Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Friday 9 January 2009 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

N34410A

7/7/7/7/2/3

N 3 4 4 1 0 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which equation represents the reaction for which the enthalpy change is the lattice energy of sodium fluoride, NaF?

☒ **A** $Na(s) + \frac{1}{2}F_2(g) \rightarrow NaF(s)$

☒ **B** $Na(g) + F(g) \rightarrow NaF(s)$

☒ **C** $Na^+(g) + F^-(g) \rightarrow NaF(s)$

☒ **D** $Na(g) + \frac{1}{2}F_2(g) \rightarrow NaF(s)$

(Total for Question 1 = 1 mark)

2 **Theoretical** lattice energies can be calculated from electrostatic theory. Which of the following affects the magnitude of the theoretical lattice energy of an alkali metal halide, M^+X^-?

☒ **A** The first electron affinity of X.

☒ **B** The first ionization energy of M.

☒ **C** The enthalpy of atomization of M.

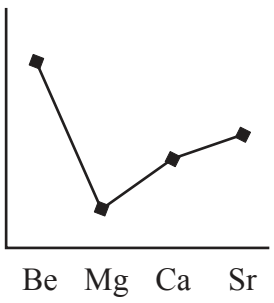
☒ **D** The radius of the X^- ion.

(Total for Question 2 = 1 mark)

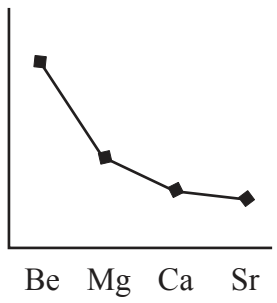
Use this space for any rough working. Anything you write in this space will gain no credit.

3 Which of the following graphs shows the variation in the ionic radius of the Group 2 elements?

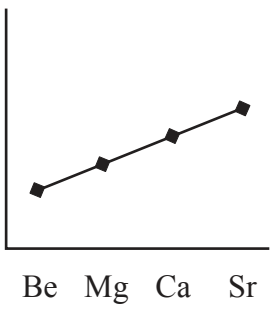
☒ **A**



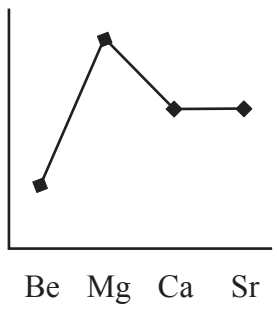
☒ **B**



☒ **C**



☒ **D**



(Total for Question 3 = 1 mark)

4 The first five ionization energies of an element, **Z**, are:

790, 1600, 3200, 4400, 16100 kJ mol^{-1}

In which group of the Periodic Table is **Z** found?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 The standard enthalpy changes of combustion of carbon, hydrogen and methane are shown in the table below.

Substance	Standard enthalpy change of combustion / kJ mol^{-1}
carbon, C(s)	–394
hydrogen, $H_2(g)$	–286
methane, $CH_4(g)$	–891

Which one of the following expressions gives the correct value for the standard enthalpy change of formation of methane in kJ mol^{-1}?

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

☒ **A** 394 + (2 × 286) – 891

☒ **B** –394 – (2 × 286) + 891

☒ **C** 394 + 286 – 891

☒ **D** –394 – 286 + 891

(Total for Question 5 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

6 This question is about some standard enthalpy changes, $\Delta H^{\ominus}$

A enthalpy of reaction

B enthalpy of combustion

C mean bond enthalpy

D bond enthalpy

(a) Which enthalpy change is represented by **p**?

$CH_4(g) \rightarrow CH_3(g) + H(g)$ $\Delta H^{\ominus} = p$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which enthalpy change is represented by **q**?

$CH_4(g) \rightarrow C(g) + 4H(g)$ $\Delta H^{\ominus} = 4q$

(1)

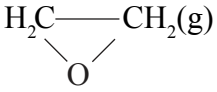
☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which enthalpy change is represented by **r**?

$H_2C{=}CH_2(g) + \frac{1}{2}O_2(g) \rightarrow$  $\Delta H^{\ominus} = r$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 3 marks)

7 Given the following data:

$\Delta H_f^{\ominus}[FeO(s)] = -270\ kJ\ mol^{-1}$

$\Delta H_f^{\ominus}[Fe_2O_3(s)] = -820\ kJ\ mol^{-1}$

select the expression which gives the enthalpy change, in kJ mol^{-1}, for the reaction:

$$2FeO(s) + \tfrac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

☒ **A** $(-820 \times \frac{1}{2}) + 270 = -140$

☒ **B** $(+820 \times \frac{1}{2}) - 270 = +140$

☒ **C** $-820 + (270 \times 2) = -280$

☒ **D** $+820 - (270 \times 2) = +280$

(Total for Question 7 = 1 mark)

8 An organic compound contains 38.4 % carbon, 4.80 % hydrogen and 56.8 % chlorine by mass. What is the empirical formula of the compound?

☒ **A** C_2H_3Cl

☒ **B** CH_3Cl

☒ **C** C_2H_5Cl

☒ **D** $C_3H_5Cl_3$

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 Which of the following contains the greatest number of hydrogen atoms?

☒ **A** 2 moles of water, H_2O

☒ **B** 1.5 moles of ammonia, NH_3

☒ **C** 1 mole of hydrogen gas, H_2

☒ **D** 0.5 moles of methane, CH_4

(Total for Question 9 = 1 mark)

10 Magnesium oxide reacts with dilute hydrochloric acid according to the following equation.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

How many **moles** of magnesium oxide, MgO, are required to neutralize 20 cm^3 of 0.50 mol dm^{-3} hydrochloric acid, HCl?

☒ **A** 0.0010

☒ **B** 0.0050

☒ **C** 0.010

☒ **D** 0.020

(Total for Question 10 = 1 mark)

11 Hydrogen and oxygen react according to the following equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

If all volumes are measured at 110 °C and one atmosphere pressure, the volume of steam produced after 50 cm^3 of hydrogen react completely with 25 cm^3 of oxygen is

☒ **A** 25 cm^3

☒ **B** 50 cm^3

☒ **C** 75 cm^3

☒ **D** 100 cm^3

(Total for Question 11 = 1 mark)

12 Hydrogen peroxide decomposes on heating as follows:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

What mass of hydrogen peroxide is required to give 16 g of oxygen gas?

☒ **A** 8.5 g

☒ **B** 17 g

☒ **C** 34 g

☒ **D** 68 g

(Total for Question 12 = 1 mark)

13 The equation for the dehydration of cyclohexanol, $C_6H_{11}OH$, to cyclohexene, C_6H_{10} is:

$$C_6H_{11}OH \rightarrow C_6H_{10} + H_2O$$

50.0 g of cyclohexanol produced 32.8 g of cyclohexene.

[Molar masses / g mol^{-1} : cyclohexanol = 100; cyclohexene = 82]

Calculate the percentage yield of cyclohexene.

☒ **A** 32.8 %

☒ **B** 40.0 %

☒ **C** 65.6 %

☒ **D** 80.0 %

(Total for Question 13 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

14 How many isomers are there of C_5H_{12}?

☒ **A** Two

☒ **B** Three

☒ **C** Four

☒ **D** Five

(Total for Question 14 = 1 mark)

15 In a molecule of ethene, C_2H_4, how many π (pi) bonds are present?

☒ **A** One

☒ **B** Two

☒ **C** Three

☒ **D** Four

(Total for Question 15 = 1 mark)

16 The mechanism of the reaction represented by the equation

$$C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$$

is an example of

☒ **A** Free radical substitution

☒ **B** Free radical addition

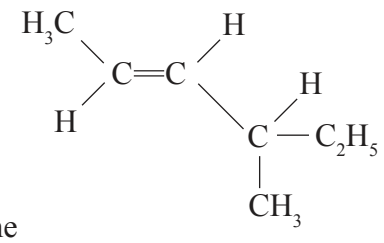
☒ **C** Electrophilic substitution

☒ **D** Electrophilic addition

(Total for Question 16 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

17 What is the systematic name for the following compound?



- ☒ **A** *Z*-4-methylhex-2-ene
- ☒ **B** *E*-2-ethylpent-3-ene
- ☒ **C** *Z*-4-ethylpent-2-ene
- ☒ **D** *E*-4-methylhex-2-ene

(Total for Question 17 = 1 mark)

18 Propene reacts with hydrogen chloride gas to give mainly

- ☒ **A** 1-chloropropane ($CH_3CH_2CH_2Cl$)
- ☒ **B** 2-chloropropane ($CH_3CHClCH_3$)
- ☒ **C** 3-chloroprop-1-ene ($CH_2{=}CHCH_2Cl$)
- ☒ **D** 1,2-dichloropropane ($CH_3CHClCH_2Cl$)

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 (a) (i) Complete the electronic configuration of the magnesium atom.

(1)

$1s^2$ .....

(ii) Complete the electronic configuration of the chlorine atom.

(1)

$1s^2$ .....

(b) (i) Write the equation, including state symbols, for the reaction of magnesium with chlorine.

(2)

(ii) Name the type of bonding present in magnesium chloride.

(1)

.....

(iii) Draw a diagram (using dots or crosses) to show the bonding in magnesium chloride. Include **ALL** the electrons in each species and the charges present.

(3)

(c) State the type of bonding that exists in solid magnesium.

(1)

Type .....

*(d) Explain fully why the melting temperature of magnesium is higher than that of sodium.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 19 = 12 marks)

20 (a) A gaseous sample of an element can be analysed using a mass spectrometer.

(i) Describe briefly how positive ions are formed from gaseous atoms in a mass spectrometer.

(2)

(ii) What is used to accelerate the positive ions in a mass spectrometer?

(1)

(iii) What is used to deflect the positive ions in a mass spectrometer?

(1)

(b) The following data were obtained from the mass spectrum of a sample of chromium.

Mass/charge ratio	% abundance
50.0	4.3
52.0	83.8
53.0	9.5
54.0	2.4

Calculate the relative atomic mass of chromium in this sample. Give your answer to **three** significant figures.

(2)

(c) Explain why the four isotopes of chromium behave identically in chemical reactions.

(1)

(d) In which block of the Periodic Table is chromium found?

(1)

(Total for Question 20 = 8 marks)

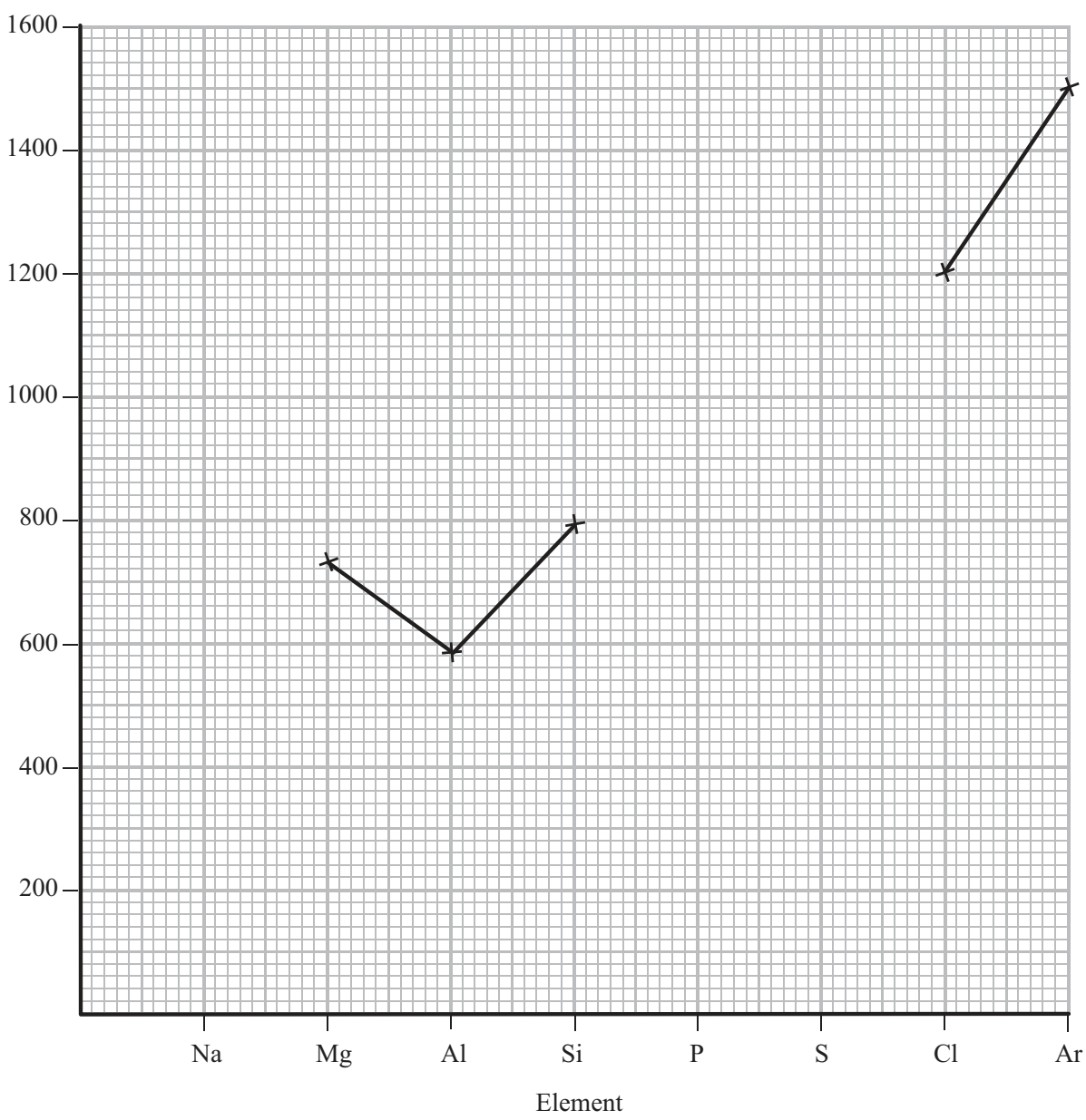
21 (a) Define the term **first ionization energy**.

(3)

(b) Write an equation, with state symbols, to illustrate the process occurring when the **second** ionization energy of sodium is measured.

(2)

(c) The graph below shows the variation in the **first** ionization energies of some of the elements in Period 3.



(i) On the graph, use crosses to show the approximate values of the first ionization energies for the elements Na, P and S.

Join the crosses to complete your graph.

(3)

*(ii) Explain why the first ionization energies generally increase across the period sodium to argon (Na to Ar).

(3)

*(iii) Explain why the first ionization energy of aluminium is less than that of magnesium.

(2)

(d) Place the following species

S^+ S S^-

in order of increasing first ionization energy, starting with the lowest.

(1)

Lowest first ionization energy		Highest first ionization energy
.....	.....	.....

(Total for Question 21 = 14 marks)

22 (a) Define the term **covalent bond**.

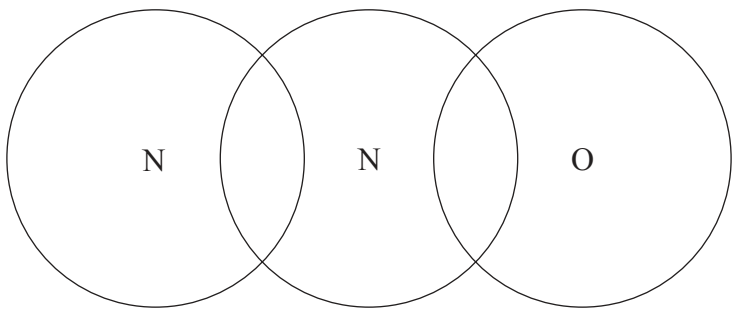
(2)

(b) Nitrogen forms an oxide called nitrous oxide, N_2O. The bonding in nitrous oxide can be represented as:

$$N \equiv N \rightarrow O$$

Complete the diagram below for the N_2O molecule using dots or crosses to represent electrons. Just show all of the outer shell electrons.

(3)



(Total for Question 22 = 5 marks)

23 The standard enthalpy change, $\Delta H_1^{\ominus}$, for the decomposition of potassium hydrogencarbonate, $KHCO_3$, is impossible to determine directly.

$$2KHCO_3(s) \rightarrow K_2CO_3(s) + CO_2(g) + H_2O(l)$$

The value of $\Delta H_1^{\ominus}$ can be calculated from the standard enthalpy changes which accompany the reactions below:

$KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + CO_2(g) + H_2O(l)$ $\Delta H_2^{\ominus}$

$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$ $\Delta H_3^{\ominus}$

Procedure:

- The solids were added to separate 30 cm^3 portions of dilute hydrochloric acid. The acid was in excess for both solids.
- The maximum temperature change for each experiment was noted.

Results:

- The following results were obtained **with $KHCO_3(s)$**.

  Mass of $KHCO_3$ used = 2.00 g

  Temperature change = −4.9 °C

- The experiment with $K_2CO_3(s)$ gave a $\Delta H_3^{\ominus}$ value of −34 kJ mol^{-1}.

Assumption:

- The dilute hydrochloric acid solution has a density of 1 g cm^{-3}.

(a) (i) Calculate the heat energy absorbed, in joules, by the reaction of the $KHCO_3(s)$ with the solution of dilute hydrochloric acid.

Use the expression

energy absorbed (J) = mass of solution × 4.18 × temperature change

(1)

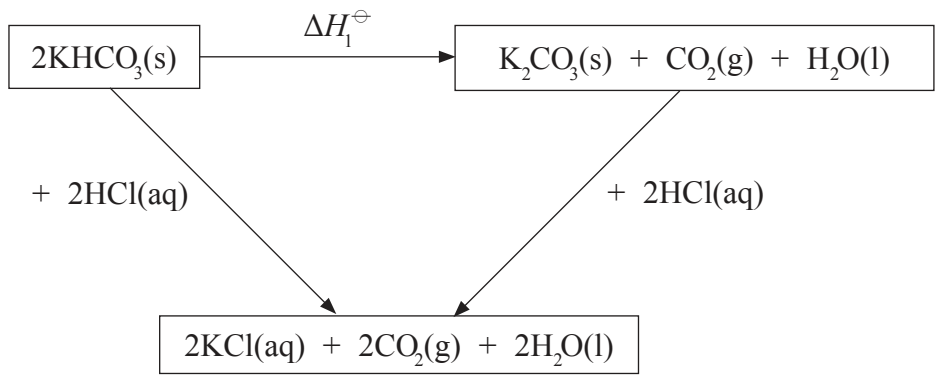
(ii) Calculate the number of moles of $KHCO_3(s)$ used. Assume that the molar mass of $KHCO_3(s)$ is 100 g mol^{-1}.

(1)

(iii) Use your answers to (a)(i) and (ii) to calculate, in **kJ mol^{-1}**, the enthalpy change when one mole of $KHCO_3(s)$ reacts completely with the acid (i.e. $\Delta H_2^{\ominus}$). Include a sign in your answer.

(2)

(b) A Hess Cycle based on these reactions is shown below.



(i) Apply Hess's Law to obtain an expression for $\Delta H_1^{\ominus}$ in terms of $\Delta H_2^{\ominus}$ and $\Delta H_3^{\ominus}$.

(1)

$\Delta H_1^{\ominus}$ =

(ii) Use your answers to (a)(iii) and (b)(i), and the $\Delta H_3^{\ominus}$ value of –34 kJ mol^{-1}, to calculate a value for $\Delta H_1^{\ominus}$ in kJ mol^{-1}. Include a sign in your answer.

(2)

(c) The maximum errors for the apparatus used in the experiment with the $KHCO_3(s)$ were as follows:

Balance	± 0.01 g
Measuring cylinder	± 0.5 cm^3

(i) Calculate the maximum percentage error in using each of the following pieces of apparatus in the $KHCO_3(s)$ experiment:

(2)

Balance

Measuring cylinder

(ii) Suggest a piece of apparatus that could have been used to measure the volume of dilute hydrochloric acid more accurately in this experiment.

(1)

(Total for Question 23 = 10 marks)

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

(1)

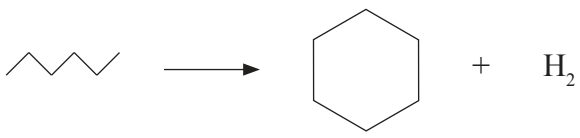
(b) Alkanes are used as fuels. In the petrochemical industry, useful hydrocarbons are often produced from longer chain molecules.

Name the type of reaction shown below.

(i) 

(1)

Type of reaction .....

(ii) 

(1)

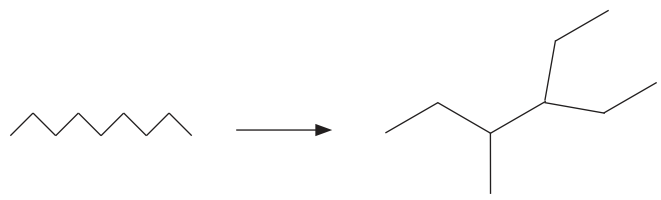
Type of reaction .....

(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.



compound 1 **compound 2**

(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)

.....

.....

QUESTION 24 CONTINUES ON THE NEXT PAGE.

(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 24 = 11 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103