yield of 1-bromopropane in this reaction is

(1)

- ☐ **A** bromine is very unreactive
- ☐ **B** a gaseous reactant always gives a low yield
- ☐ **C** the reaction is very slow
- ☐ **D** the reaction produces a mixture of organic products

(iv) Calculate the volume of propane, in dm^3, measured at room temperature and

pressure, that is needed to produce 14.7 g of 1-bromopropane, assuming a percentage yield of 31.0%.
Give your answer to an appropriate number of significant figures.
[Molar gas volume at r.t.p. = 24.0 $dm^3\ mol^{-1}$]

(3)

(Total for question = 7 marks)

Q3.

Catalytic converters in cars remove unwanted substances such as nitrogen monoxide, carbon monoxide and unreacted hydrocarbons from the exhaust fumes.

The formula of the nitrogen monoxide free radical can be written as NO•

(i) Which is true for the NO• free radical ?

(1)

- ☐ **A** NO• is formed during thermal decomposition of LiNO3
- ☐ **B** NO• has a total of 15 protons, 15 neutrons and 16 electrons
- ☐ **C** NO• is a species with an unpaired electron
- ☐ **D** NO• is formed by heterolytic fission

(ii) It has been suggested that unreacted hydrocarbons and nitrogen monoxide are removed in a catalytic converter by reacting them together.

The reaction between decane and nitrogen monoxide produces carbon dioxide, water and nitrogen as the only products.
Complete the balanced equation for this reaction.
State symbols are not required.

(2)

.... $C_{10}H_{22}$ + ... NO $\rightarrow$

(iii) Give a possible reason why this reaction might not proceed according to the equation in (ii).

(1)

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(Total for question = 4 marks)

Q4.

This question is about organic compounds.

Organic compounds can be grouped together in homologous series.

(i) Describe **two** characteristics of a homologous series.

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(ii) Name the homologous series to which propene belongs.

(1)

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(Total for question = 3 marks)

Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about hydrocarbons.

When hydrocarbons undergo complete combustion, there is a change in the total volume of gases.

(i) Ethane burns in excess oxygen.

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$$

All gas volumes are measured at the same temperature and pressure when water is a gas.
What is the **increase** in the total volume when 100 cm^3 of ethane is burned in excess oxygen?

(1)

- ☐ **A** 50 cm^3
- ☐ **B** 100 cm^3
- ☐ **C** 200 cm^3
- ☐ **D** 500 cm^3

(ii) A combustion experiment was carried out using conditions under which water was a liquid.

A cyclic hydrocarbon, C_xH_y, was mixed with excess oxygen and ignited.
Under the conditions of the experiment, this hydrocarbon was gaseous and had a volume of 25 cm^3.
The equation for the complete combustion of C_xH_y is

$$C_xH_y(g) + (x + \frac{y}{4})O_2(g) \rightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$$

The total gas volume **decreased** by 75 cm^3.
The remaining gases were shaken with aqueous sodium hydroxide and the total gas volume **decreased** by a further 125 cm^3.
All gas volumes were measured at the same temperature and pressure.
Suggest the identity of the cyclic hydrocarbon by calculating the molecular formula of C_xH_y.
Include the **skeletal formula** of the cyclic hydrocarbon.

(3)

(Total for question = 4 marks)

Q6.

This question concerns the combustion of fossil fuels in power stations.

One of the problems associated with the combustion of some fossil fuels is the production of acidic gases, including the oxides of nitrogen and sulfur.

(i) Explain how oxides of sulfur and nitrogen can be formed from the combustion of fossil fuels.

(2)

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(ii) Some power stations use a process of flue gas desulfurisation (FGD) to remove sulfur oxides from the gaseous combustion products.
One such process, known as wet scrubbing, uses a mixture of calcium carbonate and water to react with sulfur dioxide.

Two relevant equations are

$$SO_2(g) + CaCO_3(s) \rightarrow CaSO_3(s) + CO_2(g)$$
$$CaSO_3(s) + 2H_2O(l) + \tfrac{1}{2}O_2(g) \rightarrow CaSO_4{\cdot}2H_2O(s)$$

Explain why this process is an incomplete solution to the problem of burning fossil fuels.
Use the equations provided to illustrate your answer.

(2)

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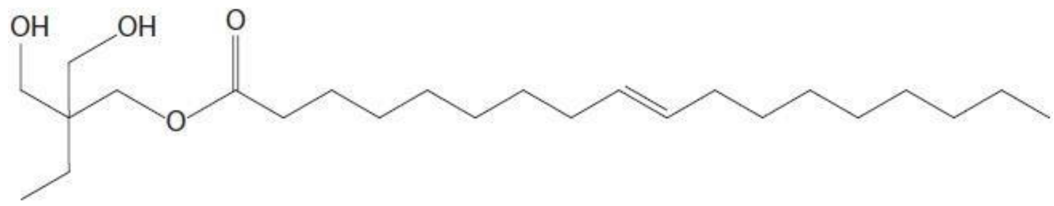
(Total for question = 4 marks)

Q7.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Compound **X** is a component of synthetic oils used as lubricants, for instance in the gearboxes of ships.



compound **X**

An alternative to synthetic oil is known as mineral oil and consists solely of hydrocarbons separated from crude oil.

(i) What is the name of the process used to separate different hydrocarbons from crude oil?

(1)

☐ **A** cracking
☐ **B** reforming
☐ **C** fractional distillation
☐ **D** heating under reflux

(ii) Explain why compound **X** is likely to have a higher boiling temperature than hydrocarbons of a similar molecular mass and shape.

A detailed description of how the intermolecular forces arise is not required.

(2)

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(Total for question = 3 marks)

Q8.

During cracking, carbon to carbon bonds are broken.

Explain the **two** major reasons for cracking hydrocarbons.

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(Total for question = 3 marks)

Q9.

Some alkanes are used as fuels for transport. Crude oil, which is a mixture of hydrocarbons, is the major source of these alkanes. Crude oil is processed by fractional distillation, cracking and reforming.

Fractional distillation produces fractions which contain molecules of a similar boiling temperature. Molecules containing six carbon atoms are found in both the petrol fraction and the higher boiling kerosene fraction.

(i) Identify, by name or structural formula, the unbranched alkane with six carbon atoms found in kerosene.

(1)

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(ii) Explain why **isomers** of the alkane in (i) have lower boiling temperatures and so are found in the petrol fraction.

(3)

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(Total for question = 4 marks)

Q10.

Ethane reacts with chlorine in the presence of ultraviolet light to form a mixture of products.

(i) In the initiation step, chlorine molecules are converted into radicals.

$$Cl_2 \rightarrow 2Cl\bullet$$

Identify the type of bond broken and the type of bond fission occurring in this step.

(1)

	Bond broken	Bond fission
☐ **A**	π	heterolytic
☐ **B**	σ	heterolytic
☐ **C**	π	homolytic
☐ **D**	σ	homolytic

(ii) Write the propagation steps to show the formation of C_2H_5Cl.

(2)

(iii) State how some butane, C_4H_{10}, is formed in the reaction.

(1)

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(Total for question = 4 marks)

Q11.

This is a question about hydrocarbons.

State what is meant by the term **hydrocarbon**.

(1)

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(Total for question = 1 mark)

Q12.

This is a question about catalytic converters in car exhaust systems.

When petrol is burnt in a car engine, pollutant gases including carbon monoxide and nitrogen monoxide are formed.

(i) Write the equation for the reaction between these two polluting gases that takes place on the surface of a catalytic converter. State symbols are not required.

(1)

(ii) Describe the stages by which the reaction in (i) occurs in a catalytic converter.

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(Total for question = 4 marks)

Q13.

Write the equation for reforming heptane into cycloheptane, showing the **skeletal** formulae of the organic molecules.

(2)

(Total for question = 2 marks)

Q14.

Ethane can also be converted into chloroethane.

(i) Give the reagent and condition required to convert ethane into chloroethane.

(1)

Reagent

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Condition

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(ii) What is the mechanism and type of reaction by which ethane is converted into chloroethane?

(1)

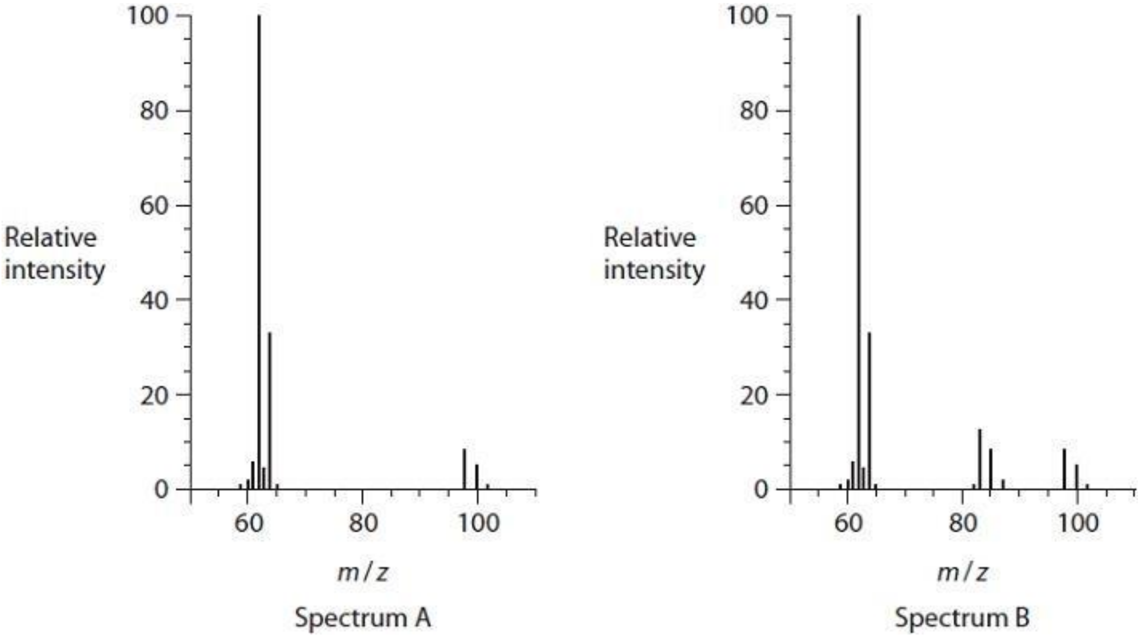
- ☐ **A** electrophilic addition
- ☐ **B** free radical addition
- ☐ **C** free radical substitution
- ☐ **D** nucleophilic substitution

(iii) Further reactions of chloroethane result in the formation of small amounts of the isomers 1,1-dichloroethane and 1,2-dichloroethane.

Write equations to show the formation of these products.
Curly arrows are not required.

(3)

(iv) The mass spectra of the two isomers of dichloroethane are shown.



Deduce the molecular formulae of the species responsible for the molecular ion peaks at *m* / *z* 98, 100 and 102.
The molecular formulae for the species producing these peaks are the same in both spectra.

(2)

(v) State why in both spectra the peaks at 98, 100 and 102 have different relative intensities.

(1)

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(vi) Explain how the presence of the peaks at 83, 85 and 87 in Spectrum B allows the identification of the isomer responsible for this spectrum.

(2)

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(Total for question = 10 marks)