Epsom College

Chemistry Department

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Scholarship Paper

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1 Hour

The paper is designed to be challenging and some parts may stretch slightly beyond application of GCSE knowledge.

- A calculator may be used
- A periodic table is provided at the back of the paper
- You have 1 hour to complete this paper
- The paper is challenging; answer as many questions as you can and do not worry if you can't do all the paper.

Q1.

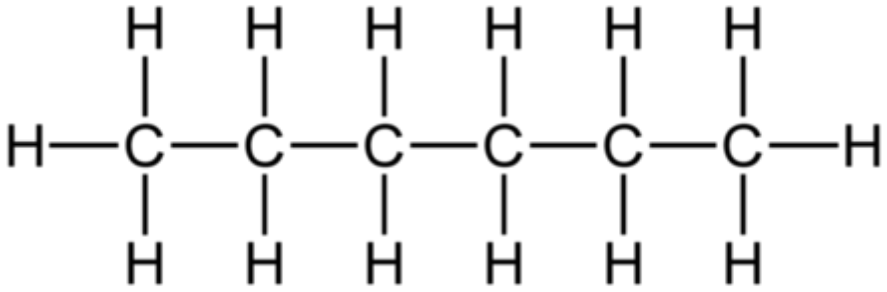
1.12 g of iron reacts with oxygen to form 1.60 g of an oxide of iron. Use relative atomic masses: Fe = 56, O = 16.

What is the formula of this oxide of iron?

- **A** FeO_5
- **B** Fe_2O_{10}
- **C** Fe_3O_2
- **D** Fe_2O_3

(Total for question = 1 mark)

Q2.



The systematic name of the compound shown above is

- **A** Butane.
- **B** Hexane.
- **C** Decane.
- **D** Heptane.

(Total for Question = 1 mark)

Q3.

One possible method for the formation of nitric acid involves the reaction between dinitrogen tetroxide and water.

$$3N_2O_4 + 2H_2O \rightarrow 4HNO_3 + 2NO$$

Calculate the atom economy for the formation of nitric acid from this reaction. The atom economy is the mass of the useful products, divided by the mass of all products, multiplied by 100.

(1)

(Total for question = 1 mark)

Q4.

This question is about the structure of the atom and isotopes.

The following excerpt is taken from the book *Inorganic Chemistry* by Bailey and Snellgrove, fourth impression 1938.

> *"Some of the electrons are also contained in the nucleus, whilst the remainder are ..... arranged in rings revolving round the nucleus ..... The two isotopes [of chlorine] have therefore 18 and 20 electrons respectively in the nucleus and 17 [electrons] external to it."*

(a) Identify and correct **two** errors in the excerpt.

(2)

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(b) What is the structure of a 1+ ion of the carbon-13 isotope?

(1)

- ☒ **A** six protons, six neutrons and five electrons
- ☒ **B** six protons, seven neutrons and six electrons
- ☒ **C** six protons, seven neutrons and five electrons
- ☒ **D** seven protons, six neutrons and six electrons

(Total for question = 3 marks)

Q5.

This question is about sodium sulfide.

(a) Sulfur reacts with sodium to form the compound sodium sulfide, Na_2S.

(i) Draw a dot-and-cross diagram for sodium sulfide ; only the outer electrons need be shown. Include the charges present.

(2)

(ii) Which statement about the electrical conductivity of sodium sulfide is correct?

(1)

☒ **A** it conducts when solid and liquid

☒ **B** it conducts when solid but not when liquid

☒ **C** it conducts when liquid but not when solid

☒ **D** it does not conduct when solid or liquid

(iii) The melting temperature of sodium sulfide is higher than that of sodium chloride, even though both contain ionic bonding.
Explain this difference in melting temperature.

(2)

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(Total for question = 5 marks)

Q6.

Lithium reacts with water to produce hydrogen.

$$Li(s) + H_2O(l) \rightarrow LiOH(aq) + \tfrac{1}{2}H_2(g)$$

(a) In an experiment, 0.069 g (0.01 mol) of lithium produced 90 cm^3 of hydrogen at room temperature and pressure. What is the percentage yield of hydrogen?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(1)

- ☐ **A** 45%
- ☐ **B** 60%
- ☐ **C** 75%
- ☐ **D** 90%

(b) Which of the following is **not** a possible reason for the yield being less than 100%?

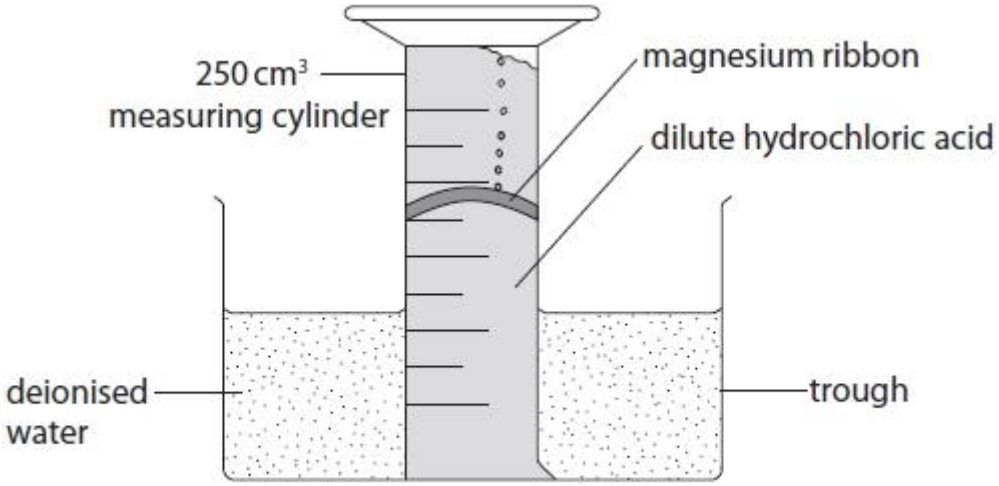
(1)

- ☐ **A** Some oil remained on the surface of the lithium.
- ☐ **B** Hydrogen gas is very soluble in water.
- ☐ **C** A layer of oxide was present on the surface of the lithium.
- ☐ **D** Some of the hydrogen gas escaped collection.

(Total for question = 2 marks)

Q7.

A student used the apparatus in the diagram to determine the molar volume of a gas.



Assume clamps are in place to secure the apparatus

The student used a piece of magnesium ribbon, which was about 5 cm in length, and the dilute hydrochloric acid was in excess. The experiment was repeated three times at 24°C and the following results were obtained.

	Experiment 1	Experiment 2	Experiment 3
Mass of magnesium / g	0.04	0.04	0.04
Volume of hydrogen gas / cm^3	31	25	32

The equation for the reaction is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) (i) Calculate the number of moles of magnesium used by the student in each experiment.

(1)

(ii) Use your answer from part (a)(i) to deduce the number of moles of hydrogen gas that should be produced.

(1)

(iii) Calculate, using the Ideal Gas Equation, $pV = nRT$, the volume of hydrogen gas, in **cm^3**, that should be produced in each of these experiments. In the equation V is in m^3. 1m^3 = 1,000,000cm^3
[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1} $p = 101\,000$ Pa]

(4)

(b) Give a reason why the student repeated the experiment three times.

(1)

.....

.....

(Total for question = 7 marks)

Q8.

Propane is a saturated hydrocarbon with molecular formula C_3H_8.

*(a) Explain the meaning of the terms **saturated** and **hydrocarbon**.

(2)

Saturated

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.....

Hydrocarbon

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(b) Propane is sold in small cylinders for use as a fuel in camping stoves. The enthalpy change of combustion of propane can be measured by experiment using one of these cylinders.

A known mass of propane is burned to heat a container of water, and the temperature rise of the water is measured.
The results of the experiment are shown below.

Mass of propane burned	0.33 g
Temperature of water at start	18.0 °C
Final temperature of water	45.1 °C
Mass of water in container	100 g

(i) How would the mass of propane which was burned be measured?

(1)

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(ii) Calculate the energy transferred in the experiment, using the results above and the following expression.
Energy transferred (J) = mass × specific heat capacity × temperature change
The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

(1)

(iii) Calculate the enthalpy change of combustion of propane, ΔH_c, in kJ mol^{-1}.
Give your answer to **three** significant figures and include a sign.

(3)

(iv) The results of this experiment are inaccurate due to heat loss.
Suggest **one** other source of error, other than measurement errors and limitations of the equipment.

(1)

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(Total for question = 8 marks)

Q9.

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

(a) Write the equation, including state symbols, which represents the reaction taking place when one mole of ethane is burnt completely in oxygen.

(2)

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

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

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

Rewrite this equation using displayed formulae.

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

(4)

(Total for question = 6 marks)

Q10.
Crude oil is a complex mixture of hydrocarbons. Initial separation is achieved by fractional distillation of the crude oil. The separate fractions are further refined to produce hydrocarbons such as decane, $C_{10}H_{22}$.

(a) Give the general formula of alkanes.

(1)

(b) Carbon monoxide, CO, is formed during the incomplete combustion of decane.

(i) Write an equation for the incomplete combustion of decane, forming carbon monoxide and water only.

(1)

(ii) Explain why incomplete combustion can occur.

(1)

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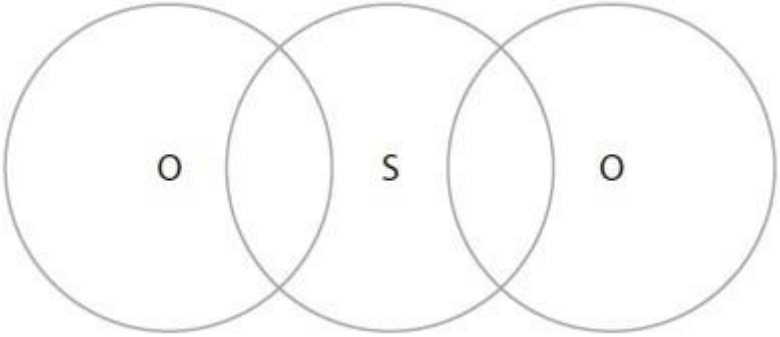
(c) 'Low-sulfur fuel' is now supplied to petrol stations. The removal of sulfur from diesel and petrol reduces the emission of toxic oxides of sulfur from vehicle exhausts. One such oxide is sulfur dioxide, SO_2.

The bonding in sulfur dioxide may be represented as shown below.

$$O = S \rightarrow O$$

Complete the dot and cross diagram below for the SO_2 molecule, showing only outer shell electrons. Use dots to represent the oxygen electrons and crosses to represent the sulfur electrons.

(3)

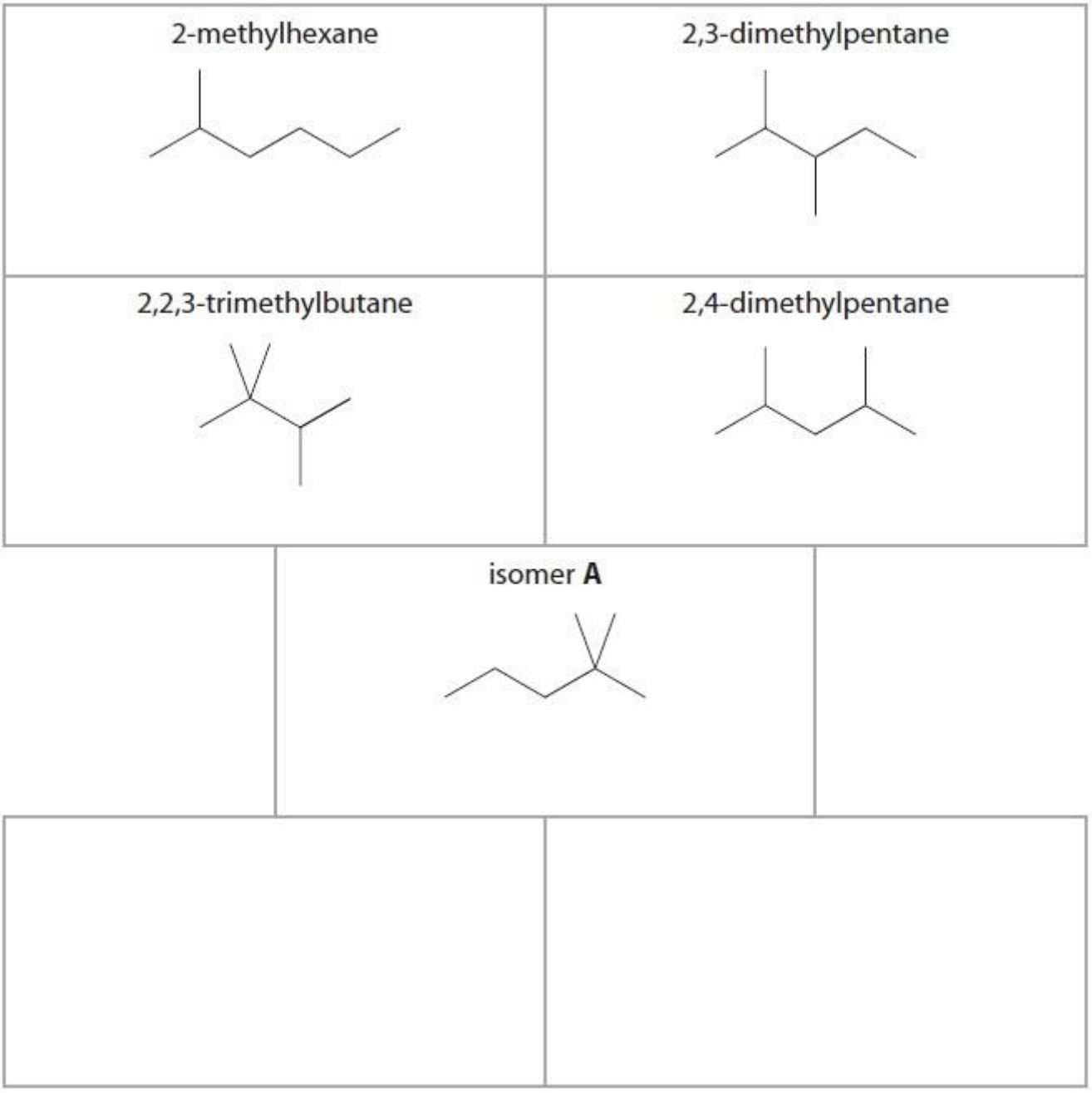


(d) Another alkane produced from crude oil is heptane, C_7H_{16}. The reforming of heptane produces methylcyclohexane and only one other product. A methylcyclohexane molecule is made from a ring of six carbon atoms bonded to a methyl group.

(i) Use the information given above to give the **structure** of methylcyclohexane.

(1)

(e) Five branched-chain isomers of heptane are shown in the boxes below.



(i) Give the systematic name of isomer **A**.

(1)

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(ii) In the empty boxes above, draw skeletal formulae for two other **branched-chain** isomers of C_7H_{16}, with no side-chain having more than one carbon atom.

(2)

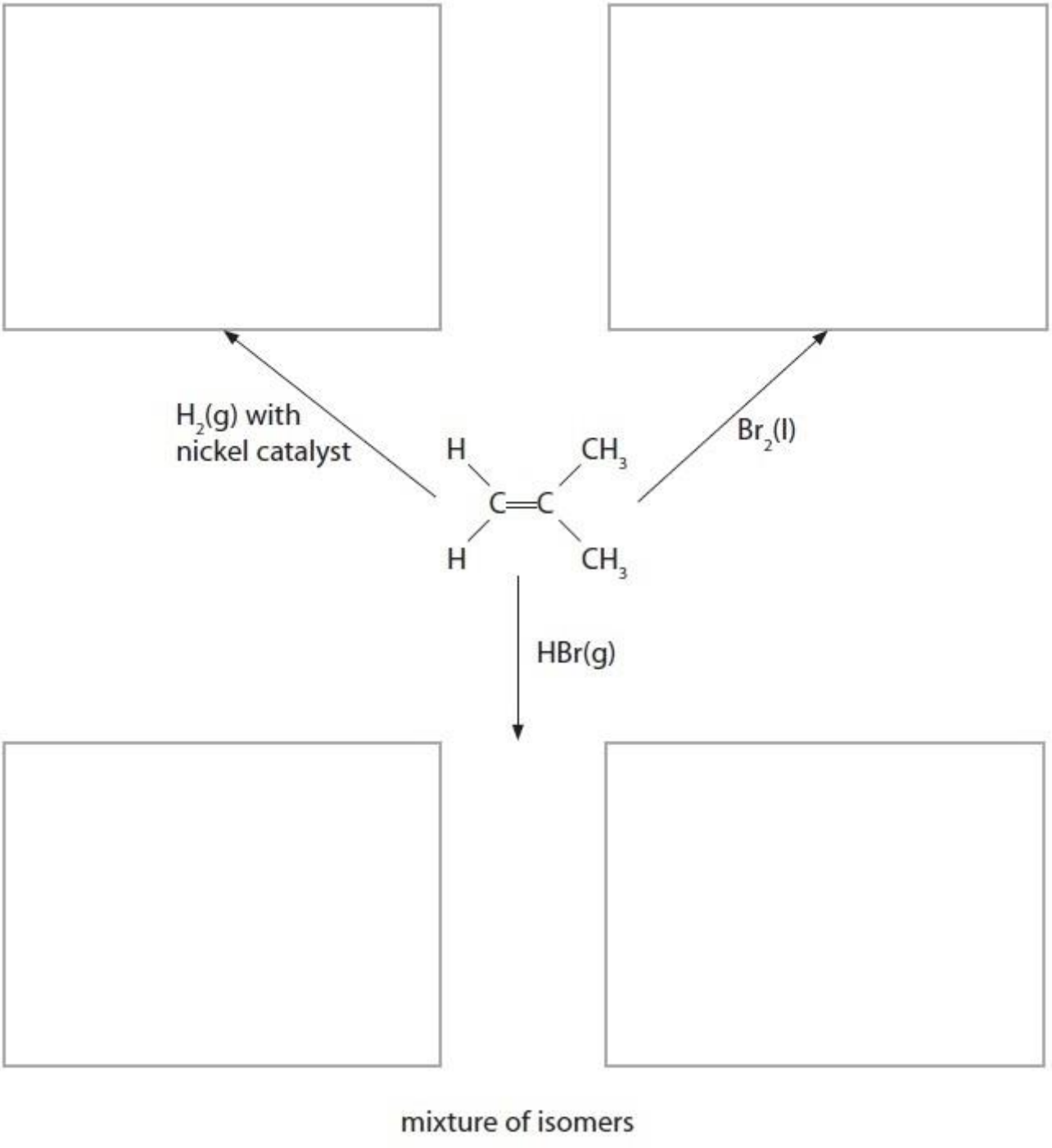
(Total for question = 10 marks)

Q11.

Alkenes are unsaturated hydrocarbons. They are used in the industrial production of many organic compounds.

(a) Add structural formulae to the flowchart below to show the organic product formed in each addition reaction of 2-methylpropene.

(4)



(c) Ethene, C_2H_4, was prepared from ethanol, C_2H_5OH, by the following reaction

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

A chemist reacted 9.2 g of ethanol, C_2H_5OH, and obtained 4.2 g of ethene.

Calculate the percentage yield of ethene in the reaction.

(2)

(Total for Question = 6 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

The Periodic Table of the Elements

Mark Scheme

Q1.

Question Number	Correct Answer	Mark
	D	**1**

Q2.

Question Number	Correct Answer	Reject	Mark
	D		1

Q3.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• 80.8(%)	Example of calculation: %=[252 ÷ (252 + 60)] x 100 = 80.769(%) Ignore sf except one Do not award 80.7(%)	**(1)**

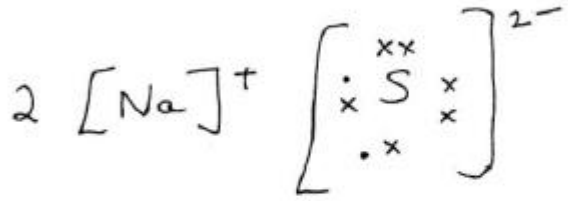
Q4.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	An answer that makes reference to any **two** of the following: • no electrons are found within the nucleus **(1)** • the isotopes of chlorine have 18 and 20 neutrons not electrons **(1)** • electrons are not in rings around the nucleus but in orbitals **(1)**	Answers can be given in either order. Check for answers alongside the written text if not given on the lines provided. Allow chlorine only has 17 electrons/ chlorine doesn't have 35/37 electrons Allow isotopes have different number of neutrons not electrons Allow isotopes have same number of electrons Allow regions / energy levels / shells / sub shells	**(2)**

Question Number	Answer	Mark
(b)	**C** (six protons, seven neutrons and five electrons)	**(1)**

Q5.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• $(1s^2 2s^2)\ 2p^6\ 3s^2 3p^4$	Allow numbers written as subscripts; $2p_x^2\ 2p_y^2\ 2p_z^2;\ 3p_x^2\ 3p_y^1\ 3p_z^1$	**1**

Question number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	• two Na^+ with empty outer shell, or 8e representing second shell (1) • S^{2-} with 6 crosses and 2 dots (or vv) (1)	 Allow all dots or all crosses Allow $[Na]^+ + [Na]^+$ Do not award $[Na]_2^+$ Allow for one mark, correct dot and cross diagrams (with two sodiums) and charges missing	**2**

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	**C** (It conducts when liquid but not when solid)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iii)	An answer that makes reference to the following points: • attractive force between sodium ion and anion is greater with sulfide (1) • (because) the sulfide ion has a higher charge than the chloride ion/has charge 2- while chloride is 1- (1)		**2**

Q6.

Question Number	Correct Answer	Reject	Mark
(a)	C		1

Question Number	Correct Answer	Reject	Mark
(b)	B		1

Q7.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	• calculation of moles of magnesium	Example of calculation: (n= 0.04 ÷ 24.3 =) 0.001646 (mol) Allow 0.04 ÷ 24 = 0.001667 (mol) Ignore significant figures except 1	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	• calculation of moles of hydrogen	Answer to (a)(i)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	• temperature changed to Kelvin **(1)** • rearrangement of equation so $V=nRT \div p$ and substituting the numbers **(1)** • calculation of V in m^3 / dm^3 **(1)** • answer converted in cm^3 and to a whole number **(1)**	Example of calculation: 24°C = 297 K $V= \frac{0.001646 \times 8.31 \times 297}{101000}$ $= 4.022 \times 10^{-5}$ (m^3) $= 4.022 \times 10^{-5} \times 10^{6} = 40$ cm^3	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	An answer that making reference to any of the following: • To identify anomalies **and** discard • To identify random errors **and** discard • Identify precise results **and** use them • Identify imprecise results **and** discard them	Allow To improve reliability/ reproducibility Ignore reference to confidence in the results Ignore 'make results more precise' Do not award "to improve accuracy"	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	An answer that makes reference to three of the following linked pairs: • **issue:** hydrogen escapes from the apparatus **(1)** • **improvement:** use a sealed apparatus with a gas syringe /use a conical flask / bung with a gas syringe **(1)** • **issue:** magnesium ribbon covered with oxide **(1)** • **improvement:** clean with abrasive before weighing **(1)** • **issue**: mass of magnesium may be less than 0.04 g (i.e. as low as 0.035 g) **or** mass of magnesium required is too small to be measured accurately by the balance available **(1)** • **improvement:** use more precise balance/ use larger mass (so percentage error is less) **(1)** • **issue:** large measuring cylinder cannot measure volume accurately (as the graduations are too far apart)	Maximum **three** marks for issues identified Maximum **three** marks for improvement identified which must be linked with associated issue identified or near-miss Do not award impurities in magnesium Allow measurement uncertainty for measurement accuracy	**(6)**

	(1) • **improvement:** use a smaller measuring cylinder/burette/ conical flask / bung with a gas syringe **(1)**	If more than three issues are given, then maximum 4 marks if incorrect chemistry is stated e.g. reference to 'not all the magnesium reacting' Ignore reference to: The solubility of hydrogen gas Changes in temperature Changes in acid concentration Air already in the apparatus Measuring the length of Mg	

Q8.

Question Number	Acceptable Answers	Reject	Mark
(a)	(Contains) **only** (C—C) single bonds/ **only** σ bond(s) OR (Contains) no (C=C) double bond(s)/no triple bond(s) OR Cannot undergo addition (reactions) ALLOW Has maximum number of hydrogen atoms / has maximum amount of hydrogen /can form no more bonds / no pi-bonds. IGNORE references to alkanes **(1)** (Compound of) carbon and hydrogen **ONLY/ENTIRELY/PURELY** **(1)**	"**Mixture** of carbon and hydrogen only"	2

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	Measure mass (of cylinder) before and after (burning)		1

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	Energy transferred = (100 x 4.18 x 27.1 =) 11327.8 (J) / 11.328 **kJ** Ignore SF except 1 SF		1

Question Number	Acceptable Answers	Reject	Mark
(b)(iii)	Mol propane = 0.33/ 44 = 0.0075 **(1)** ΔH_c = (– 11.3278/ 0.0075) = (– 1510.4) = –1510 (kJ mol^{-1}) **(1)** Sign and 3SF **(1)** Allow TE from b(ii)		3

Question Number	Acceptable Answers	Reject	Mark
(b)(iv)	Incomplete combustion Allow carbon monoxide forms soot forms Ignore references to specific heat capacity of the apparatus or evaporation **of propane**	Evaporation of water Transfer losses Not under standard conditions Not all the fuel burns	1

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	$C_3H_8(g) + \mathbf{5}O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ + 6490 kJ mol^{-1} $3C\mathbf{(g)} + 8H(g) + \mathbf{10}\ O\ (g)$ Balancing **and** state symbol required		1

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	Z = (6x C=O + 8xO-H = 4830 + 3712) = (+)8542 (kJ mol^{-1})		1

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	ΔH_x = 6490 - 8542 = -2052 (kJ mol^{-1}) Allow TE from 21(c)(ii)		1

Question Number	Acceptable Answers	Reject	Mark
(c)(iv)	Bond energy calculation based on $H_2O(g)$ OR $\Delta H_c^{\ominus}$ based on $H_2O(l)$ Allow Bond energy varies with environment/ mean bond energies do not equal actual bond energies for these reactants Ignore reference to standard conditions		1

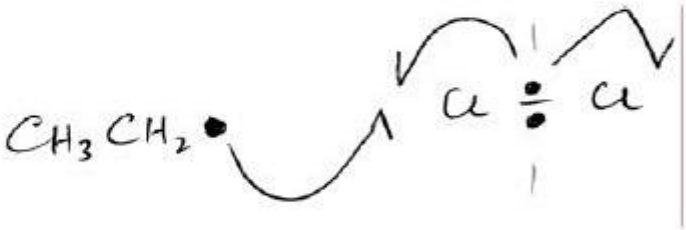
Q9.

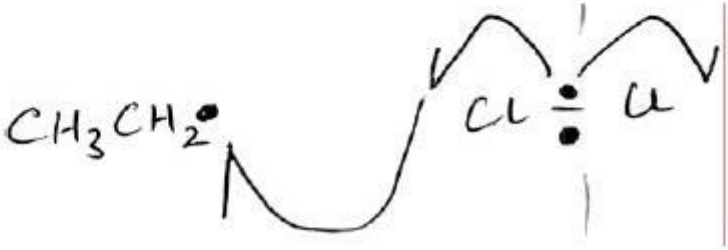
Question Number	Acceptable Answers	Reject	Mark
(a)	$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Formulae and states **(1)** Balancing of correct entities **(1)**	Multiples	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)	Notice the first mark is for the equation and there are 3 separate additional marks for the calculation H H H H | | | | H-C-C-H + Cl-Cl → H-C-C-Cl + H-Cl | | | | H H H H **(1)** Check all bonds displayed especially Cl-Cl and H-Cl **Calculation marks:** +413 + 243 **(1)** (−)(346 + 432) **(1)** OR 656 **(1)** (−) 778 **(1)** = −122 (kJ mol^{-1}) **(1)** Fully correct answer to calculation with no working **(3)** Extra 5x413 and 347 may be included on both sides, giving 3068 and (-)3190 Allow other same values(s) missing from both sides Bonds breaking **(1)** Bonds making **(1)** [Bonds breaking - bonds making] to give correct answer **with sign** **(1)**	Incorrect / no sign and / or incorrect units Incorrect units loses this mark	**4**

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	Initiation **(1)** Allow homolysis / atomization / homolytic (fission) Ignore any reference to free radical substitution UV / (sun)light **(1)** Ignore reference to high temperature	Free radical substitution alone Photolysis	**2**

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	$CH_3CH_2\bullet$ + Cl-Cl → CH_3CH_2Cl + Cl• OR $CH_3CH_2\bullet$ + Cl-Cl → C_2H_5Cl + Cl• Both products correct including dot (1) Two half headed arrows showing homolytic breaking of Cl-Cl bond **(1)** Half headed arrow from radical to pair with a Cl arrow OR One arrow from chlorine bond clearly to ethyl radical **(1)** Arrows must be single-headed		**3**





The two dots in the covalent bond do not have to be shown

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	$Cl\bullet + Cl\bullet \rightarrow Cl_2$ **(1)** $\bullet CH_2CH_3 + \bullet CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3$ / C_4H_{10} **(1)** $\bullet CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2Cl$ **(1)** Penalise missing dots once Allow $\bullet C_2H_5$ for $\bullet CH_2CH_3$ Di and tri substitution steps	C_4H_{12} $CH_3CH_2CH_3CH_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
(d)	$C_2H_6 \rightarrow C_2H_4 + H_2$ Allow **2**$C_2H_6 \rightarrow C_2H_4 +$ **2**CH_4		**1**

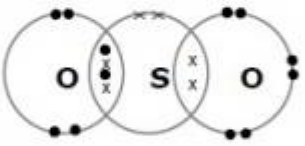
Question Number	Acceptable Answers	Reject	Mark
(e)	Any two from: (It) produces (more) petrol / gasoline / diesel / jet fuel / LPG / liquid petroleum gas / fuel **(1)** Short chain alkanes / lighter fractions are more useful products **(1)** Demand is greater for shorter chain alkanes / lighter fractions / smaller molecules OR converts surplus of low demand fractions **(1)** It produces ethane / short chain alkenes for making poly(ethene) / ethane-1,2-diol / ethanol / plastics / polymers **(1)** Smaller alkanes give less pollution/burn more efficiently **(1)** Recycles waste products **(1)** As a source of hydrogen **(1)** **NB** examiners need to look carefully at the vowel in the middle of alk**a**ne / alk**e**ne / eth**a**ne / eth**e**ne if not clear do not give BOD	Points based on atom economy / renewable fuels alone Easier to transport / store Short chain alkenes / ethene more useful alone Recycles alone	2

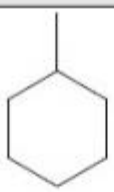
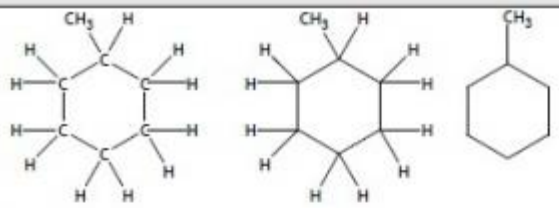
Q10.

Question Number	Acceptable Answers	Reject	Mark
(a)	C_nH_{2n+2} IGNORE 'where n=1, 2, 3 etc' or 'where n is greater than 1'		**1**

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	$C_{10}H_{22} + 10½O_2 \rightarrow 10CO + 11H_2O$ ALLOW 21 / 2 O_2 ALLOW any correct multiples IGNORE state symbols, even if incorrect	21 [O]	**1**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	Any statement that makes it clear there is not enough air or oxygen e.g. Limited supply of air / limited supply of oxygen / not enough air / not enough oxygen / lack of oxygen / little amount of oxygen/ small amount of oxygen IGNORE "it is not completely oxidized"		**1**

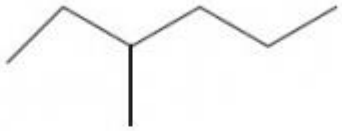
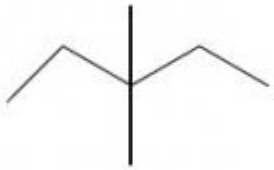
Question Number	Acceptable Answers	Reject	Mark
(c)	**First mark** Dative pair of e^- between S and right-hand O **(1)** **Second mark** Two bond pairs between S and left-hand O **(1)** **Third mark** Two lone pairs on left-hand O, one lone pair on central S and three lone pairs on right-hand O atom **(1)** If 2 double bonds between sulfur and each oxygen then the third mark can be given for two lone pairs on both oxygens and one lone pair on central S  NOTE ALLOW dots and crosses that have been reversed Lone pair electrons can be shown as separated (rather than having to be paired up) – **it is the total number of electrons in each outer shell that matters** Stand alone marks If molecule shown as charged then 2 max		**3**

Question Number	Acceptable Answers	Reject	Mark
(d)(i)		 benzene ring	**1**

Question Number	Acceptable Answers	Reject	Mark
(d)(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ALLOW $C_6H_{11}CH_3$ IGNORE state symbols, even if incorrect	Formulae other than molecular formulae Any other structural or displayed formulae	**1**

Question Number	Acceptable Answers	Reject	Mark
(d) (iii)	Any **ONE** of: (a cyclic alkane) has more efficient combustion allows smoother burning increases octane number reduces knocking / less likely to produce pre-ignition is a more efficient fuel burns better / easier to burn /combusts more easily / improves combustion IGNORE (a cyclic alkane): increases the volatility of a fuel "ignites more easily" "is a better fuel" "burns more cleanly" IGNORE (a cyclic alkane) has a lower boiling point mentions of viscosity safer fuel	Less pollution / reduce waste High atom economy Produces useful products / hydrogen Used to make polymers Produces substances in higher demand / more valuable	**1**

Question Number	Acceptable Answers	Reject	Mark
(e)(i)	2,2-dimethylpent**ane** IGNORE missing hyphen/missing comma	2-dimethylpentane	**1**

Question Number	Acceptable Answers	Reject	Mark
(e)(ii)	 **(1)**  **(1)** IGNORE names even if incorrect IGNORE different length bonds IGNORE direction of methyl groups		**2**

Question Number	Acceptable Answers	Reject	Mark
(f)(i)	U.V. / U.V.light / light / sunlight ALLOW high temperature	 heat alone	**1**

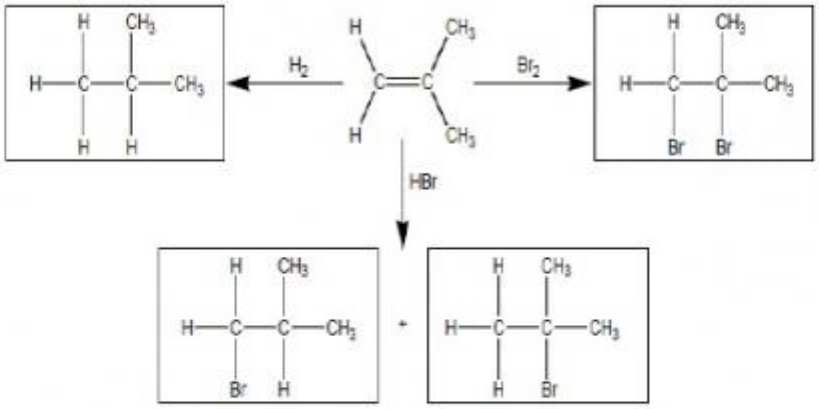
Question Number	Acceptable Answers	Reject	Mark
(f)(ii)	$Cl_2 \rightarrow Cl^{\cdot} + Cl^{\cdot}$ / $Cl_2 \rightarrow 2Cl^{\cdot}$ IGNORE any curly arrows, even if incorrect IGNORE C_4H_{10} given on both sides		**1**

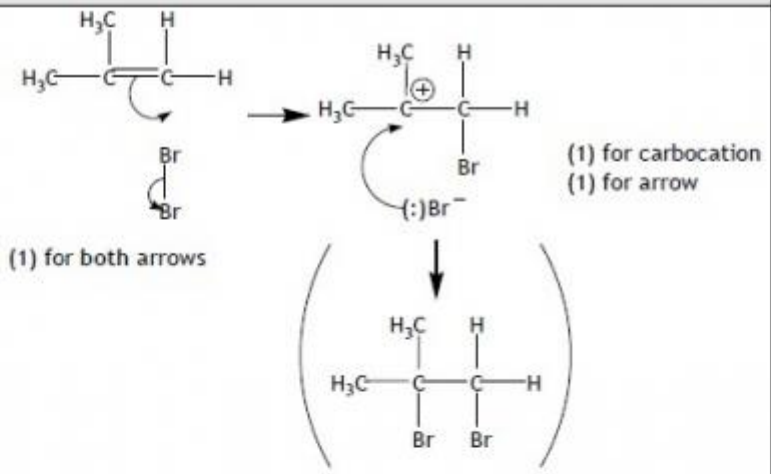
Question Number	Acceptable Answers	Reject	Mark
(f)(iii)	Homolytic (fission) IGNORE any formulae and arrows	Photolysis (fission) / free radical (fission)	**1**

Question Number	Acceptable Answers	Reject	Mark
(f)(iv)	**(First propagation step)** $C_4H_{10} + Cl^{\cdot} \rightarrow C_4H_9^{\cdot} + HCl$ **(1)** **(Second propagation step)** $C_4H_9^{\cdot} + Cl_2 \rightarrow C_4H_9Cl + Cl^{\cdot}$ **(1)** Formulae can be displayed 'dots' can be anywhere on free radical but no dots at all scores zero ALLOW in either order Incorrect alkane / halogenoalkane but two correct propagation steps scores 1 out of 2	Any reactions involving Hydrogen radicals scores zero Reverse of first reaction	**2**

Question Number	Acceptable Answers	Reject	Mark
(f)(v)	Any **ONE** of: $C_4H_9^{\cdot} + Cl^{\cdot} \rightarrow C_4H_9Cl$ OR $Cl^{\cdot} + Cl^{\cdot} \rightarrow Cl_2$ OR $C_4H_9^{\cdot} + C_4H_9^{\cdot} \rightarrow C_8H_{18}$		**1**

Q11.

Question Number	Acceptable Answers	Reject	Mark
(a)	 **(1)** for each correct product ALLOW correct displayed / skeletal / semi-skeletal / structural / semi-structural formula in each case ALLOW any order of symbols after or before each carbon ALLOW brackets or no brackets around Br/ CH_3 for example $CH_2BrCH_3CBrCH_3$		**4**

Question Number	Acceptable Answers	Reject	Mark
(b)			**3**
	First mark **Double-headed** arrow from alkene must start from somewhere on C=C bond Partial charge on Br_2 molecule must be correct if shown	Single-headed arrow	
	Second mark is for either correct primary or secondary carbocation and is a standalone mark		
	Third mark **Double-headed** arrow from bromide ion can start from the minus sign, a lone pair on Br^-, or from the Br and can go to the C or the + sign on the intermediate The **negative charge** must be present on the **bromide ion** The final product, if shown, must be correct to gain third mark Mechanisms with other electrophiles (e.g. HBr, BrOH) can score 2nd and 3rd marks	Bromine / bromide free radicals Single-headed arrow (Penalise again)	

Question Number	Acceptable Answers	Reject	Mark
(c)	**First mark is for calculating the theoretical maximum mass of ethene from 9.2 g ethanol:-** (46 g C_2H_5OH gives 28 g C_2H_4 so 9.2 g C_2H_5OH gives maximum mass of) **5.6 g** C_2H_4 **(1)** **Second mark is for calculating the percentage yield from candidate's theoretical maximum mass:-** (4.2/5.6 x 100% =) **75** (%) IGNORE s.f. except 1 s.f. OR **First mark** Amount of ethene = 4.2/28 = 0.15 (mol) and amount of ethanol = 9.2/46 = 0.20 (mol) **(1)** **Second mark** % yield = 0.15/0.20 = 75 % **(1)** **NOTE** Correct answer with no working scores **(2)** % yield TE on candidate's theoretical mass / moles only if % yield ‹100% If molar masses are reversed, award one mark for 27.8%	**(0)** for $\frac{4.2}{9.2}$ x 100%	**2**