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Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference **WCH11/01**

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 1: Structure, Bonding and Introduction to Organic Chemistry

You must have:
Scientific calculator

January 2022

Total Marks

Instructions

- Use **black** ink or **black** 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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Element **X** is in Group 2 of the Periodic Table and element **Y** is in Group 7. **X** and **Y** are not the symbols of the elements.

(a) What is the formula of the compound formed from **X** and **Y**?

(1)

- ☒ **A** **XY**
- ☒ **B** $\mathbf{X_2Y}$
- ☒ **C** $\mathbf{XY_2}$
- ☒ **D** $\mathbf{X_2Y_2}$

(b) Under what conditions does the compound formed from **X** and **Y** conduct electricity?

(1)

- ☒ **A** in the solid state and in the liquid state and in aqueous solution
- ☒ **B** in the solid state and in aqueous solution only
- ☒ **C** in the solid state and in the liquid state only
- ☒ **D** in the liquid state and in aqueous solution only

(Total for Question 1 = 2 marks)

2 Which of these compounds would you expect to have the highest melting temperature?

- ☒ **A** NaCl
- ☒ **B** NaF
- ☒ **C** KCl
- ☒ **D** KF

(Total for Question 2 = 1 mark)

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3 A drop of an aqueous solution of green copper(II) chromate(VI) is placed in the centre of a strip of damp filter paper.
The ends of the filter paper are connected to a DC power supply.

What is observed after a few minutes?

- ☒ **A** a green colour has moved to the negative end
- ☒ **B** a green colour has moved to the positive end
- ☒ **C** a yellow colour has moved to the positive end and a blue colour to the negative end
- ☒ **D** a blue colour has moved to the positive end and a yellow colour to the negative end

(Total for Question 3 = 1 mark)

4 Which of these isoelectronic ions has the smallest ionic radius?

- ☒ **A** N^{3-}
- ☒ **B** F^{-}
- ☒ **C** Na^{+}
- ☒ **D** Al^{3+}

(Total for Question 4 = 1 mark)

5 Which properties of a **cation** result in the greatest polarising power?

- ☒ **A** large radius and large charge
- ☒ **B** large radius and small charge
- ☒ **C** small radius and small charge
- ☒ **D** small radius and large charge

(Total for Question 5 = 1 mark)

6 Which properties of an **anion** result in it being most easily polarised?

- ☒ **A** large radius and large charge
- ☒ **B** large radius and small charge
- ☒ **C** small radius and small charge
- ☒ **D** small radius and large charge

(Total for Question 6 = 1 mark)

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7 What is the ionic equation for the reaction between aqueous solutions of barium nitrate and sodium sulfate?

- ☒ **A** $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(s)$
- ☒ **B** $2Ba^+(aq) + SO_4^{2-}(aq) \rightarrow Ba_2SO_4(s)$
- ☒ **C** $Na^{2+}(aq) + 2NO_3^-(aq) \rightarrow Na(NO_3)_2(s)$
- ☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 7 = 1 mark)

8 Which of these molecules is **not** polar?

- ☒ **A** CO_2
- ☒ **B** HCl
- ☒ **C** H_2O
- ☒ **D** NH_3

(Total for Question 8 = 1 mark)

9 The concentration of nitrogen dioxide in a sample of air is 0.5 ppm.

What is the percentage of nitrogen dioxide molecules in this sample of air?

- ☒ **A** 0.5 %
- ☒ **B** 0.005 %
- ☒ **C** 0.00005 %
- ☒ **D** 0.0000005 %

(Total for Question 9 = 1 mark)

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10 Ethane reacts with bromine in the presence of ultraviolet radiation.

(a) What is the equation for the reaction?

(1)

☒ **A** $C_2H_6 + Br_2 \rightarrow C_2H_4Br_2 + H_2$

☒ **B** $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

☒ **C** $C_2H_6 + Br_2 \rightarrow 2CH_3Br$

☒ **D** $C_2H_6 + Br_2 \rightarrow CH_4 + CH_2Br_2$

(b) The ultraviolet radiation is needed for

(1)

☒ **A** homolytic breaking of a Br—Br bond

☒ **B** heterolytic breaking of a Br—Br bond

☒ **C** homolytic breaking of a C—H bond

☒ **D** heterolytic breaking of a C—H bond

(Total for Question 10 = 2 marks)

11 All alkanes have the same

☒ **A** empirical formula

☒ **B** general formula

☒ **C** molecular formula

☒ **D** structural formula

(Total for Question 11 = 1 mark)

12 A single molecule of decane, $C_{10}H_{22}$, is cracked.

Which of these mixtures could **not** be formed?

☒ **A** pentene and pentane

☒ **B** ethene, butene and butane

☒ **C** propene, propane and butene

☒ **D** hexene and propane

(Total for Question 12 = 1 mark)

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13 How many structural isomers have the formula $C_3H_6Cl_2$?

- ☒ **A** 2
- ☒ **B** 3
- ☒ **C** 4
- ☒ **D** 5

(Total for Question 13 = 1 mark)

14 The equation for the complete combustion of hexane is shown.

$$C_6H_{14} + 9\frac{1}{2}O_2 \rightarrow 6CO_2 + 7H_2O$$

How many molecules of carbon dioxide are formed when 2×10^{-3} mol of hexane undergoes complete combustion?

[Avogadro constant $L = 6.02 \times 10^{23}$ mol^{-1}]

- ☒ **A** 1.20×10^{21}
- ☒ **B** 7.22×10^{21}
- ☒ **C** 8.43×10^{21}
- ☒ **D** 3.18×10^{23}

(Total for Question 14 = 1 mark)

15 Which pollutant **cannot** form when alkane fuels are burned in car engines?

- ☒ **A** hydrogen chloride
- ☒ **B** sulfur dioxide
- ☒ **C** carbon particulates
- ☒ **D** carbon monoxide

(Total for Question 15 = 1 mark)

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16 Iron(III) oxide is reduced by hydrogen in a two-step process.

Step 1: $3Fe_2O_3 + H_2 \rightarrow 2Fe_3O_4 + H_2O$

Step 2: $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$

What is the maximum mass of iron that could be produced from 39.9 tonnes of Fe_2O_3?

[A_r values: H = 1.0 O = 16.0 Fe = 55.8]

- ☒ **A** 6.98 tonnes
- ☒ **B** 13.95 tonnes
- ☒ **C** 27.90 tonnes
- ☒ **D** 41.85 tonnes

(Total for Question 16 = 1 mark)

17 Which of these solutions contains the greatest number of ions?

- ☒ **A** 20.0 cm^3 of 0.5 mol dm^{-3} KCl
- ☒ **B** 0.40 dm^3 of 0.03 mol dm^{-3} KCl
- ☒ **C** 10.0 cm^3 of 0.6 mol dm^{-3} $CaCl_2$
- ☒ **D** 0.15 dm^3 of 0.04 mol dm^{-3} $CaCl_2$

(Total for Question 17 = 1 mark)

18 Potassium chlorate(V) decomposes on heating to form oxygen.

$2KClO_3 \rightarrow 2KCl + 3O_2$

What is the atom economy (by mass) for the formation of oxygen?

[A_r values: O = 16.0 Cl = 35.5 K = 39.1]

- ☒ **A** 13.1 %
- ☒ **B** 26.1 %
- ☒ **C** 39.2 %
- ☒ **D** 64.3 %

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

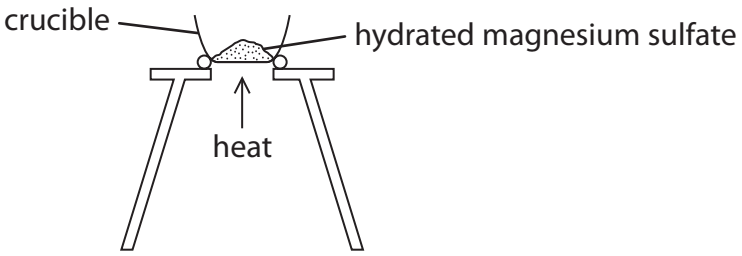
19 This question is about the amount of water of crystallisation in hydrated magnesium sulfate, $MgSO_4 \cdot \mathbf{x}\, H_2O$.

(a) The value of **x** in the formula was determined in an experiment.

Procedure

Step **1** A crucible was weighed, a spatula measure of hydrated magnesium sulfate was added and the crucible was reweighed.

Step **2** The crucible containing the hydrated magnesium sulfate was heated using the apparatus shown.



Step **3** After heating for two minutes, the crucible containing the magnesium sulfate was allowed to cool and was reweighed.

(i) Complete the table of results.

(1)

Measurement	Mass / g
Mass of empty crucible	21.21
Mass of crucible and hydrated magnesium sulfate before heating	26.71
Mass of crucible and magnesium sulfate after heating for two minutes	24.12
Mass of magnesium sulfate after heating for two minutes	
Mass of water lost	

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(ii) Use these results to calculate the value of **x** in $MgSO_4 \cdot \mathbf{x} H_2O$.
Give your answer to the nearest whole number.

[A_r values: H = 1.0 O = 16.0 Mg = 24.3 S = 32.1]

(4)

(b) The correct value of **x** is greater than the value calculated in (a) (ii).

Suggest a way of improving the method to obtain a more accurate result, using the same apparatus.
Justify your answer.

(2)

(Total for Question 19 = 7 marks)

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20 This question is about copper and its compounds.

(a) Complete the electronic configurations of Cu and Cu^{2+}.

(2)

Cu [Ar] .....

Cu^{2+} [Ar] .....

(b) A sample of copper contains the isotopes ^{63}Cu and ^{65}Cu.

(i) Complete the table to show the numbers of subatomic particles in the atoms of these two isotopes of copper.

(2)

Isotope	Protons	Neutrons	Electrons
^{63}Cu			
^{65}Cu			

(ii) Explain the term isotopes, using the information in the table.

(2)

.....

.....

.....

.....

.....

(iii) State why the two isotopes of copper have the same chemical reactions.

(1)

.....

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(iv) The relative atomic mass of copper in this sample is 63.4.

Calculate the percentage abundances of the isotopes ^{63}Cu and ^{65}Cu in this sample.
You **must** show your working.

(2)

(c) Copper(II) sulfate, $CuSO_4$, can be made by reacting solid copper(II) carbonate with dilute sulfuric acid.

(i) Write an equation for the reaction that occurs.
State symbols are not required.

(1)

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(ii) An experiment was carried out to produce pure, dry crystals of hydrated copper(II) sulfate, $CuSO_4 \cdot 5H_2O$.
Copper(II) carbonate was mixed with 50.0 cm^3 of 1.00 mol dm^{-3} sulfuric acid until no more reacted.
The mass of $CuSO_4 \cdot 5H_2O$ obtained was 10.87 g.

Calculate the percentage yield for this reaction, giving your answer to an appropriate number of significant figures.

[Molar mass of $CuSO_4 \cdot 5H_2O$ = 249.6 g mol^{-1}]

(4)

(Total for Question 20 = 14 marks)

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21 This question is about alkenes.

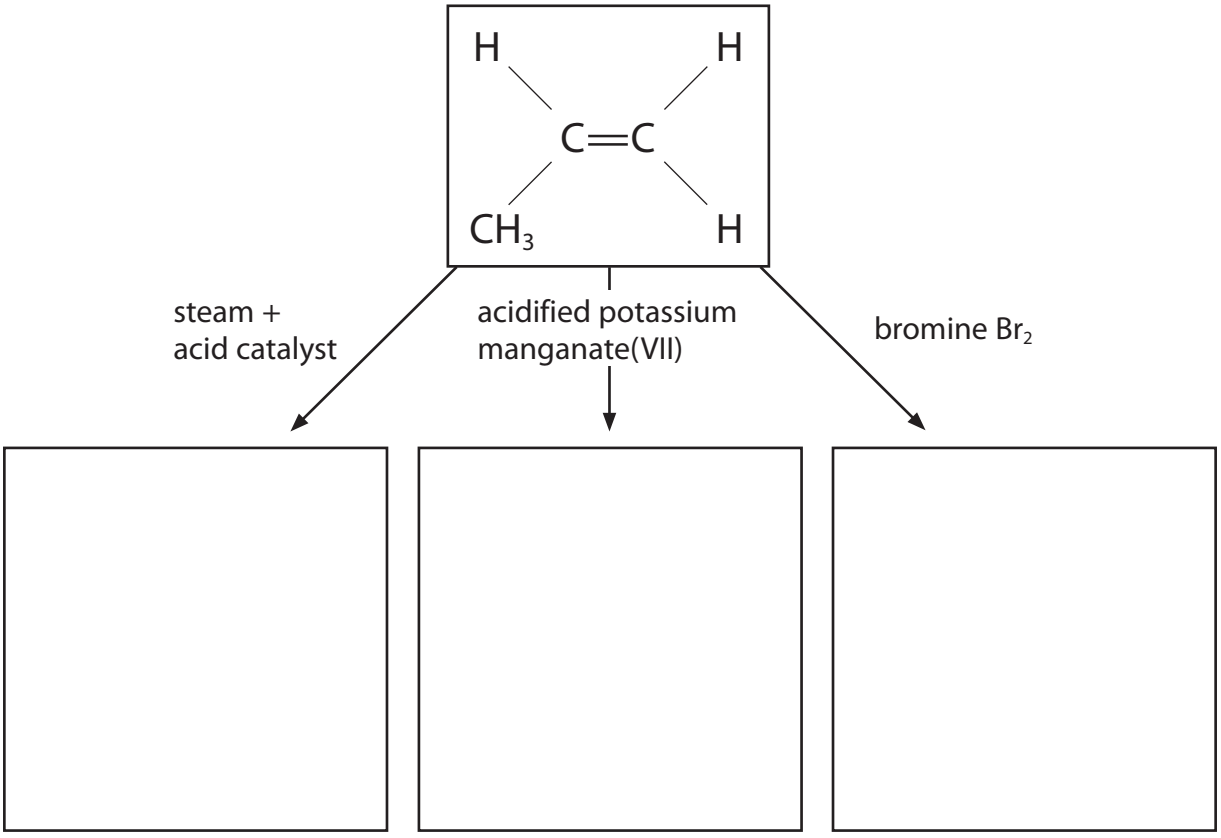
Alkenes contain a carbon to carbon double bond that consists of a σ bond and a π bond.

(a) Complete the diagram to show the areas of electron density for each bond. Label the σ bond and the π bond.

(2)

C C

(b) Propene, C_3H_6, is an alkene. The reagents needed for three reactions of propene are shown.



(i) In each box, draw the structure of the organic product of the reaction.

(3)

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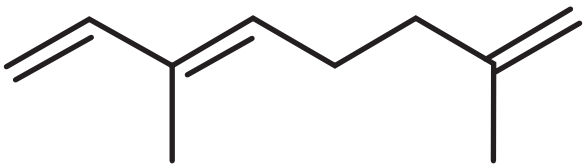
(ii) Propene also reacts with hydrogen bromide, HBr.

Give the mechanism for this reaction to form the **major** product.
Include curly arrows, and relevant lone pairs and dipoles.

(3)

(c) Alpha-ocimene contains three carbon to carbon double bonds. It is found in plants and has a sweet smell. The skeletal formula of alpha-ocimene is shown.



(i) Give the molecular formula of alpha-ocimene.

(1)

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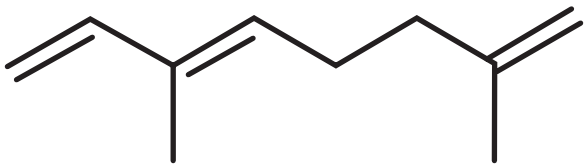
(ii) On the skeletal formula, draw a circle around the part of the molecule that gives rise to the geometric isomerism of alpha-ocimene.

(1)



(iii) Draw the **skeletal** formula of the other geometric isomer of alpha-ocimene.

(1)

(iv) In an experiment, 0.050 mol of alpha-ocimene reacted with 3.6 dm^3 of hydrogen, H_2, in the presence of a catalyst.

Deduce the structure of the product of this reaction.
You **must** show your working.

[Molar volume of H_2 = 24 $dm^3\,mol^{-1}$]

(3)

Calculation

Structure

(Total for Question 21 = 14 marks)

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22 This question is about the bonding in the elements of Period 3 in the Periodic Table.

The melting temperatures of the Period 3 elements are shown in the table.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Melting temperature / °C	98	650	660	1423	44	120	–101	–189

(a) Sodium, magnesium and aluminium are metals.

(i) State what is meant by metallic bonding.

(1)

(ii) Melting temperature depends on the strength of metallic bonding.

Explain why the metallic bonding in magnesium is much stronger than that in sodium.

(3)

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(b) (i) In the elements silicon, phosphorus, sulfur and chlorine, the atoms are joined by covalent bonds.

Describe the attraction between the atoms in a covalent bond.

(1)

(ii) Explain why the melting temperature of silicon is much higher than that of phosphorus, by referring to their structures.

(3)

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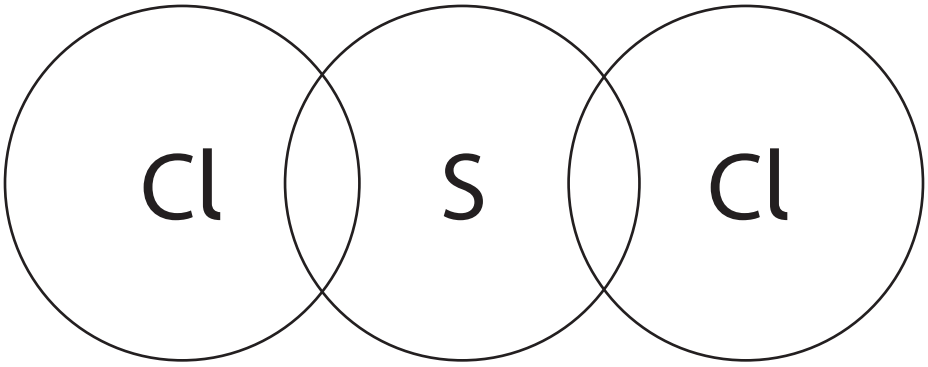
(c) Sulfur reacts with chlorine to form sulfur dichloride, SCl_2.

(i) Complete the dot-and-cross diagram of a molecule of sulfur dichloride.
Use dots (•) for the chlorine electrons and crosses (×) for the sulfur electrons.
Show the outer shell electrons only.

(2)



(ii) Suggest a value for the Cl—S—Cl bond angle. Justify your answer.

(3)

(Total for Question 22 = 13 marks)

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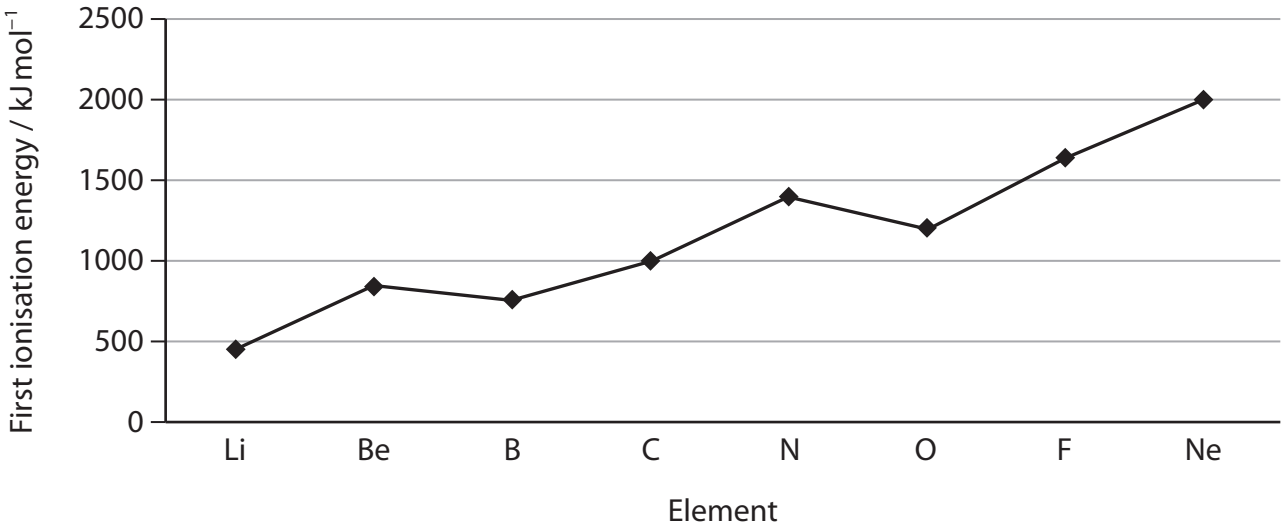
23 This question is about the ionisation energies of the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of the Period 2 elements are shown.



(i) Give an equation that represents the first ionisation energy of lithium. Include state symbols.

(1)

(ii) Explain why there is a general increase in the first ionisation energy across the period.

(2)

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(iii) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

(2)

(b) All the successive ionisation energies of nitrogen are shown in the table.

Ionisation number	1	2	3	4	5	6	7
Ionisation energy / kJ mol^{-1}	1402	2856	4578	7475	9445	53 267	64 360

Explain the trend in the successive ionisation energies of nitrogen.

(2)

(Total for Question 23 = 7 marks)

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24 A 0.210 g sample of a volatile organic liquid **C** is injected into a gas syringe and heated in an oven.
At 100 kPa and 358 K, the syringe contains 72.5 cm^3 of gas.

(a) Calculate the molar mass of **C**.

[$pV = nRT$ $R = 8.31\ J\ mol^{-1}\ K^{-1}$]

(4)

(b) The organic liquid **C** is a hydrocarbon.

Give a possible name or formula for **C**, using your answer in (a).

(1)

(Total for Question 24 = 5 marks)

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

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		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 damstadtium 110	[272] Rg roentgenium 111							

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

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
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

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