Questions

Q1. If the mean C−−H bond enthalpy is +***x***, which of the following represents a process with
an enthalpy change of +**4*x***?

☒ **A** $C(g) + 4H(g) \rightarrow CH_4(g)$

☒ **B** $CH_4(g) \rightarrow C(g) + 4H(g)$

☒ **C** $CH_4(g) \rightarrow C(s, graphite) + 2H_2(g)$

☒ **D** $C(s, graphite) + 2H_2(g) \rightarrow CH_4(g)$

(Total for question = 1 mark)

Q2. Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

(Total for Question = 1 mark)

Q3.

This question is about the gas ethane, C_2H_6, and its reactions.

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

(b) Ethane can react with chlorine to form chloroethane and hydrogen chloride.

$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$

Bond	Bond enthalpy/kJ mol^{-1}
C—H	413
C—C	347
C—Cl	346
H—Cl	432
Cl—Cl	243

Rewrite this equation using displayed formulae.

Use the equation you have written, together with the bond enthalpy data, to calculate the enthalpy change for the reaction.

(4)

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

(2)

Type

.....

Conditions

.....

(ii) Complete the equation below for the third step of the reaction, and show the movement of electrons using the appropriate arrows.

(3)

$CH_3CH_2\bullet + Cl—Cl \rightarrow$

(iii) Write equations for **two** termination steps in this reaction.

(2)

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1:

.....

.....

Reason 2:

.....

.....

(Total for question = 16 marks)

Q4.

The enthalpy change for the reaction

$$CH_4(g) \rightarrow C(g) + 4H(g)$$

is +1648 kJ mol^{-1}. Hence the mean bond enthalpy for the C–H bond is

☒ **A** +329.6 kJ mol^{-1}

☒ **B** +412.0 kJ mol^{-1}

☒ **C** +1648 kJ mol^{-1}

☒ **D** +6592 kJ mol^{-1}

(Total for question = 1 mark)

Q5.

Some mean bond enthalpy values are given in the table below.

Bond	Mean bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

What is the enthalpy change for the reaction shown below in kJ mol^{-1}?

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

☒ **A** +436 + 151 − 299 = +288

☒ **B** −436 − 151 + 299 = −288

☒ **C** +436 +151 − (2 × 299) = −11

☒ **D** −436 − 151 + (2 × 299) = +11

(Total for question = 1 mark)

Q6.

Calculate the enthalpy change, in kJ mol^{-1}, for the reaction

$$H_2(g) + ½O_2(g) \rightarrow H_2O(g)$$

DATA:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
O=O	+498
H—O	+464

☒ **A** −243

☒ **B** −6

☒ **C** +6

☒ **D** +221

(Total for question = 1 mark)

Q7. Consider the following information:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

For the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** +288

☒ **B** +144

☒ **C** −11

☒ **D** −5.5

(Total for Question = 1 mark)

Q8.

The standard enthalpy changes of formation of some sulfur species are:

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$S_8(s)$	0
$S_8(g)$	+103
S(g)	+279

The enthalpy of atomization of sulfur is (in kJ mol^{-1})

☒ **A** 103 ÷ 8

☒ **B** 279 ÷ 8

☒ **C** 279

☒ **D** (103 ÷ 8) + 279

(Total for Question = 1 mark)

Q9. The enthalpy change of atomization of iodine is the value of ΔH for the process

☒ **A** $I_2(s) \rightarrow I_2(g)$

☒ **B** $I_2(s) \rightarrow 2I(g)$

☒ **C** $I_2(g) \rightarrow 2I(g)$

☒ **D** $\frac{1}{2}I_2(s) \rightarrow I(g)$

(Total for question = 1 mark)

Q10.

(a) State the general formula of the alkanes, using the letter ***n*** to denote the number of carbon atoms in each molecule.

(1)

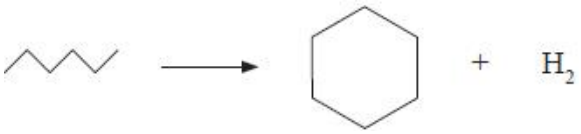
(b) Alkanes are used as fuels. In the petrochemical industry, useful hydrocarbons are often produced from longer chain molecules.

Name the type of reaction shown below.

(i) 

(1)

Type of reaction .....

(ii) 

(1)

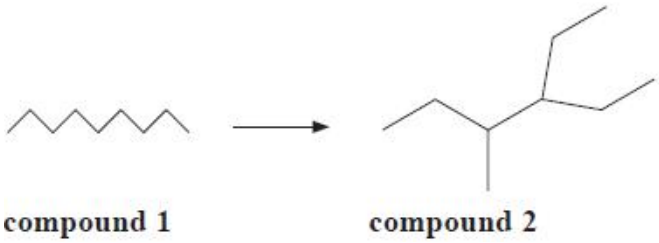
Type of reaction .....

(c) By what **type** of formula are the **organic** molecules in (b) represented?

(1)

.....

(d) Another reaction carried out in industry can be represented as shown below.



(i) Give the molecular formula of **compound 2**.

(1)

.....

(ii) Give the name of **compound 2**.

(1)

.....

(e) An equation for the reaction between methane and chlorine is:

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

The reaction occurs in the presence of ultraviolet (UV) light via a free-radical chain mechanism.

The initiation step is $Cl_2 \rightarrow 2Cl\bullet$

The next step could be

EITHER	$CH_4 + Cl\bullet \rightarrow \bullet CH_3 + HCl$	(Step **A**)
OR	$CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$	(Step **B**)

(i) Use the following data to calculate a value for the enthalpy change for each of the Steps, **A** and **B**.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
C – H	+ 413
C – Cl	+ 346
H – Cl	+ 432

Enthalpy change for Step A $CH_4 + Cl\bullet \rightarrow \bullet CH_3 + HCl$

Answer ..... kJ mol^{-1}

Enthalpy change for Step B $CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$

Answer ..... kJ mol^{-1}

(ii) Use your answer to (i) to justify which of the Steps, **A** or **B**, is the more likely.

(1)

.....

.....

(f) Another halogenoalkane, bromomethane, CH_3Br, is a toxic gas used to protect plants against insects.

Health and Safety advice states that concentrations above 5 parts per million (ppm) by volume of this gas are harmful.

A research laboratory contains 2.5×10^5 dm^3 of air. Calculate the maximum volume

of bromomethane, in dm^3, allowed in the laboratory to comply with the advice given.

(1)

(Total for question = 11 marks)