Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Thursday 9 January 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

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 ▶

P42986A

6/6/6/6/2/2/

P 4 2 9 8 6 A 0 1 2 4

PEARSON

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 of the following ions would be deflected **least** in a mass spectrometer?

☒ **A** $^{35}Cl^{+}$

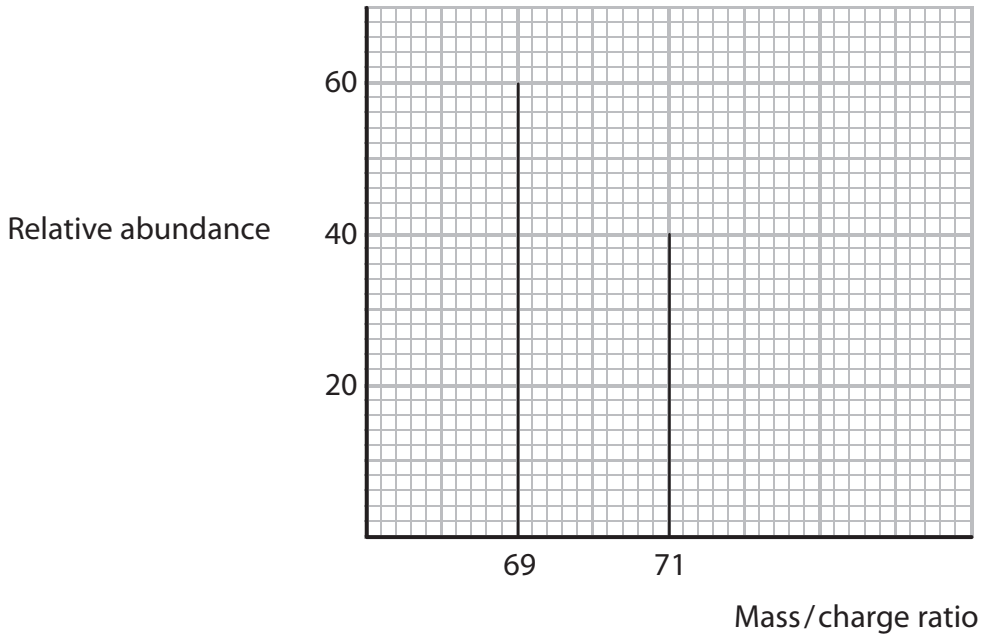
☒ **B** $^{35}Cl^{2+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{37}Cl^{2+}$

(Total for Question 1 = 1 mark)

2 The mass spectrum of an element is shown below.



The relative atomic mass of the element is

☒ **A** 69.4

☒ **B** 69.8

☒ **C** 70.0

☒ **D** 70.2

(Total for Question 2 = 1 mark)

3 In a mass spectrometer, positive ions are accelerated by

☒ **A** bombarding them with fast-moving electrons.

☒ **B** bombarding them with fast-moving protons.

☒ **C** passing them between charged plates.

☒ **D** passing them through a magnetic field.

(Total for Question 3 = 1 mark)

4 The number of unpaired electrons in a nitrogen atom in its ground state is

☒ **A** 0

☒ **B** 1

☒ **C** 2

☒ **D** 3

(Total for Question 4 = 1 mark)

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

5 Four sequences of ionization energies of elements, in kJ mol^{-1}, are shown below.

A 590 1145 4912 6474 8144

B 520 496 419 403 376

C 1000 1251 1521 419 590

D 631 658 650 653 717

(a) The sequence giving the first ionization energies of elements going down a Group in the Periodic Table is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) The sequence showing the first five ionization energies of calcium is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) The sequence showing the first ionization energy of successive elements, in which atomic number increases by one each time, starting with an element in Group 6 is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 3 marks)

6 Which of the following ions has the **smallest** ionic radius?

☒ **A** Ca^{2+}

☒ **B** K^{+}

☒ **C** S^{2-}

☒ **D** Cl^{-}

(Total for Question 6 = 1 mark)

7 A liquid, which conducts electricity, continues to conduct when it is cooled and solidified. Which of the following could it be?

☒ **A** Mercury

☒ **B** Bromine

☒ **C** Molten sodium chloride

☒ **D** Tetrachloromethane

(Total for Question 7 = 1 mark)

8 Calculate the number of **atoms** in one mole of hydrogen peroxide, H_2O_2.

[The Avogadro constant, $L = 6.0 \times 10^{23}$ mol^{-1}]

☒ **A** 1.5×10^{23}

☒ **B** 6.0×10^{23}

☒ **C** 1.2×10^{24}

☒ **D** 2.4×10^{24}

(Total for Question 8 = 1 mark)

9 When 0.1 mol of atoms of an element reacts with chlorine, there is an increase in mass of 7.1 g.

The element could be

☒ **A** carbon.

☒ **B** sodium.

☒ **C** magnesium.

☒ **D** aluminium.

(Total for Question 9 = 1 mark)

10 Magnesium nitrate is decomposed by heat in the following reaction.

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

In an experiment, 0.10 mol of magnesium nitrate was heated. What is the maximum volume of gas, measured in dm^3 at room temperature and pressure, which could be obtained?

[Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure]

☒ **A** 0.24

☒ **B** 2.4

☒ **C** 4.8

☒ **D** 6.0

(Total for Question 10 = 1 mark)

11 Ammonia gas decomposes when heated.

$$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$$

In an experiment, a sample of 500 cm^3 of ammonia was heated and 20% decomposed.

The total volume of gas present at the end of the experiment, in cm^3, was

☒ **A** 200

☒ **B** 400

☒ **C** 600

☒ **D** 1000

(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 standard enthalpy change for the formation of ethene, C_2H_4, is +52.2 kJ mol^{-1} and that of ethane, C_2H_6, is –84.7 kJ mol^{-1}.

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

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

☒ **A** –32.5

☒ **B** –136.9

☒ **C** +136.9

☒ **D** This cannot be calculated using only the data above.

(Total for Question 12 = 1 mark)

13 Which of the following equations represents a reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H^{\ominus}_{f,298}$?

☒ **A** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

☒ **B** $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

☒ **C** $H_2O(g) \rightarrow H_2O(l)$

☒ **D** $H_2O(s) \rightarrow H_2O(l)$

(Total for Question 13 = 1 mark)

14 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
CO in carbon monoxide	+1077
O=O	+498
C=O in carbon dioxide	+805

The enthalpy change for the reaction

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

in units of kJ mol^{-1} is

☒ **A** –284

☒ **B** +35

☒ **C** +521

☒ **D** +770

(Total for Question 14 = 1 mark)

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

(1)

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

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

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

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

(b) The UV radiation initially causes the formation of

(1)

☒ **A** Cl^- ions.

☒ **B** Cl^+ ions.

☒ **C** $Cl^\bullet$ free radicals.

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

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

(1)

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

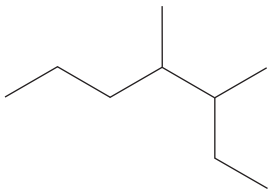
☒ **B** initiation is occurring.

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

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

(Total for Question 15 = 3 marks)

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



☒ **A** 5-ethyl-4-methylhexane

☒ **B** 2-ethyl-3-methylhexane

☒ **C** 4,5-dimethylheptane

☒ **D** 3,4-dimethylheptane

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

17 This question is about some of the elements in Period 3 of the Periodic Table.

(a) (i) An atom of silicon has mass number 29. Complete the table below showing the numbers of sub-atomic particles in this atom of silicon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{29}Si	Number
protons	
electrons	
neutrons	

(ii) Complete the electronic configuration of silicon.

(1)

$1s^2$.....

*(b) Explain the following, referring to differences in structure and bonding.

(i) Silicon has a higher melting temperature than phosphorus.

(3)

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(ii) Magnesium has a higher melting temperature than sodium.

(2)

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(c) Suggest why the atomic radius decreases going across the Periodic Table from sodium to silicon.

(2)

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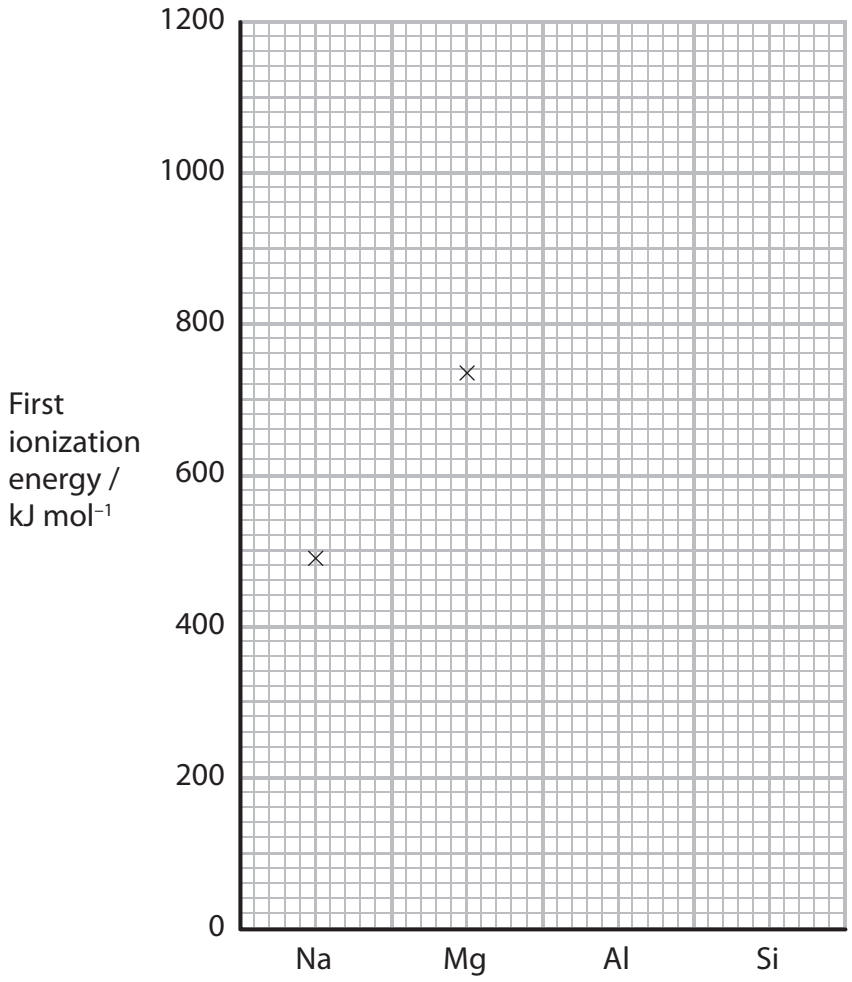
.....

(d) At room temperature, silicon tetrachloride, $SiCl_4$, is a liquid that does not conduct electricity.

Draw a dot and cross diagram illustrating the bonding in silicon chloride. Show only the outer electron shells of the atoms. Use crosses to represent the electrons from silicon and dots to represent the electrons from chlorine.

(2)

(e) The diagram below shows the values of the first ionization energies of sodium and magnesium.



(i) On the diagram, add crosses to mark the approximate positions for the values of the first ionization energies of the elements Al and Si.

(1)

*(ii) Justify your suggested values in terms of the atomic structure and electronic configuration of the elements.

(2)

Aluminium .....

.....

.....

Silicon .....

.....

.....

(Total for Question 17 = 14 marks)

18 Barium chloride can be made by reacting solid barium carbonate with dilute hydrochloric acid in the following reaction.

$$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) (i) Write the ionic equation for the reaction of solid barium carbonate with hydrogen ions from the hydrochloric acid. State symbols are not required.

(1)

(ii) State **two** observations you would make while the reaction is taking place. No change of colour occurs.

(2)

Observation 1 .....

Observation 2 .....

(b) In an experiment to prepare crystals of hydrated barium chloride, $BaCl_2.2H_2O$, a volume of 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid, HCl, was transferred to a beaker and solid barium carbonate, $BaCO_3$, was added until it was in excess.

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

(1)

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

The molar mass of barium carbonate is 197.3 g mol^{-1}.

(1)

(iii) Why was an **excess** of barium carbonate used in the experiment?

(1)

.....

.....

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

(1)

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.....

(v) The barium chloride solution was left to crystallize. The crystals were separated and dried carefully. A sample of 5.35 g of hydrated crystals, $BaCl_2 \cdot 2H_2O$, which has molar mass 244 g mol^{-1}, was obtained. Calculate the percentage yield of this reaction.

(2)

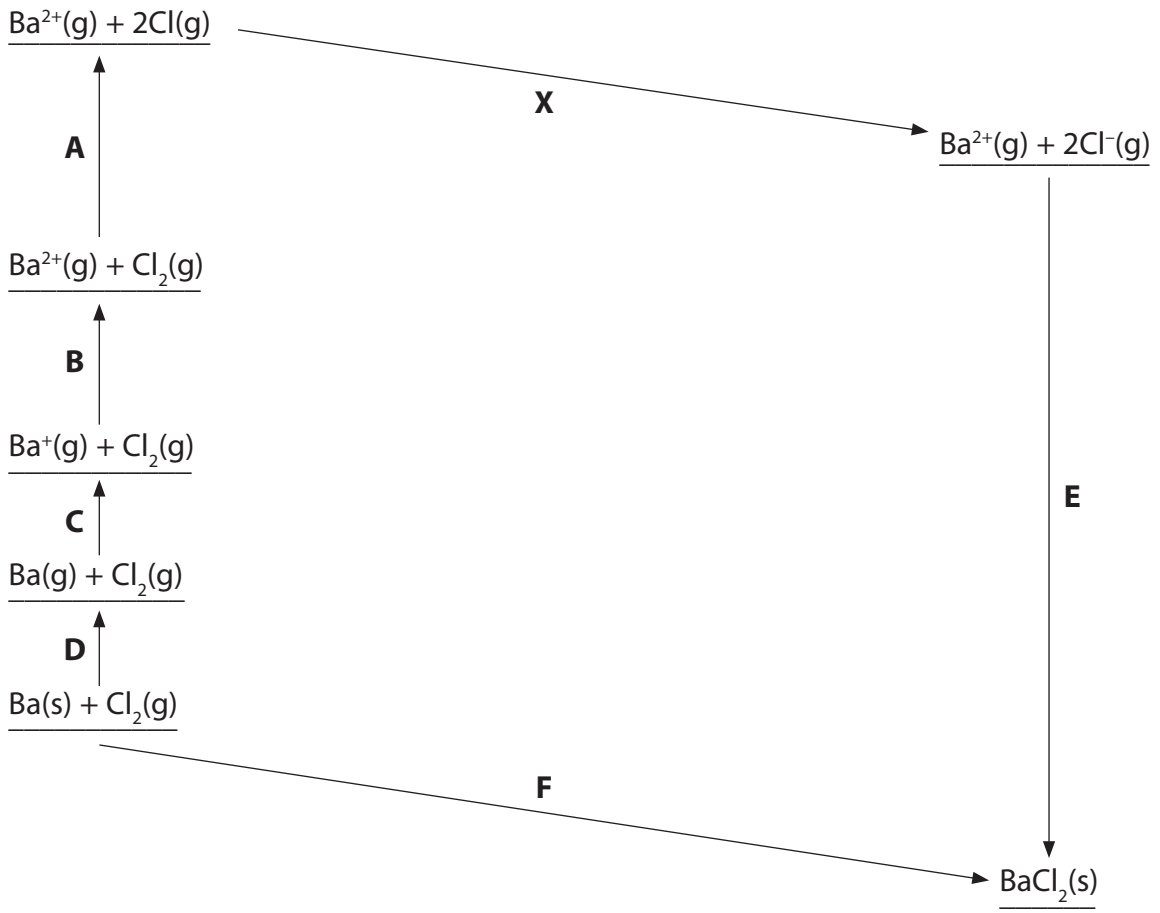
(vi) Give **one** reason why the yield of crystals is less than 100%, even when the reactants contain no impurities.

(1)

.....

.....

(c) The diagram below, which is not drawn to scale, shows how the lattice energy of barium chloride can be calculated using the Born-Haber cycle.



(i) Using the letters **A** to **F**, complete the table below by matching each letter to its corresponding energy change.

(3)

(ii) The energy change **X** is –697.6 kJ mol^{-1}.

In the table, add the name of the enthalpy change which is occurring in this stage of the cycle.

(1)

Energy change	Letter	ΔH / kJ mol^{-1}
Lattice energy of barium chloride		
Enthalpy change of atomization of barium		180.0
Enthalpy change of atomization of $Cl_2(g)$ to 2Cl(g)		243.4
First ionization energy of barium		503
Second ionization energy of barium		965
	X	$2 \times (-348.8)$ $= -697.6$
Enthalpy change of formation of barium chloride		–858.6

(iii) Use the data to calculate the lattice energy of barium chloride.

(2)

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

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

What can you deduce from the fact that the experimental and theoretical values for the lattice energy of barium chloride are very close?

(2)

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.....

(Total for Question 18 = 18 marks)

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19 This question is about the flammable liquid, methanol, CH_3OH.

(a) Methanol starts to have toxic effects when it is present in blood at levels of above 200 mg in 1000 g.

Express this concentration in parts per million.

(1)

(b) The enthalpy change of combustion of methanol was measured using a spirit burner to heat a known mass of water in a calorimeter. The temperature increase of the water in the calorimeter was measured when a known mass of methanol was burned.

(i) Write an equation for the complete combustion of methanol, CH_3OH, under standard conditions. Include state symbols in the equation.

(2)

(ii) Identify **two** other products that could form if the combustion was **incomplete**.

(1)

1 .....

2 .....

(c) The results of the experiment are summarised in the table below.

Mass of water in the calorimeter	150.0 g
Mass of spirit burner + contents (initial)	52.24 g
Mass of spirit burner + contents (final)	51.60 g
Temperature of water (initial)	21.4 °C
Temperature of water (final)	37.2 °C

(i) Calculate the heat energy produced in this experiment using the equation

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

(1)

(ii) Calculate the number of moles of methanol burned in this experiment.

(1)

(iii) Calculate the enthalpy change of combustion of methanol in kJ mol^{-1}. Give your answer to **three** significant figures.

(2)

(iv) The experimental result differs from the true value for the enthalpy change of combustion of methanol.

State **one** factor in the experimental method, other than heat losses or incomplete combustion, which causes the result to differ from the true value.

Explain the effect this factor has on the magnitude of the experimental value compared to the true value.

(2)

Factor .....

.....

.....

Explanation .....

.....

.....

(d) The value of the enthalpy change for the combustion of methanol can be calculated from the mean bond enthalpies of the substances in the reaction.

Give **two** reasons why this value differs from the value obtained in the experiment, even after corrections are made for experimental error.

(2)

Reason 1 .....

.....

Reason 2 .....

.....

(Total for Question 19 = 12 marks)

20 This question is about the chemistry of alkenes, which are unsaturated hydrocarbons.

(a) State what is meant by the term **unsaturated** as applied to a hydrocarbon.

(1)

.....

.....

(b) An organic compound, **X**, is an unsaturated hydrocarbon with molecular formula C_4H_8.

(i) Draw the displayed formulae and give the names of **two** unbranched molecules with molecular formula C_4H_8 which are *E/Z* isomers.

(3)

Isomer 1	Isomer 2
Name:	Name:

(ii) Both isomers react with a solution of acidified aqueous potassium manganate(VII).

State the colour change that you would observe when this reaction is carried out.

(1)

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

(iii) Draw the structure of the organic product of this reaction with either one of these isomers.

(1)

(iv) Compounds such as C_4H_8 are formed when fractions of crude oil are cracked.

State what is meant by the term **cracking** when applied to processing a fraction obtained from crude oil.

(1)

.....

.....

(v) Write an equation to show the cracking of the hydrocarbon octane into C_4H_8 and a saturated hydrocarbon as the only products.

(1)

(c) Another alkene is propene, C_3H_6.

Describe the mechanism for the addition reaction of propene with bromine, Br_2, to form $C_3H_6Br_2$.

In your answer you should include:

- the name for the type of addition which occurs
- the name of the product
- the mechanism using curly arrows to show the movement of electron pairs.

(5)

Type of addition .....

Name of product .....

Mechanism

(d) Propene can polymerize to form poly(propene).

(i) State, with a reason, the atom economy for this reaction.

(1)

.....

.....

(ii) Draw a section of this polymer, showing **two** repeat units.

(1)

(iii) Poly(propene) is used to make synthetic fibres which are extremely light and act as good insulators.

Comment on the sustainability of this use of poly(propene).

(1)

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.....

(Total for Question 20 = 16 marks)

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

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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							

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

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
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

* Lanthanide series

* Actinide series