Alkanes: Formulae, Reactions & Structure

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Alkanes: Formulae, Reactions & Structure
Booklet	Question Paper 1

Time Allowed: **59 minutes**

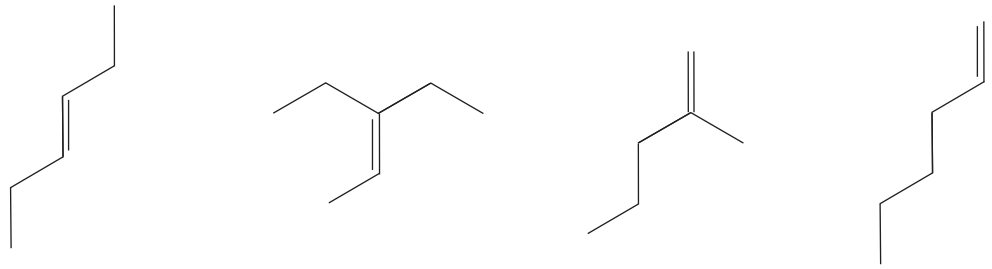
Score: **/49**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The following molecules are alkenes.



P Q R S

(a) Which molecule has a geometric isomer?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(b) Which molecule would produce 2-bromohexane as the **major** product on addition of hydrogen bromide?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(c) Which molecule has 14 hydrogen atoms?

(1)

☒ **A** P

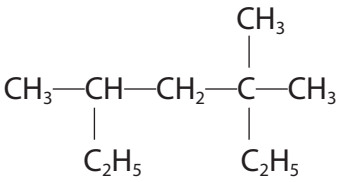
☒ **B** Q

☒ **C** R

☒ **D** S

(Total for Question 1 = 3 marks)

2 What is the systematic name for the following molecule?



- ☒ **A** 2,4-diethyl-2-methylpentane
- ☒ **B** 2,4-diethyl-4-methylpentane
- ☒ **C** 3,3,5-trimethylheptane
- ☒ **D** 3,5,5-trimethylheptane

(Total for Question 2 = 1 mark)

3 Which of the following is a step in the propagation stage of the chlorination of methane?

- ☒ **A** $Cl_2 \rightarrow Cl^{\bullet} + Cl^{\bullet}$
- ☒ **B** $CH_3^{\bullet} + Cl^{\bullet} \rightarrow CH_3Cl$
- ☒ **C** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$
- ☒ **D** $CH_4 + Cl^{\bullet} \rightarrow CH_3Cl + H^{\bullet}$

(Total for Question 3 = 1 mark)

4 How many structural isomers have the molecular formula C_6H_{14}?

- ☒ **A** Four
- ☒ **B** Five
- ☒ **C** Six
- ☒ **D** Seven

(Total for Question 4 = 1 mark)

5 (a) Which of the following represents the equation for the reaction between ethane and chlorine in the presence of UV radiation?

(1)

☒ **A** $C_2H_6 + Cl_2 \rightarrow C_2H_4Cl_2 + H_2$

☒ **B** $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

☒ **C** $C_2H_6 + Cl_2 \rightarrow 2CH_3Cl$

☒ **D** $C_2H_6 + 2Cl_2 \rightarrow 2CH_3Cl + 2HCl$

(b) The UV radiation initially causes the formation of

(1)

☒ **A** Cl^- ions.

☒ **B** Cl^+ ions.

☒ **C** $Cl^\bullet$ free radicals.

☒ **D** $C_2H_5^\bullet$ free radicals.

(c) Once it has started, the reaction can proceed for a time without UV light because

(1)

☒ **A** a chain reaction is occurring.

☒ **B** initiation is occurring.

☒ **C** a substitution reaction is occurring.

☒ **D** termination steps cannot occur without UV light.

(Total for Question 5 = 3 marks)

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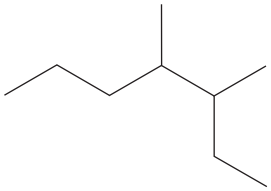
6 Which of the following is the systematic name for the hydrocarbon shown below?



☒ **A** 5-ethyl-4-methylhexane

☒ **B** 2-ethyl-3-methylhexane

☒ **C** 4,5-dimethylheptane

☒ **D** 3,4-dimethylheptane

(Total for Question 6 = 1 mark)

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7 Alkanes react with halogens in the presence of ultraviolet (UV) light.

(a) Write the equation for the overall reaction of bromine with methane to form bromomethane. State symbols are not required.

(1)

(b) Propane reacts with chlorine to produce C_3H_7Cl. There are two possible isomers with this molecular formula.

Draw the **skeletal** formulae of these two isomers and give their systematic names.

(4)

Name:	Name: .....

(c) Ethane reacts with chlorine in UV light by a free radical substitution mechanism involving a number of steps.

(i) Explain why ethane does not react with electrophiles.

(1)

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(ii) Explain why ethane undergoes substitution and not addition reactions.

(1)

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(iii) The first step of the reaction of chlorine with ethane in UV light involves homolytic fission.

Write the equation for this fission and state the name of this reaction step.

Curly half-arrows are not required.

(2)

Equation:

Name of reaction step .....

(iv) The ethyl free radical is an intermediate in the propagation stage of the reaction. Draw the dot-and-cross diagram of this free radical.

Use dots (•) for the hydrogen electrons, crosses (x) for the electrons of one of the carbon atoms and asterisks (*) for the electrons of the other carbon atom. Show only outer shell electrons.

(2)

(v) What change to the reaction mixture of ethane and chlorine would increase the production of polychlorinated alkanes such as 1,1-dichloroethane and 1,2-dichloroethane?

(1)

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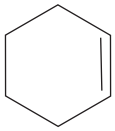
.....

(Total for Question 7 = 12 marks)

8 The reaction of liquid bromine is a standard test for alkenes.

(a) (i) Complete the equation for the reaction of cyclohexene with liquid bromine, using a skeletal formula.

(1)



$+ Br_2 \rightarrow$

(ii) What colour change would you see when this reaction occurs?

(1)

From ..... to .....

(b) Gaseous but-1-ene is another alkene that readily reacts with liquid bromine.

Using molecular formulae, the equation for the reaction is

$$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$$

(i) Using the bond enthalpy values in the table, calculate the enthalpy change for this reaction.

(2)

Bond	Bond enthalpy /kJ mol^{-1}
C—H	413
C—C	347
C═C	612
C—Br	290
Br—Br	193

(ii) Give **one** reason why the value calculated for the reaction in part (b)(i) using bond enthalpies is different from the true value.
Do **not** consider experimental error, mean bond enthalpy values or non-standard conditions.

(1)

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(iii) Using appropriate curly arrows, write the mechanism of the reaction between but-1-ene and bromine.

(3)

(iv) Identify, by name or by displayed formula, the product formed when bromine **water** is added to but-1-ene.

(1)

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(Total for Question 8 = 9 marks)

9 Compound **X** has the molecular formula C_5H_{12}.

(a) Draw the **displayed** formulae of the **three** structural isomers of C_5H_{12}.

(2)

(b) C_5H_{12} reacts with chlorine to form a mixture of products.

(i) Classify the type and mechanism of this reaction.

(2)

(ii) Write the equations for the two propagation steps for this mechanism. Use the molecular formula, C_5H_{12}, in your first equation. Curly arrows are not required.

(2)

(iii) Write the equation for **one** termination step for this mechanism. Curly arrows are not required.

(1)

(c) An experiment was carried out to determine the enthalpy change of combustion of compound **X**, C_5H_{12}.

100.0 g of water was heated by burning 0.144 g of compound **X**.

The temperature rise of the water was 14.5 °C.

(i) Calculate the energy transferred, in **kJ**, in this experiment.

Use the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

energy transferred = ... kJ

(ii) Calculate the number of moles of compound **X** used in this experiment.

(1)

moles of **X** = ...

(iii) Calculate the enthalpy change of combustion of compound **X**. Include a sign and units in your answer.

(2)

enthalpy change of combustion = ...

(iv) The Data Book values for the enthalpy changes of combustion of the three structural isomers with the formula C_5H_{12} are:

-3509.1 kJ mol^{-1}

-3503.4 kJ mol^{-1}

-3492.5 kJ mol^{-1}

The experimental value calculated in (c)(iii) is very different from these values. Give **two** reasons, other than heat loss, for this large difference.

(2)

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(v) Explain why it is **not** possible to deduce which of the isomers is compound **X** by comparing this experimental value and the Data Book values.

(1)

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*(d) Complete the Hess cycle and use it to calculate the enthalpy change of combustion of C_5H_{12} from the following data.

Show all of your working.

Standard enthalpy change of formation of $C_5H_{12}(l)$	–173.2 kJ mol^{-1}
Standard enthalpy change of combustion of $H_2(g)$	–285.8 kJ mol^{-1}
Standard enthalpy change of combustion of carbon(s, graphite)	–393.5 kJ mol^{-1}

(4)

$C_5H_{12}(l) + 8O_2(g)$ ⟶ $5CO_2(g) + 6H_2O(l)$

..... + ... + ...

(Total for Question 9 = 18 marks)