Chapter 15: Hydrocarbons

Homework marking scheme

1 a i Isomers are compounds with the same molecular formula [1]
but different structural formulae. [1]

ii [2]

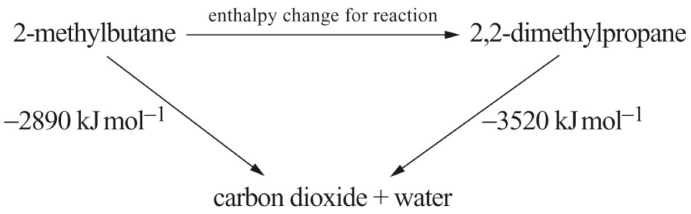
2-methylbutane 2,2-dimethylpropane

b i heat change = mass × specific heat capacity × change in temperature
= 200 × 4.18 × 30 [1]
= 25 080 J = 25.1 kJ [1]

ii number of moles of 2-methylbutane
$= \frac{0.626}{72} = 8.69 \times 10^{-3}$ mol [1]
standard enthalpy of combustion
$= \frac{25.1}{8.69 \times 10^{-3}}$ [1]
$= -2890$ kJ mol^{-1} [1]

iii heat change is the same, 25.1 kJ [1]
number of moles of 2,2-dimethylpropane
$= \frac{171}{24000} = 7.13 \times 10^{-3}$ [1]
standard enthalpy of combustion
$= \frac{25.1}{7.13 \times 10^{-3}}$ [1]
$= -3520$ kJ mol^{-1} [1]

c



cycle with carbon dioxide and water as the third corner and where the directions of the three arrows are correct, [1]
labelling arrows with correct enthalpies. [1]
$\Delta H_{reaction} + (-3520) = -2890$ [1]
$\Delta H_{reaction} = -2890 - (-3520) = +630$ kJ mol^{-1} [1]

d The 2-methylbutane has a greater surface area [1]
therefore, a greater number of van der Waals' forces/induced dipoles. [1]
It has stronger intermolecular forces and therefore more energy required to separate molecules (and a higher boiling point). [1]

2 a

	Carbon	Hydrogen
divide by A_r to find the number of moles	$\frac{85.7}{12} = 7.15$	$\frac{14.3}{1} = 14.3$
divide by smallest quantity to find relative number of atoms	$\frac{7.15}{7.15} = 1$	$\frac{14.3}{7.15} = 2$

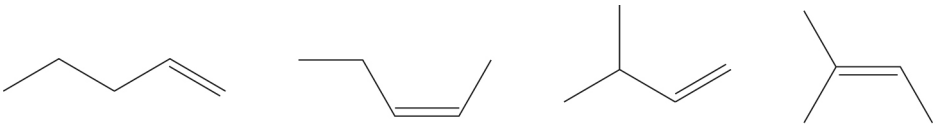
empirical formula = CH_2 [2]

b the volume of CO_2 is 5× the volume of X [1]
there must be five carbons in each molecule of X [1]
the molecular formula is C_5H_{10}. [1]

c the alkenes [1]
it must be unsaturated/contain a double C=C because it decolorises bromine [1]
the formula fits the general formula for alkenes, which is C_nH_{2n}. [1]

d i Structural isomers are compounds having same molecular formula [1]
but different structural formulae. [1]

ii



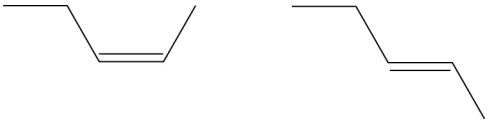
pent-1-ene pent-2-ene 2-methylbut-1-ene 2-methylbut-2-ene

1 mark for each correct structure and correct name [4]
Remember: skeletal formulae do not show carbon or hydrogen atoms.

e i pent-2-ene [1]

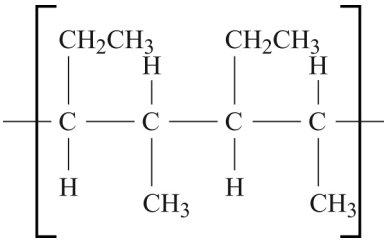
ii geometric or *cis–trans* isomerism [1]

iii [2]



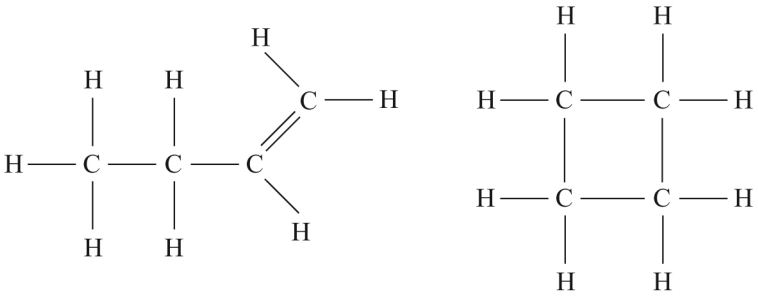
iv They have no free rotation about the C=C [1]
each carbon of the C=C bond has two different groups attached. [1]

v



four-carbon chain with bonds at end not attached (shown as dashed) [1]
CH_2CH_3 and CH_3 groups should be on **different** adjacent carbons but not necessarily on different sides of the chain. [1]

3 a



1 mark for each structure.

Note: that carbon and hydrogen atoms are shown for displayed formulae. [2]

b i $C_4H_8 + Br_2 \rightarrow C_4H_7Br + HBr$

correct reactants [1]

for correct products. [1]

ii Initiation: [1]

$Br_2 \rightarrow 2Br\bullet$ [1]

Propagation: [1]

$C_4H_8 + Br\bullet \rightarrow HBr + C_4H_7\bullet$ [1]

$C_4H_7\bullet + Br_2 \rightarrow C_4H_7Br + Br\bullet$ [1]

Termination: [1]

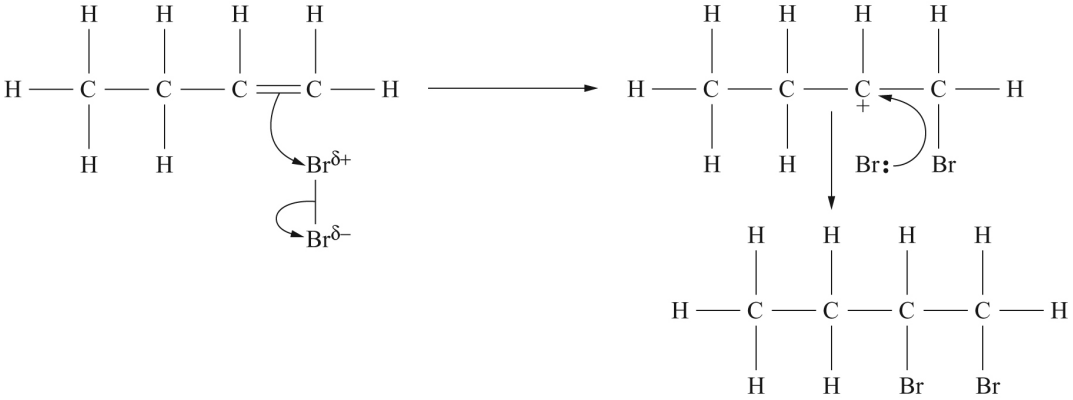
Any one of the following:

$Br\bullet + Br\bullet \rightarrow Br_2$

$C_4H_7\bullet + Br\bullet \rightarrow C_4H_7Br$

$C_4H_7\bullet + C_4H_7\bullet \rightarrow C_8H_{14}$ [1]

c



curly arrow coming from double bond to space in between the carbon and the bromine [1]

curly arrow coming from the bond between the two bromines to the lower bromine [1]

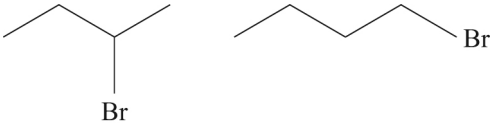
dipoles on the Br_2 molecule [1]

positive charge on one of the two carbons of the double bond [1]

curly arrow coming from the lone pair on the bromide ion to the positive carbonium ion. [1]

Note: in the first diagram the arrows must be drawn accurately, making sure that the arrows come from the bonds. In the second diagram the curly arrow must come from the lone pair of electrons or the negative charge.

d i [2]



ii The major product is the left-hand product, i.e. 2-bromobutane [1]
because its intermediate carbonium ion (cation) has the stabilising effect of two electron-donating alkyl groups. [1]
The other product has only one electron-donating alkyl group and therefore its carbonium ion is less stable. [1]

e Bromine is a non-polar molecule. [1]
It is more soluble in non-polar solvents (like dissolves with like). [1]
Cyclohexane is a polar solvent, water is a polar solvent. [1]