mock papers 1

SECTION A

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^-?

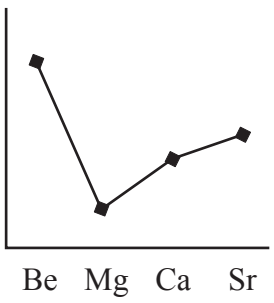
- ☒ **A** The first electron affinity of X.
- ☒ **B** The first ionization energy of M.
- ☒ **C** The enthalpy of atomization of M.
- ☒ **D** The radius of the X^- ion.

(Total for Question 2 = 1 mark)

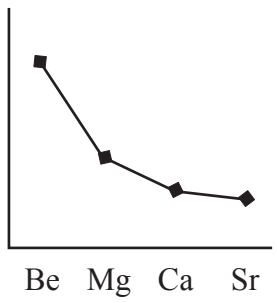
Use this space for any rough working. Anything you write in this space will gain no credit.

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

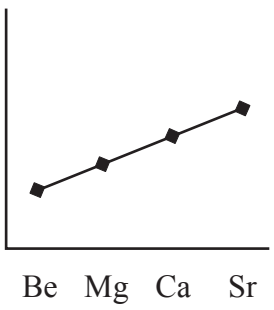
☒ **A**



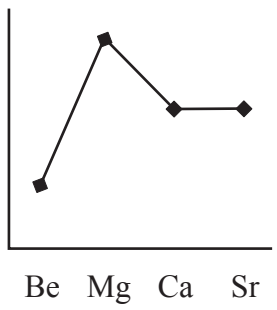
☒ **B**



☒ **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)

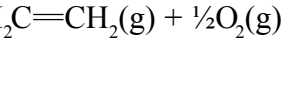
☒ **A**

☒ **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)

Turn over ▶

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

$$C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$$

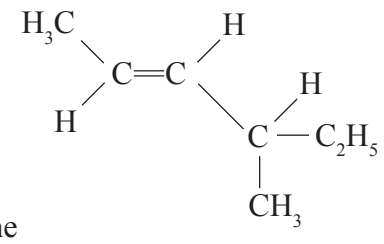
is an example of

- ☒ **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)

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(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)

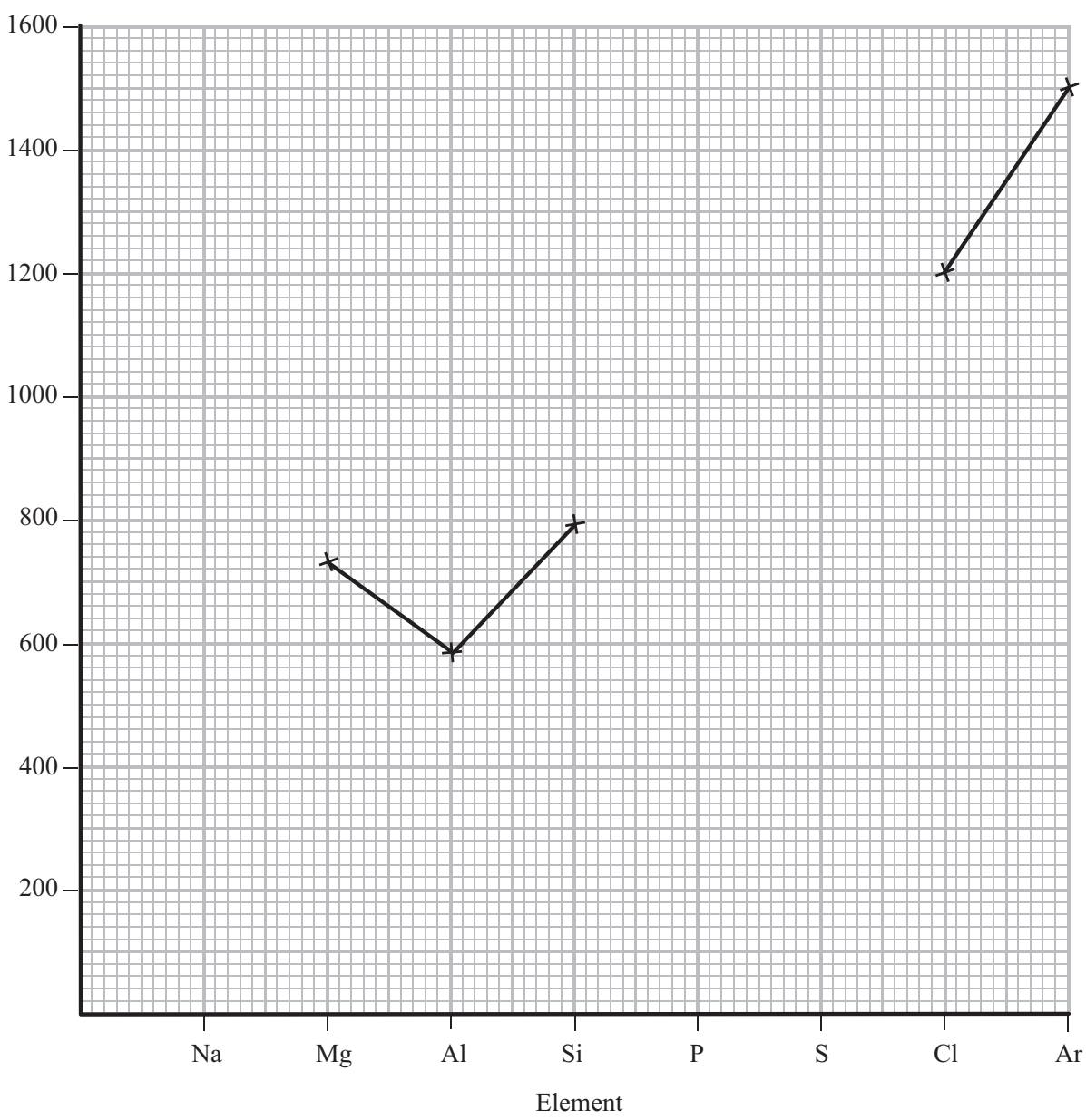
21 (a) Define the term **first ionization energy**.

(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)

Turn over ▶

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

(3)

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

(2)

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(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**.

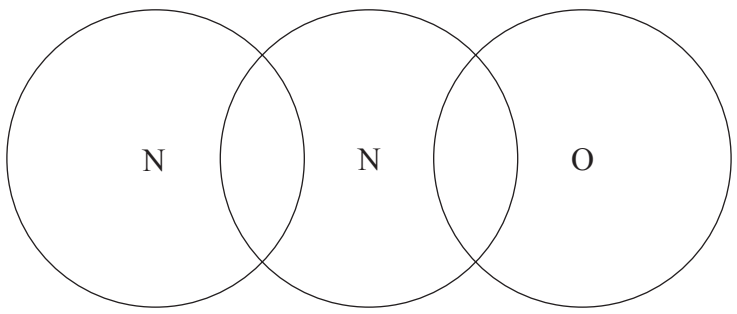
(2)

(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)

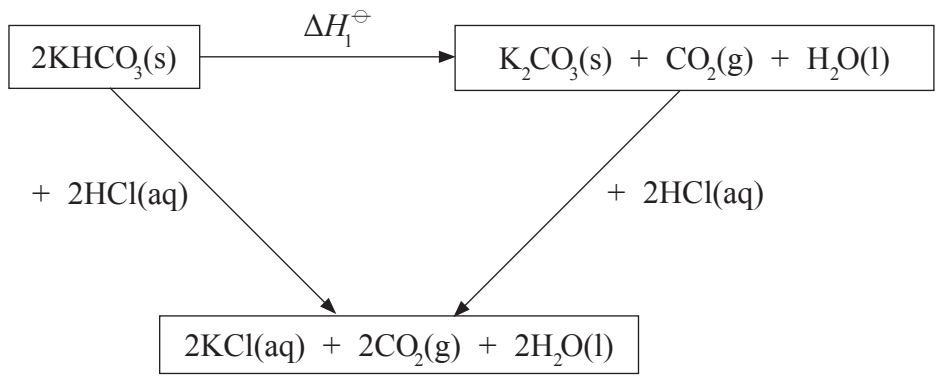
(ii) Calculate the number of moles of $KHCO_3(s)$ used. Assume that the molar mass of $KHCO_3(s)$ is 100 g mol^{-1}.

(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)

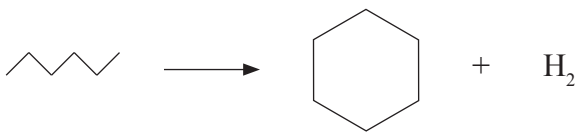
(b) Alkanes are used as fuels. In the petrochemical industry, useful hydrocarbons are often produced from longer chain molecules.

Name the type of reaction shown below.

(i) 

(1)

Type of reaction .....

(ii) 

(1)

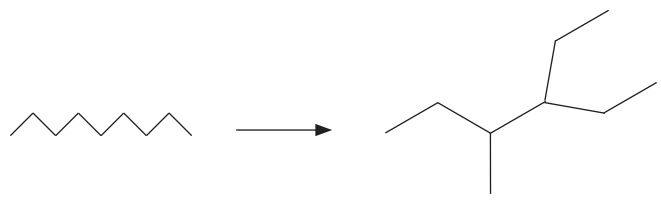
Type of reaction .....

(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}

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

mock papers 2

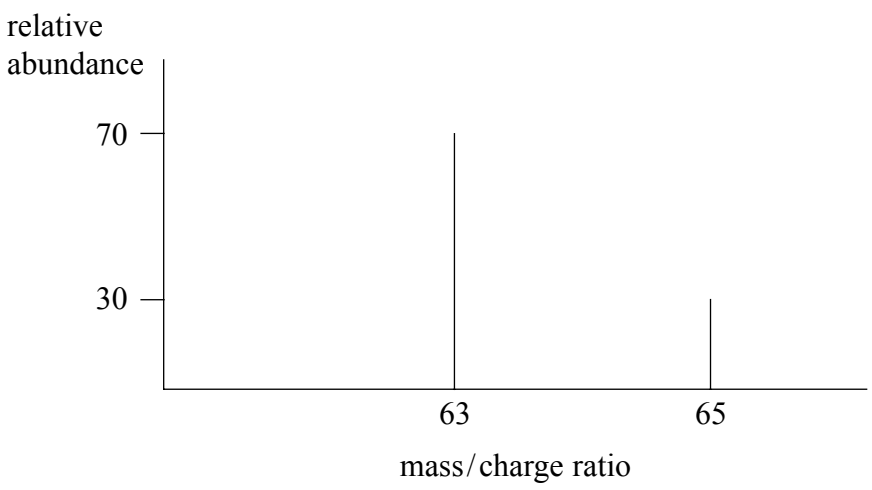
SECTION A

1 The nucleus of a $^{23}_{11}Na$ atom contains

- ☒ **A** 11 protons and 12 neutrons.
- ☒ **B** 11 protons and 12 electrons.
- ☒ **C** 23 protons and 11 neutrons.
- ☒ **D** 23 protons and 11 electrons.

(Total for Question 1 = 1 mark)

2 The mass spectrum for a sample of a metal is shown below.



The relative atomic mass of the metal is

- ☒ **A** 63.2
- ☒ **B** 63.4
- ☒ **C** 63.6
- ☒ **D** 64.0

(Total for Question 2 = 1 mark)

3 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 3 = 1 mark)

4 A compound was analysed and found to contain

1.45 g carbon 0.482 g hydrogen 1.69 g nitrogen

[Relative atomic masses: C = 12; H = 1; N = 14]

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** CH_4N

☒ **C** CH_5N

☒ **D** C_2H_4N

(Total for Question 4 = 1 mark)

5 17.1 g of aluminium sulfate, $Al_2(SO_4)_3$, was dissolved in water.

Calculate the number of sulfate ions, SO_4^{2-}, present in the solution formed.

[Assume the molar mass of $Al_2(SO_4)_3$ is 342 g mol^{-1} and the Avogadro Constant is 6×10^{23} mol^{-1}.]

☒ **A** 3×10^{21}

☒ **B** 1×10^{22}

☒ **C** 3×10^{22}

☒ **D** 9×10^{22}

(Total for Question 5 = 1 mark)

6 Calculate the mass of calcium hydroxide, $Ca(OH)_2$, present in 100 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume the molar mass of $Ca(OH)_2$ is 74.0 g mol^{-1}.]

☒ **A** 0.570 g

☒ **B** 0.740 g

☒ **C** 1.85 g

☒ **D** 3.70 g

(Total for Question 6 = 1 mark)

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

7 The first five successive ionization energies of an element, **X**, are shown in the table below.

Ionization energy	first	second	third	fourth	fifth
Value / kJ mol^{-1}	590	1100	4900	6500	8100

Which ion is **X** most likely to form when it reacts with chlorine?

☒ **A** X^+

☒ **B** X^{2+}

☒ **C** X^{3+}

☒ **D** X^{4+}

(Total for Question 7 = 1 mark)

8 Which of the following alkenes exhibits **E-Z** isomerism?

☒ **A** $H_3CCH{=}C(CH_3)_2$

☒ **B** $(CH_3)_2C{=}CH_2$

☒ **C** $H_2C{=}CHCH_2CH_3$

☒ **D** $H_3CCH{=}CHCH_3$

(Total for Question 8 = 1 mark)

9 Which of the following covalent bonds is the shortest?

☒ **A** H—F

☒ **B** H—Cl

☒ **C** H—Br

☒ **D** H—I

(Total for Question 9 = 1 mark)

10 Which of the following substances, obtained from the fractional distillation of crude oil, has the lowest boiling temperature?

☒ **A** refinery gas

☒ **B** kerosene

☒ **C** diesel oil

☒ **D** lubricating oil

(Total for Question 10 = 1 mark)

11 Sodium hydrogensulfate, $NaHSO_4$, reacts with sodium hydroxide, NaOH, as shown below.

$$NaHSO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

0.0100 mol of sodium hydrogensulfate is neutralized with dilute sodium hydroxide, concentration 0.200 mol dm^{-3}.

Calculate the volume of sodium hydroxide required.

☒ **A** 20.0 cm^3

☒ **B** 50.0 cm^3

☒ **C** 100 cm^3

☒ **D** 500 cm^3

(Total for Question 11 = 1 mark)

12 Which of the following ions would undergo the greatest deflection in a mass spectrometer?

☒ **A** $^{35}Cl^{2+}$

☒ **B** $^{35}Cl^{+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{35}Cl^{37}Cl^{+}$

(Total for Question 12 = 1 mark)

13 Which pair of atomic numbers represents elements which are both in the p-block of the Periodic Table?

☒ **A** 4, 8

☒ **B** 6, 12

☒ **C** 8, 16

☒ **D** 10, 20

(Total for Question 13 = 1 mark)

14 The electronic structure of an atom of an element in Group 6 of the Periodic Table could be

☒ **A** $1s^2\ 2s^2\ 2p^2$

☒ **B** $1s^2\ 2s^2\ 2p^4$

☒ **C** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

☒ **D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$

(Total for Question 14 = 1 mark)

15 Which of the following formulae for compounds of germanium, Ge, is unlikely to be correct, given the position of germanium in the Periodic Table?

☒ **A** GeF_3

☒ **B** GeS_2

☒ **C** GeO_2

☒ **D** GeH_4

(Total for Question 15 = 1 mark)

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

16 The electronic configurations of the atoms of four different elements are given below. For which element would you expect the value of the first ionization energy to be the largest?

☒ **A** $1s^1$

☒ **B** $1s^2$

☒ **C** $1s^2\ 2s^1$

☒ **D** $1s^2\ 2s^2$

(Total for Question 16 = 1 mark)

17 Which of the following gas samples occupies the greatest volume at the same temperature and pressure?

[Relative atomic masses: H = 1; C = 12; O = 16; F = 19; Ne = 20]

☒ **A** 1 gram of ethane

☒ **B** 1 gram of oxygen

☒ **C** 1 gram of fluorine

☒ **D** 1 gram of neon

(Total for Question 17 = 1 mark)

18 Which of the following has the smallest ionic radius?

☒ **A** F^-

☒ **B** Na^+

☒ **C** Mg^{2+}

☒ **D** O^{2-}

(Total for Question 18 = 1 mark)

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

19 Which of the following does **not** have exactly 10 electrons?

☒ **A** An ion of fluorine, F^-

☒ **B** A molecule of methane, CH_4

☒ **C** A molecule of nitrogen, N_2

☒ **D** An ion of sodium, Na^+

(Total for Question 19 = 1 mark)

20 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

☒ **A** The carbon dioxide is toxic and kills plants.

☒ **B** The smoke produced reflects sunlight and leads to global warming.

☒ **C** The water produced results in a damaging increase in rainfall.

☒ **D** The carbon dioxide produced absorbs heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

21 This question is about hydrocarbons.

(a) Liquefied petroleum gas (LPG) is a fuel sold as an alternative to petrol. It is a mixture of liquefied C_3 and C_4 alkanes.

(i) Suggest a reason why the alkanes are liquefied.

(1)

.....

.....

(ii) There are two C_4 alkanes.

Draw **skeletal** formulae of each of the C_4 alkanes in the spaces provided.

Name each alkane.

(4)

First skeletal formula	Second skeletal formula
Name:	Name: .....

(iii) Complete the following sentence.

(1)

Compounds with the same molecular formula but different structural formula are called .....

(b) Propane, C_3H_8, reacts with chlorine, Cl_2, in a substitution reaction.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

The mechanism for this reaction is described in three stages.

(i) Give the **initiation step** for this reaction and state the condition necessary for this step to occur.

(2)

Initiation step

Condition .....

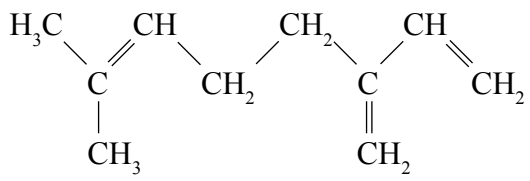
(ii) Give the TWO **propagation steps** for this reaction.

(2)

(iii) Give a possible **termination step** for this reaction.

(1)

(c) Myrcene, $C_{10}H_{16}$, is a naturally occurring compound which is used in perfumes.



Myrcene

(i) Name the functional group in myrcene.

(1)

.....

(ii) What colour change would you observe when bromine, dissolved in an organic solvent, is added to myrcene?

(1)

From ..... **To** .....

(iii) Classify the type and mechanism of the reaction that occurs when myrcene reacts with bromine, Br_2.

(2)

.....

.....

(iv) In an experiment, 1.36 g of myrcene (molar mass: 136 g mol^{-1}) was found to react with 0.72 dm^3 of hydrogen, H_2, in the presence of a nickel catalyst.

Use this information to draw the structural formula of the product of the reaction between myrcene and hydrogen.

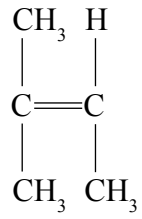
[Assume the molar volume of H_2 under the conditions of the experiment is 24 $dm^3\,mol^{-1}$.]

(2)

Calculation

Hence structural formula of the product

(d) Myrcene is one of a group of compounds related to 2-methylbut-2-ene shown below.



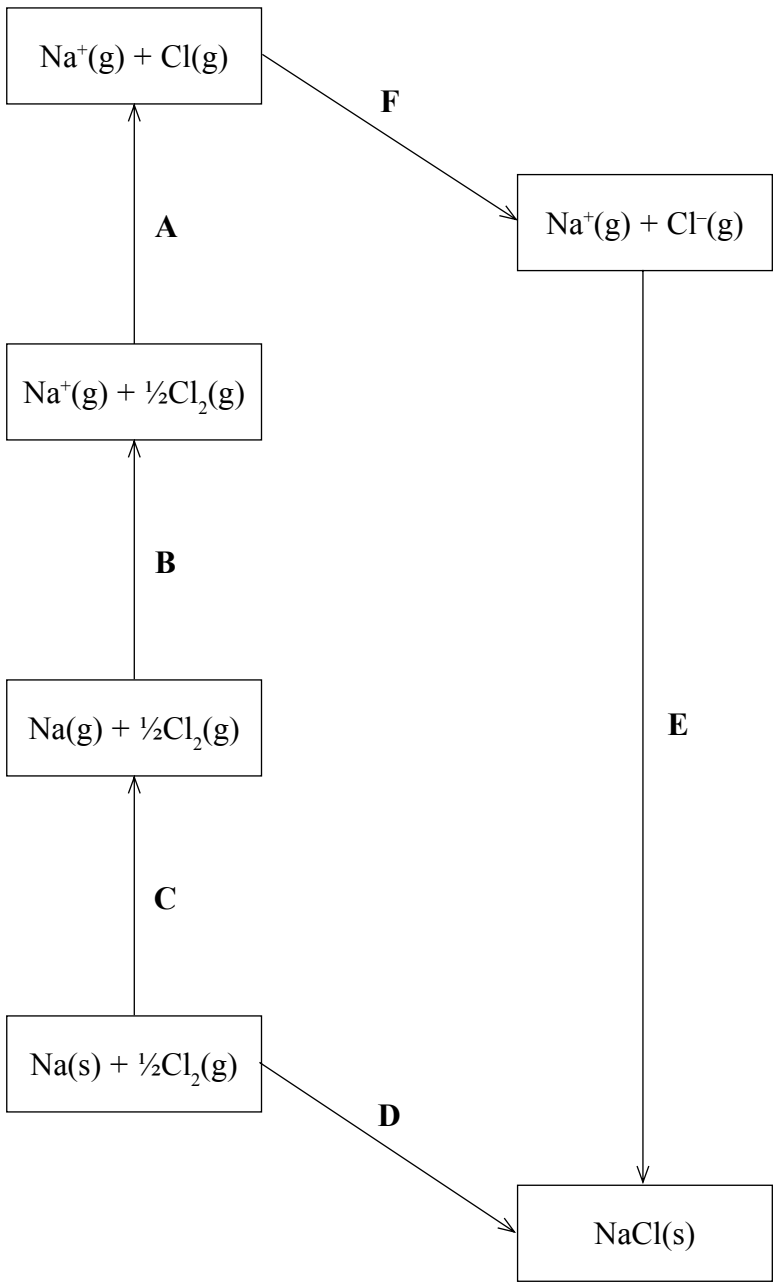
2-methylbut-2-ene undergoes addition polymerization in a similar way to ethene.

Draw the structural formula of the repeat unit of the polymer formed.

(2)

(Total for Question 21 = 19 marks)

22 The Born-Haber cycle for the formation of sodium chloride from sodium and chlorine may be represented by a series of steps labelled **A** to **F** as shown.



(a) (i) Complete the table below by adding the letters **A** to **F** next to the corresponding energy changes.

(3)

Energy change	Letter	ΔH /kJ mol^{-1}
Lattice energy for sodium chloride		–775
Enthalpy change of atomization of sodium		+109
Enthalpy change of atomization of chlorine		+121
First ionization energy of sodium		+494
First electron affinity of chlorine		
Enthalpy change of formation of sodium chloride		–411

(ii) Calculate the first electron affinity of chlorine, in kJ mol^{-1}, from the data given.

(2)

Turn over ▶

(b) Lattice energies can be calculated from electrostatic theory (theoretical values) as well as by Born-Haber cycles (experimental values).

Compound	Experimental lattice energy / kJ mol^{-1}	Theoretical lattice energy / kJ mol^{-1}
NaCl	–770	–766
AgI	–889	–778

(i) Comment on the fact that there is close agreement between the values for sodium chloride, NaCl.

(1)

*(ii) Explain, in terms of chemical bonding, why the experimental value for silver iodide, AgI, is more exothermic than the value calculated theoretically for the same compound.

(2)

*(c) Suggest why the first ionization energies of the Group 1 elements decrease down the group.

(2)

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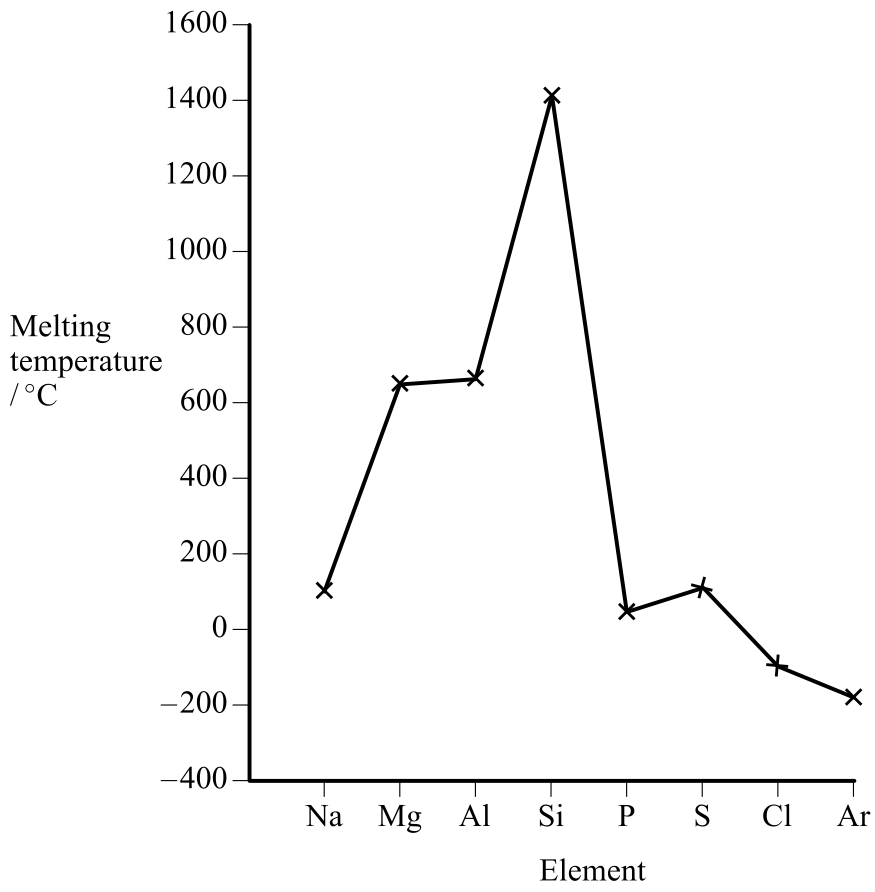
(Total for Question 22 = 10 marks)

Turn over ▶

23 The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(a) Complete the table below to show the type of structure and bonding for the elements shown.

(3)

Element	Structure	Bonding
sodium		
silicon		
sulfur		

(b) Explain why silicon has a much higher melting temperature than sulfur.

(2)

*(c) Explain why the melting temperature increases from sodium to aluminium.

(2)

(d) Magnesium forms the basic oxide magnesium oxide, MgO. This oxide is almost insoluble in water. On gentle warming with dilute sulfuric acid, magnesium oxide reacts to form aqueous magnesium sulfate solution.

*(i) Describe how you would use the above reaction to prepare a pure sample of magnesium sulfate.

(5)

(ii) Suggest what action should be taken if a pupil spilt a small quantity of dilute sulfuric acid on a laboratory bench.

(1)

(e) The data in the table below will be useful when answering this question.

Soluble in water	Insoluble in water
$MgSO_4$	$MgCO_3$ $SrCO_3$ $SrSO_4$

Magnesium carbonate reacts with dilute sulfuric acid.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

(i) Explain why the reaction between strontium carbonate and dilute sulfuric acid stops after a few seconds.

(1)

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(ii) Strontium sulfate is produced when aqueous sodium sulfate is added to aqueous strontium chloride.

Give the **ionic** equation for the reaction, including state symbols.

(2)

(Total for Question 23 = 16 marks)

24 Propanone, C_3H_6O, undergoes complete combustion to form carbon dioxide and water.

$$C_3H_6O(l) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$$

(a) In an experiment to calculate the enthalpy change of combustion for propanone, 2.90 g of propanone was burned completely in oxygen.

The heat energy from this combustion raised the temperature of 200 g of water from 20.2 °C to 78.4 °C.

The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

(i) Calculate the number of moles of propanone present in 2.90 g.

[The molar mass of propanone is 58 g mol^{-1}.]

(1)

(ii) Use the expression

$$\text{energy transferred (J)} = \text{mass} \times \frac{\text{specific heat}}{\text{capacity}} \times \frac{\text{temperature}}{\text{change}}$$

to calculate the heat energy transferred to raise the temperature of 200 g of water from 20.2 °C to 78.4 °C.

(2)

(iii) Use your answers to (a)(i) and (ii) to calculate a value for the enthalpy change of combustion of propanone. Give your answer to **three** significant figures and include a sign and units.

(3)

(b) In another experiment, the enthalpy change of combustion for butanone, C_4H_8O, was found to be –1300 kJ mol^{-1}.

A Data Book value for the standard enthalpy change of combustion for butanone is –2440 kJ mol^{-1}.

(i) Suggest a reason why the value obtained in the experiment is so different from the Data Book value.

(1)

.....

(ii) This Data Book value (–2440 kJ mol^{-1}) refers to the following equation.

$$C_4H_8O(l) + 6½O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l)$$

How would the value be different if it referred to the formation of water in the **gaseous** state? Justify your answer.

(2)

Difference .....

Justification .....

.....

.....

.....

(c) Standard enthalpy changes of combustion can be used to calculate the standard enthalpy change of formation of a compound.

(i) Define the term **standard enthalpy change of formation**, making clear the meaning of **standard** in this context.

(3)

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(ii) Use the standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, given in the table below to find the standard enthalpy change of formation for ethanoic acid, CH_3COOH, in kJ mol^{-1}.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s, graphite)	–394
$H_2(g)$	–286
$CH_3COOH(l)$	–870

$$2C(s, \text{graphite}) + 2H_2(g) + O_2(g) \rightarrow CH_3COOH(l)$$

(3)

(Total for Question 24 = 15 marks)

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

SECTION A

1 The isotopes of magnesium, $^{24}_{12}Mg$ and $^{25}_{12}Mg$, both form ions with charge 2+. Which of the following statements about these ions is true?

☒ **A** Both ions have electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2$.

☒ **B** $^{25}_{12}Mg^{2+}$ has more protons than $^{24}_{12}Mg^{2+}$.

☒ **C** The ions have the same number of electrons but different numbers of neutrons.

☒ **D** The ions have the same number of neutrons but different numbers of protons.

(Total for Question 1 = 1 mark)

2 Chlorine has two isotopes with relative isotopic mass 35 and 37. Four *m/z* values are given below. Which will occur in a mass spectrum of chlorine gas, Cl_2, from an ion with a single positive charge?

☒ **A** 35.5

☒ **B** 36

☒ **C** 71

☒ **D** 72

(Total for Question 2 = 1 mark)

3 The human body contains around 0.025 g of iodine molecules, I_2. Which of the following shows the number of iodine **atoms** in 0.025 g of I_2?

The Avogadro constant is $6.02 \times 10^{23}\,mol^{-1}$.

☒ **A** $\frac{0.025}{126.9} \times 6.02 \times 10^{23}$

☒ **B** $\frac{0.025}{253.8} \times 6.02 \times 10^{23}$

☒ **C** $\frac{253.8}{0.025} \times 6.02 \times 10^{23}$

☒ **D** $\frac{126.9}{0.025} \times 6.02 \times 10^{23}$

(Total for Question 3 = 1 mark)

4 Which equation represents the reaction for which the enthalpy change is the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of sodium nitrate, $NaNO_3$?

☒ **A** $2Na(s) + N_2(g) + 3O_2(g) \rightarrow 2NaNO_3(s)$

☒ **B** $Na(s) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(s)$

☒ **C** $Na(s) + N(g) + 3O(g) \rightarrow NaNO_3(s)$

☒ **D** $Na(g) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(g)$

(Total for Question 4 = 1 mark)

5 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond enthalpy of the C–H bond?

☒ **A** $¼CH_4(g) \rightarrow ¼C(g) + H(g)$

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

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

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

(Total for Question 5 = 1 mark)

6 The first ionization energies, in kJ mol^{-1}, of four elements with consecutive atomic numbers are shown below.

A 1680

B 2080

C 496

D 738

(a) Which element could be an inert gas?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which element could be X in a covalent compound with formula HX?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which element could be Y in an ionic compound with formula YH_2?

(1)

☒ **A**

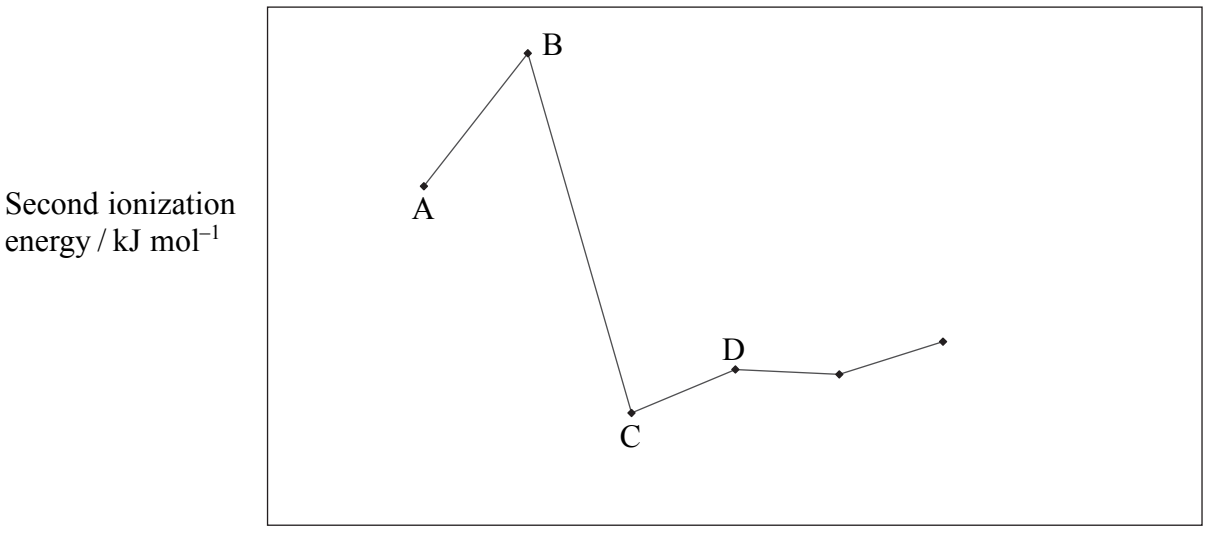
☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 3 marks)

7 The graph below shows the **second** ionization energy of a series of elements with consecutive atomic numbers.



Which element could be lithium?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8 The first five ionization energies, in kJ mol^{-1}, of aluminium are

578 1817 2745 11 578 14 831

The orbitals from which the first five electrons are removed during ionization, starting with the first electron, are

☒ **A** 1s 2s 2p 3s 3p

☒ **B** 1s 1s 2s 2s 2p

☒ **C** 3p 3s 2p 2s 1s

☒ **D** 3p 3s 3s 2p 2p

(Total for Question 8 = 1 mark)

9 Going across the Periodic Table from sodium to aluminium,

☒ **A** the melting temperature increases.

☒ **B** the radius of the atom increases.

☒ **C** the radius of the metal ion increases.

☒ **D** the bonding in the element changes from metallic to covalent.

(Total for Question 9 = 1 mark)

10 Going down Group 1 from lithium to rubidium

☒ **A** the radius of the atom decreases.

☒ **B** the radius of the ion decreases.

☒ **C** the first ionization energy decreases.

☒ **D** the polarizing power of the ion increases.

(Total for Question 10 = 1 mark)

11 A drop of concentrated nickel(II) sulfate solution, which is green, is placed on moist filter paper on a microscope slide and the ends of the slide are connected to a 24 V DC power supply. After ten minutes,

☒ **A** a blue colour has moved towards the negative terminal and a yellow colour towards the positive terminal.

☒ **B** a blue colour has moved towards the positive terminal and a yellow colour towards the negative terminal.

☒ **C** a green colour has moved towards the negative terminal but there is no other visible change.

☒ **D** a green colour has moved towards the positive terminal but there is no other visible change.

(Total for Question 11 = 1 mark)

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

12 The bonding in magnesium oxide, MgO, is

☒ **A** ionic.

☒ **B** metallic and ionic.

☒ **C** ionic and covalent.

☒ **D** metallic and covalent.

(Total for Question 12 = 1 mark)

13 Which of the following mixtures could **not** form when octane, C_8H_{18}, is cracked?

☒ **A** propane + pentene

☒ **B** butane + butene

☒ **C** pentane + propene

☒ **D** heptane + ethene

(Total for Question 13 = 1 mark)

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

14 This question is about the organic compounds with skeletal formulae as shown:

A 

B 

C 

D 

(a) Which compound is 2-methylpropane?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which compound has the molecular formula C_5H_{12}?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which compounds are isomers?

(1)

☒ **A** compound **A** and compound **C**

☒ **B** compound **B** and compound **C**

☒ **C** compound **B** and compound **D**

☒ **D** compound **C** and compound **D**

(d) Which compound reacts with acidified potassium manganate(VII) to form a diol?

(1)

☒ **A**

☒ **B**

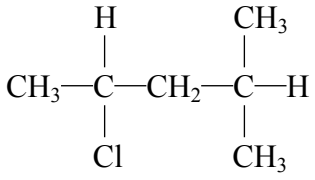
☒ **C**

☒ **D**

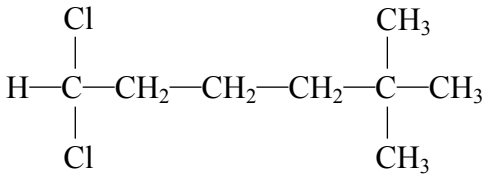
(Total for Question 14 = 4 marks)

15 The structural formula of 5-chloro-2,2-dimethylhexane is

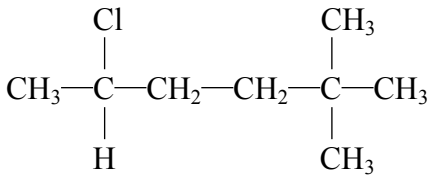
☒ **A**



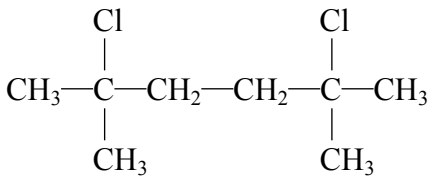
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

16 Magnesium chloride can be made by reacting solid magnesium carbonate, $MgCO_3$, with dilute hydrochloric acid.

(a) Write an equation for the reaction, including state symbols.

(2)

(b) Give TWO observations you would make when the reaction is taking place.

(2)

(c) In an experiment to make crystals of hydrated magnesium chloride, $MgCl_2.6H_2O$, magnesium carbonate was added to 25 cm^3 of hydrochloric acid with concentration 2.0 mol dm^{-3}. The molar mass of magnesium carbonate is 84.3 g mol^{-1}.

(i) How many moles of acid are used in the reaction?

(1)

(ii) What mass of magnesium carbonate, in grams, reacts with this amount of acid?

(1)

(iii) Suggest why slightly more than this mass of magnesium carbonate is used in practice.

(1)

(iv) How would you separate the magnesium chloride solution from the reaction mixture in (iii)?

(1)

(v) The magnesium chloride solution was left to crystallise. The crystals were separated and dried carefully. A sample of 3.75 g of hydrated crystals, $MgCl_2.6H_2O$, which have molar mass 203.3 g mol^{-1}, was obtained. Calculate the percentage yield of this reaction.

(2)

(vi) Give ONE reason why the yield of crystals is less than 100%, even when pure compounds are used in the preparation.

(1)

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(d) Lattice energies can be measured using the Born-Haber cycle, or calculated from electrostatic theory. Lattice energies of magnesium chloride and magnesium iodide are shown below.

Salt	Lattice energy from Born-Haber cycle using experimental data / kJ mol^{-1}	Lattice energy from electrostatic theory / kJ mol^{-1}
$MgCl_2$	–2526	–2326
MgI_2	–2327	–1944

(i) What does this data indicate about the bonding in magnesium chloride?

(1)

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*(ii) Explain why there is a greater difference between the experimental (Born-Haber) and theoretical lattice energies for magnesium iodide, MgI_2, compared with magnesium chloride.

(2)

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(e) Blood plasma typically contains 20 parts per million (ppm) of magnesium, by mass.

(i) Calculate the mass of magnesium, in grams, present in 100 g of plasma.

(1)

(ii) Magnesium chloride can be used as a supplement in the diet to treat patients with low amounts of magnesium in the blood. Suggest ONE property which makes it more suitable for this purpose than magnesium carbonate.

(1)

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.....

(Total for Question 16 = 16 marks)

17 Sulfamic acid is a white solid used by plumbers as a limescale remover.

(a) Sulfamic acid contains 14.42% by mass of nitrogen, 3.09% hydrogen and 33.06% sulfur. The remainder is oxygen.

(i) Calculate the empirical formula of sulfamic acid.

(3)

(ii) The molar mass of sulfamic acid is 97.1 g mol^{-1}. Use this information to deduce the molecular formula of sulfamic acid.

(1)

(b) A solution of sulfamic acid contains hydrogen ions. The hydrogen ions react with magnesium to produce hydrogen gas. In an experiment, a solution containing 5.5×10^{-3} moles of sulfamic acid was reacted with excess magnesium. The volume of hydrogen produced was 66 cm^3, measured at room temperature and pressure.

(i) Draw a labelled diagram of the apparatus you would use to carry out this experiment, showing how you would collect the hydrogen produced and measure its volume.

(2)

(ii) Calculate the number of moles of hydrogen, H_2, produced in this reaction.

[The molar volume of a gas is 24 $dm^3 mol^{-1}$ at room temperature and pressure]

(1)

(iii) Show that the data confirms that each mole of sulfamic acid produces one mole of hydrogen ions in solution.

(2)

(c) Plumbers use sulfamic acid powder for descaling large items such as boilers. Sulfamic acid acts as a descaler because the hydrogen ions react with carbonate ions in limescale.

(i) Write an ionic equation for the reaction of hydrogen ions with carbonate ions. State symbols are **not** required.

(1)

(ii) Suggest ONE reason why sulfamic acid is considered less hazardous than hydrochloric acid as a descaler.

(1)

(Total for Question 17 = 11 marks)

18 This question is about hexane, C_6H_{14}, and hex-1-ene, C_6H_{12}.

(a) What test would you use to distinguish between hexane and hex-1-ene? Give the results of the test for each substance.

(2)

Test: .....

.....

Result with hexane: .....

.....

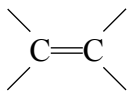
Result with hex-1-ene: .....

.....

(b) Hex-1-ene has a number of isomers, including two stereoisomers of hex-2-ene.

(i) Complete the formula to show the structure of *E*-hex-2-ene.

(1)



*(ii) Explain why stereoisomerism can occur in alkenes, and why hex-2-ene has stereoisomers but hex-1-ene does not.

(2)

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(c) The enthalpy change of combustion of hexane was measured using a spirit burner to heat a known mass of water in a calorimeter. The temperature rise of the water was measured. The results of the experiment are shown below.

Mass of hexane burnt	0.32 g
Mass of water in calorimeter	50 g
Initial temperature of water	22 °C
Final temperature of water	68 °C

The specific heat capacity of water is 4.18 J g^{-1} °C^{-1}.

(i) Calculate the energy in joules produced by burning the hexane. Use the expression

energy transferred = mass × specific heat capacity × temperature change.

(1)

(ii) Calculate the enthalpy change of combustion of hexane. The mass of 1 mole of hexane is 86 g.

Give your answer to TWO significant figures. Include a sign and units in your answer.

(3)

(iii) The value for the enthalpy change of combustion in this experiment is different from the value given in data books. Suggest TWO reasons for this difference.

(2)

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(iv) A student suggested that the results would be more accurate if a thermometer which read to 0.1°C was used. Explain why this would **not** improve the accuracy of the result. A calculation is **not** required.

(1)

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(d) Hex-1-ene can be converted to hexane in the following reaction.

$$C_6H_{12}(l) + H_2(g) \rightarrow C_6H_{14}(l)$$

(i) What catalyst is used in this reaction?

(1)

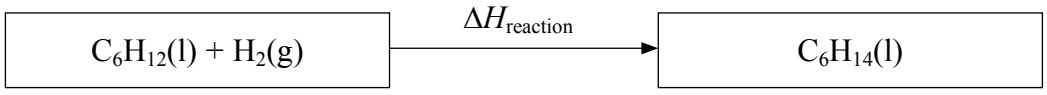
.....

(ii) The enthalpy change of this reaction $\Delta H_{reaction}$ can be calculated from the following enthalpy changes of combustion.

Substance	Enthalpy change of combustion /kJ mol^{-1}
Hex-1-ene, C_6H_{12}	–4003
Hydrogen, H_2	–286
Hexane, C_6H_{14}	–4163

Complete the Hess cycle by adding labelled arrows. Use your cycle to calculate the enthalpy change $\Delta H_{reaction}$.

(3)



$6CO_2(g) + 7H_2O(l)$

$\Delta H_{reaction}$ = ... kJ mol^{-1}

(iii) The enthalpy change for the reaction of some other alkenes with hydrogen is shown below.

Reaction	Standard enthalpy change / kJ mol^{-1}
$C_3H_6 + H_2 \rightarrow C_3H_8$	–125
$C_4H_8 + H_2 \rightarrow C_4H_{10}$	–126
$C_5H_{10} + H_2 \rightarrow C_5H_{12}$	–126

Explain why the values are so similar.

(1)

.....

.....

.....

(Total for Question 18 = 17 marks)

19 Chloroethane, C_2H_5Cl, can be made from either ethane or ethene.

(a) (i) What reagent and condition would be used to make chloroethane from **ethane**?

(2)

Reagent .....

Condition .....

(ii) State the type of reaction and mechanism by which this reaction occurs.

(2)

.....

.....

(b) (i) What reagent would be used to make chloroethane from **ethene**?

(1)

.....

(ii) Show, in full, the mechanism for this reaction in which **ethene** is converted to chloroethane.

(3)

(c) Which method of making chloroethane has

(3)

- a higher atom economy? .....
- a higher percentage yield? .....

Explain your answers.

Higher atom economy .....

.....

Higher percentage yield .....

.....

(d) The compound chloroethene, $CH_2{=}CHCl$, forms an addition polymer.

(i) Draw a diagram, using dots or crosses, to show the arrangement of electrons in chloroethene. Only the outer shell electrons need be shown.

(2)

(ii) Chloroethene can form an addition polymer. Write the displayed formula of poly(chloroethene) showing two repeat units.

(1)

*(iii) Poly(chloroethene) is commonly known as PVC. Almost a quarter of the PVC which is manufactured is used to make water pipes, which were formerly made of metal.

Give TWO factors which have to be considered when deciding which material, PVC or metal, contributes to more sustainable uses of resources in the long term.

(2)

.....

.....

.....

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.....

(Total for Question 19 = 16 marks)

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

mock papers 4

SECTION A

1 The equations below show some reactions of magnesium and its compounds.

A $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

B $Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + O_2(g)$

C $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(1)$

D $Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

(a) Which equation is **not** balanced?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation can be classified as a displacement reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 2 marks)

2 Which of these equations represents the electron affinity of chlorine?

☒ **A** $Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

☒ **B** $Cl_2(g) - 2e^- \rightarrow 2Cl^-(g)$

☒ **C** $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

☒ **D** $Cl(g) + e^- \rightarrow Cl^-(g)$

(Total for Question 2 = 1 mark)

3 Which of these equations represents the second ionization of magnesium?

☒ **A** $Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{-}$

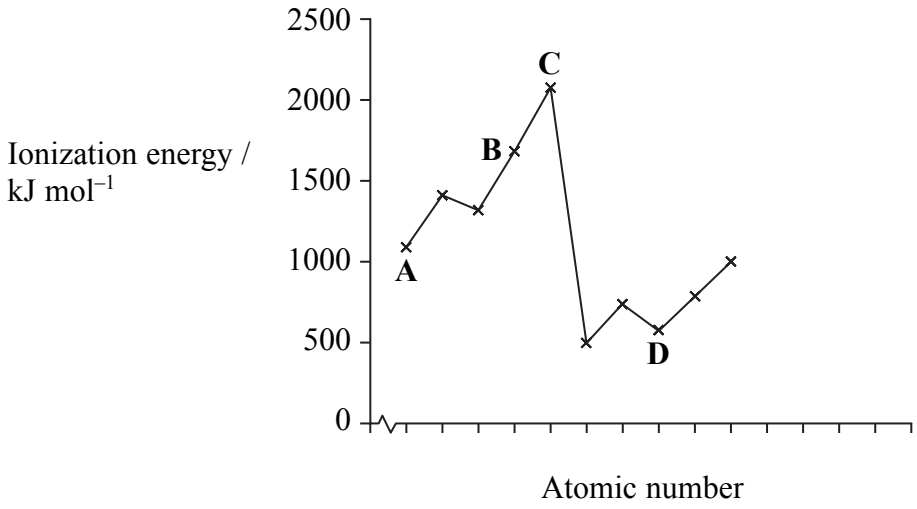
☒ **B** $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

☒ **C** $Mg^{+}(g) + e^{-} \rightarrow Mg^{2+}(g)$

☒ **D** $Mg(g) + 2e^{-} \rightarrow Mg^{2+}(g)$

(Total for Question 3 = 1 mark)

4 The sketch graph below shows the trend in first ionization energies for some elements in Periods two and three.



Select, from the elements **A to D**, the one that

(a) has atoms with five p electrons.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) is a member of Group 3.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) is likely to be very unreactive.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) normally forms four covalent bonds per atom.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 4 = 4 marks)

5 Which of these ions has the greatest ability to polarize an anion?

☒ **A** Ba^{2+}

☒ **B** Ca^{2+}

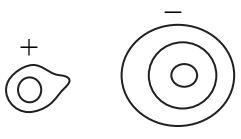
☒ **C** Cs^{+}

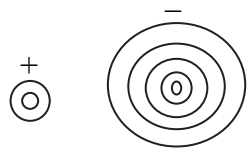
☒ **D** K^{+}

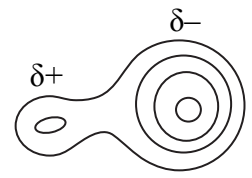
(Total for Question 5 = 1 mark)

6 Which of these electron density maps best represents the bonding in the compound lithium iodide, LiI?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 6 = 1 mark)

7 Which of these statements is **incorrect**?

☒ **A** The atomic radius of metals increases down a Group.

☒ **B** The trend in the melting temperature of successive elements across Period 2 is similar to that in Period 3.

☒ **C** A metallic structure is held together by attractions between metal atoms and delocalized electrons.

☒ **D** Na^+ and O^{2-} ions are isoelectronic.

(Total for Question 7 = 1 mark)

8 A sample of gas was prepared for use in helium-neon lasers. It contained 4 g of helium and 4 g of neon. What is the ratio of helium atoms to neon atoms in the sample?

☒ **A** 1 : 1

☒ **B** 2.5 : 1

☒ **C** 1 : 5

☒ **D** 5 : 1

(Total for Question 8 = 1 mark)

9 The overall equation for the reaction between sulfur and oxygen to form sulfur trioxide is shown below.

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

0.9 mol of $O_2(g)$ reacted completely with excess sulfur. What volume, in dm^3, of sulfur trioxide would form?

[Assume the molar gas volume = 24 dm^3 mol^{-1}]

☒ **A** $(0.9 \times 3/2) \times 24$

☒ **B** $(0.9 \times 3/2) \div 24$

☒ **C** $(0.9 \times 2/3) \times 24$

☒ **D** $(0.9 \times 2/3) \div 24$

(Total for Question 9 = 1 mark)

10 Which of these solutions does **not** contain the same total number of ions as the others?

☒ **A** 10.00 cm^3 of 0.100 mol dm^{-3} NaCl(aq)

☒ **B** 20.00 cm^3 of 0.050 mol dm^{-3} NaCl(aq)

☒ **C** 20.00 cm^3 of 0.050 mol dm^{-3} $MgCl_2$(aq)

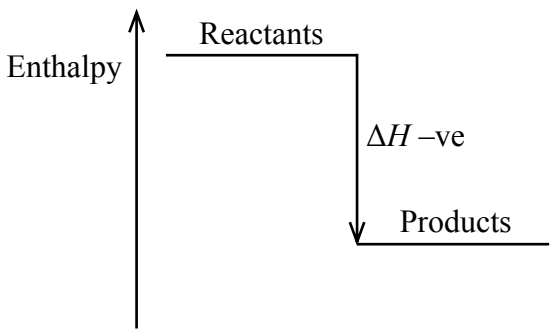
☒ **D** 13.33 cm^3 of 0.050 mol dm^{-3} $MgCl_2$(aq)

(Total for Question 10 = 1 mark)

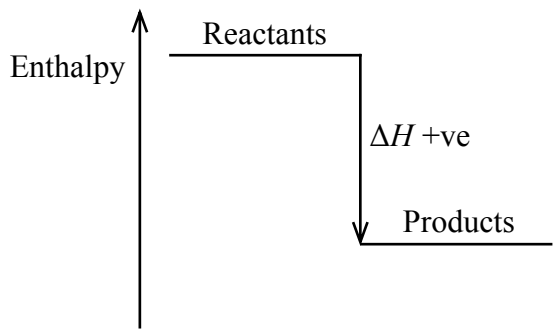
Use this space for any rough working. Anything you write in this space will gain no credit.

11 Which of these diagrams correctly represents an endothermic reaction?

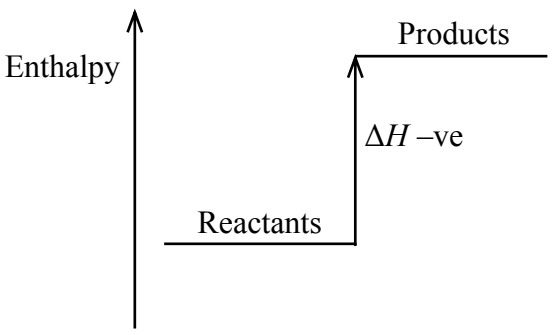
☒ **A**



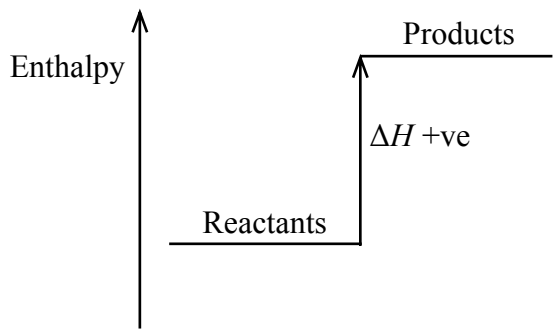
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

12 Which of these statements about carbon-carbon double bonds is **false**?

☒ **A** The two ends of a molecule cannot rotate relative to each other, about the axis of the double bond.

☒ **B** They are twice as strong as a carbon-carbon single bond.

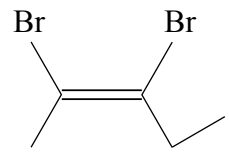
☒ **C** They have a higher electron density than a single bond.

☒ **D** They consist of a sigma bond and a pi bond.

(Total for Question 12 = 1 mark)

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

13 What is the correct name for the compound below?



☒ **A** *E*-2,3-dibromopent-2-ene

☒ **B** *E*-2,3-dibromopent-3-ene

☒ **C** *Z*-2,3-dibromopent-3-ene

☒ **D** *Z*-2,3-dibromopent-2-ene

(Total for Question 13 = 1 mark)

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

14 The equations below show some of the processes that occur when methane and chlorine react.

A $Cl_2(g) \rightarrow 2Cl\bullet(g)$

B $Cl\bullet(g) + CH_4(g) \rightarrow CH_3\bullet(g) + HCl(g)$

C $CH_3\bullet(g) + CH_3\bullet(g) \rightarrow C_2H_6(g)$

D $Cl_2(g) + CH_4(g) \rightarrow CH_3Cl(g) + HCl(g)$

(a) Which equation shows a propagation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation shows an initiation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which equation shows a termination step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 14 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

15 This question is about the properties of ions and ionic compounds.

(a) Solid calcium carbonate, $CaCO_3$, has a giant ionic structure.

(i) Draw a diagram (using dots or crosses) for a calcium **ion**. Show **ALL** the electrons and the charge on the ion.

(2)

(ii) Complete the electronic configuration for a calcium **ion**.

(1)

$1s^2$

(iii) Would you expect a calcium ion to be bigger, smaller or the same size as a calcium atom? Give TWO reasons to explain your answer.

(2)

(iv) Explain why ionic compounds have relatively high melting temperatures.

(2)

(b) Changes in the concentration of ions in a solution can be estimated by measuring the electrical conductivity of the solution.

(i) Explain why solutions of ions are able to conduct electricity.

(1)

.....

.....

(ii) Suggest why aqueous solutions of calcium chloride, $CaCl_2(aq)$, and barium chloride, $BaCl_2(aq)$, of the same molar concentration, have different electrical conductivities.

(1)

.....

.....

.....

(iii) 1 kg of a solution contains 0.100 mol of calcium ions, Ca^{2+}.

What is the concentration of the calcium ions by mass in parts per million (ppm)?

[Assume the relative atomic mass of calcium is 40.]

(2)

..... ppm

*(c) Some buildings are made from limestone, which is mainly calcium carbonate. Gases in the atmosphere such as sulfur dioxide, SO_2, and nitrogen dioxide, NO_2, can be responsible for damaging these buildings.

Describe how these gases come to be present in the atmosphere and explain how they can damage a limestone building.

(3)

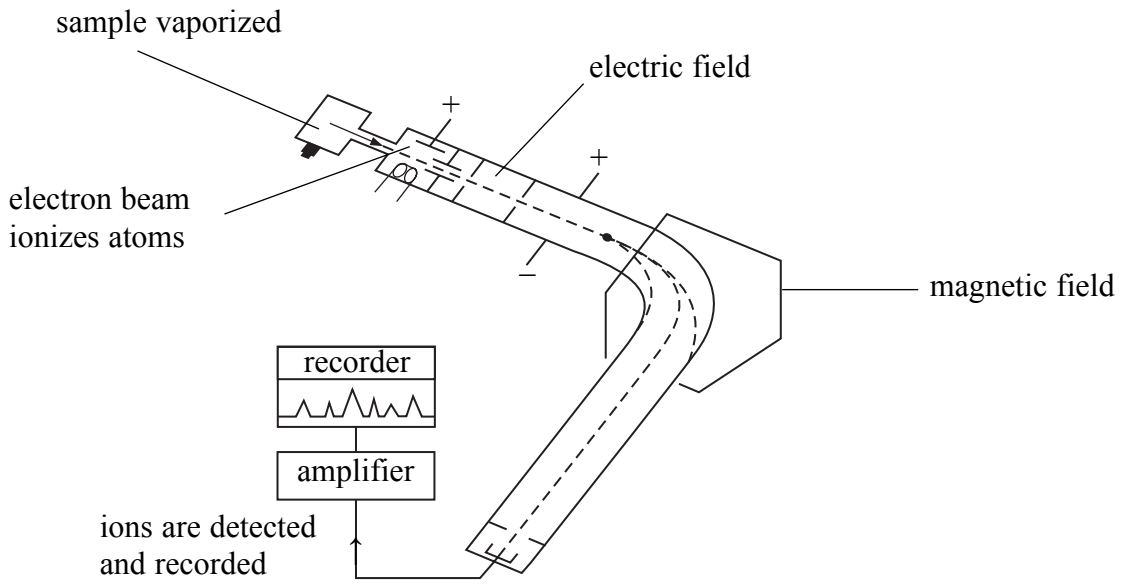
(d) The lattice energy of calcium chloride, $CaCl_2$, is -2258 kJ mol^{-1} based on an experimental Born-Haber cycle and -2223 kJ mol^{-1} based on theoretical calculations.

Would you expect its bonding to match the ionic model? Justify your answer.

(1)

(Total for Question 15 = 15 marks)

16 The diagram below shows a mass spectrometer, which can be used to determine the percentage abundances of isotopes in an element.



(a) Explain, in terms of sub-atomic particles, what is meant by the term **isotopes**.

(2)

(b) Describe the role of the following parts of the mass spectrometer.

(i) Electric field

(1)

(ii) Magnetic field

(1)

(c) A sample of the element barium is made up of four isotopes. The data below were taken from a mass spectrum of this sample.

Mass/charge ratio	% abundance
135	9.01
136	10.81
137	12.32
138	67.86

Calculate the relative atomic mass of the sample, giving your answer to **one** decimal place.

(2)

(d) The element bromine has two stable isotopes, ^{79}Br and ^{81}Br. How many peaks corresponding to Br_2^+ ions would be seen in the mass spectrum of bromine? Justify your answer.

(2)

(e) Suggest another application of mass spectrometry, other than to determine the relative atomic mass of an element.

(1)

(Total for Question 16 = 9 marks)

17 This question is about methanol and the energy changes that accompany some of its reactions.

(a) Complete the diagram (using dots and crosses) to show the bonding in methanol, CH_3OH. You should show outer electrons only.

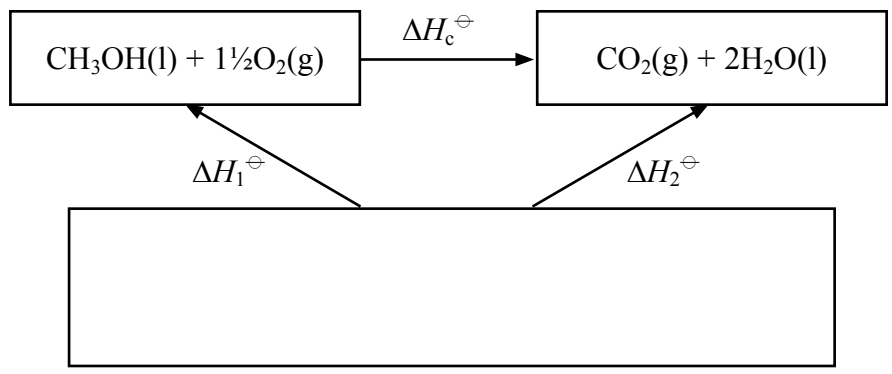
(2)

H

H C O H

H

(b) The Hess cycle below can be used to calculate the standard enthalpy change of combustion of methanol, using standard enthalpy changes of formation.



(i) Complete the cycle by filling in the empty box.

(2)

*(ii) Define the term **standard enthalpy change of formation** of a compound, making clear the meaning of **standard** in this context.

(3)

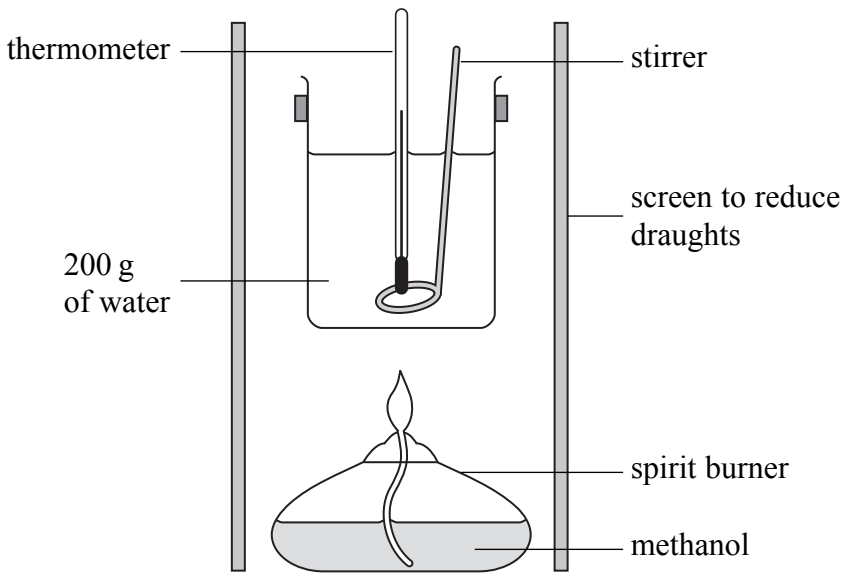
(iii) Use your cycle and the data below to calculate the standard enthalpy change of combustion of methanol, $\Delta H_c^{\ominus}$.

	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8
$CH_3OH(l)$	–239.1

(2)

Turn over ▶

(c) An experiment was carried out, using the apparatus below, to estimate the standard enthalpy change of combustion of methanol.



After burning the methanol for a few minutes, the temperature of water in the beaker had risen by 20.7 °C and the mass of methanol burnt was 0.848 g.

(i) Calculate the amount of energy transferred to the water.

Energy transferred (J) = mass of water × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of methanol, CH_3OH, burnt during the experiment.

(1)

(iii) Use your answers to (c)(i) and (ii) to calculate the experimental value for the standard enthalpy change of combustion. Include a sign and units in your answer, which should be given to **three** significant figures.

(1)

(iv) Compare your answers to (b)(iii) and (c)(iii) and give TWO reasons to explain any differences.

(2)

.....

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.....

(Total for Question 17 = 14 marks)

18 This question is about ethene and related compounds.

(a) One way to manufacture ethene is by cracking hydrocarbon molecules such as liquid paraffin.

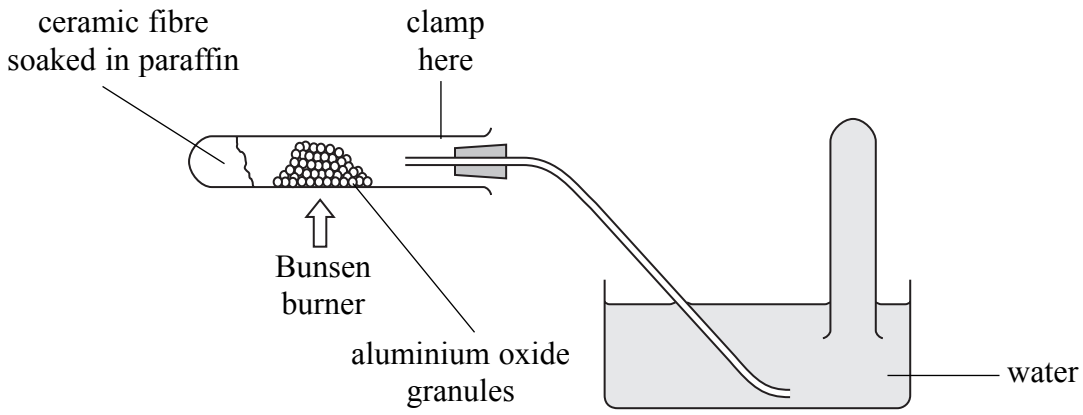
(i) Name a raw material from which liquid paraffin can be obtained.

(1)

(ii) Describe what is meant by **cracking**.

(2)

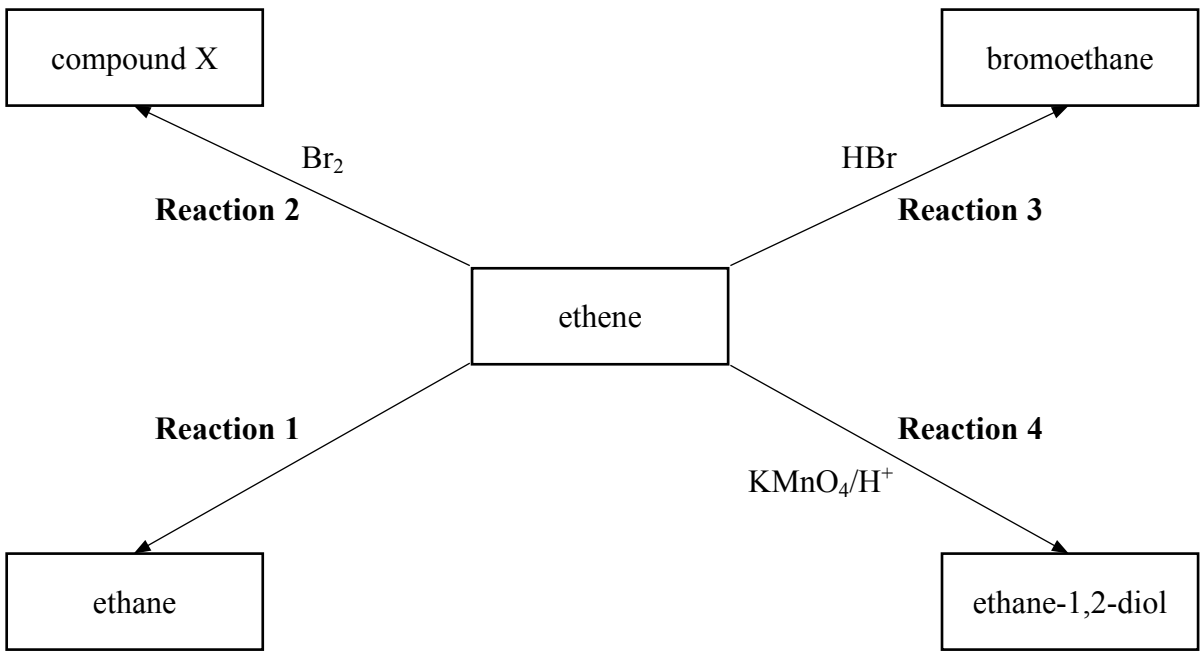
(iii) It was proposed to set up the apparatus below on a laboratory bench, in order to crack paraffin.



State TWO of the **risks** of using the apparatus in this way and suggest how you would amend the set-up to minimise each risk.

(4)

(b) Study the reaction scheme below and then answer the questions that follow.



(i) Name the reagent and catalyst needed for **Reaction 1**.

(2)

Reagent.....

Catalyst.....

(ii) Give the name and displayed formula of **compound X**.

(2)

Name.....

Displayed formula

(iii) Describe what colour change you would see during **Reaction 4** if a small amount of acidified $KMnO_4(aq)$ was shaken with ethene.

(1)

From..... **to**.....

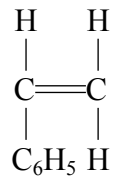
(c) (i) Use displayed formulae to show the mechanism for **Reaction 3**.

(3)

(ii) Explain why the alkene, propene, could form two products when it reacts with hydrogen bromide in a similar way.

(1)

(d) The formula of the alkene phenylethene, often called styrene, is shown below. It can be used to make the polymer poly(styrene).



phenylethene

Draw a section of the poly(styrene) polymer chain formed from **two** monomer units.

(2)

Turn over ▶

(e) The table below shows some data used in a life cycle analysis of polystyrene and paper drinking cups.

	Paper Cup	Polystyrene Cup
Raw Materials (per cup)		
Wood or bark	26 g	0 g
Petroleum fractions	2.2 g	3.4 g
Energy used (per tonne of material made)	980 kWh	280 kWh
Water released into environment (per tonne of material made)	120 m^3	2.5 m^3
Air emissions (per tonne of material made)		
Chlorine / chlorine dioxide	0.4 kg	0 kg
Sulfides / sulfur dioxide	11 kg	3.5 kg
Hydrocarbons	0 kg	40 kg

(i) Some people argue that using a polystyrene cup has less environmental impact than using a paper cup.

Choose TWO pieces of data to support this argument, explaining your choices.

(2)

(ii) Suggest TWO further pieces of information, not given in the table, regarding the life cycle of the cups that would make any assessment of the environmental impact more reliable.

(2)

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(Total for Question 18 = 22 marks)

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