O

CONVENT OF THE HOLY INFANT JESUS SECONDARY
Preliminary Examination in preparation for
the General Certificate of Education Ordinary Level 2025

CANDIDATE NAME			
CLASS		REGISTER NUMBER	

CHEMISTRY 6092/02

Paper 2 **28 August 2025**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** questions.

1 Fig. 1.1 shows some elements in the Periodic Table.

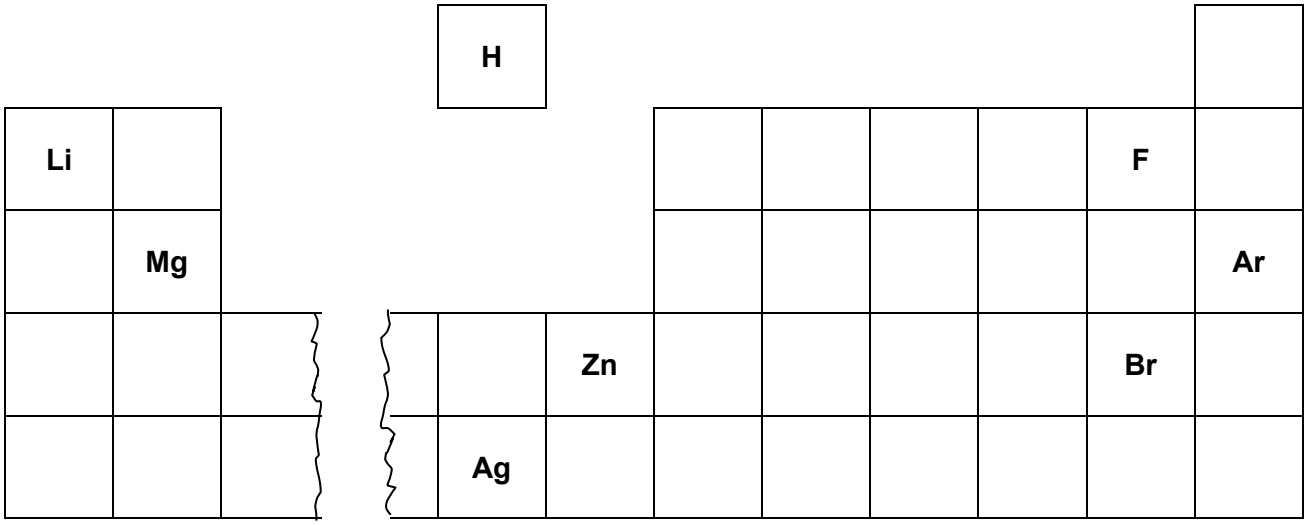


Fig. 1.1

Use the symbols from the table to identify the following elements. Each element may be used once, more than once or not at all.

(a) This element forms an amphoteric oxide.

……..…….….. [1]

(b) This element has a melting point below room temperature but a boiling point above room temperature.

……..…….….. [1]

(c) This is the **least** reactive element in its group.

……..…….….. [1]

(d) This element is used to provide an inert environment in industrial reactions.

……..…….….. [1]

(e) This element forms coloured compounds.

……..…….….. [1]

[Total: 5]

2 Chromatography can be used to separate and identify components of a mixture. Synthetic dyes are examples of mixtures that can be separated using paper chromatography.

A student wanted to find out whether a sample of black dye is pure. She carried out the following procedure:

Step 1: A start line was drawn using a pencil, on a sheet of chromatography paper.

Step 2: She placed spots of known dyes, **A**, **B**, **C**, **D** and **E** and the black dye on the start line.

Step 3: The chromatography was allowed to run using ethanol as a solvent.

Fig. 2.1 shows the results of the experiment.

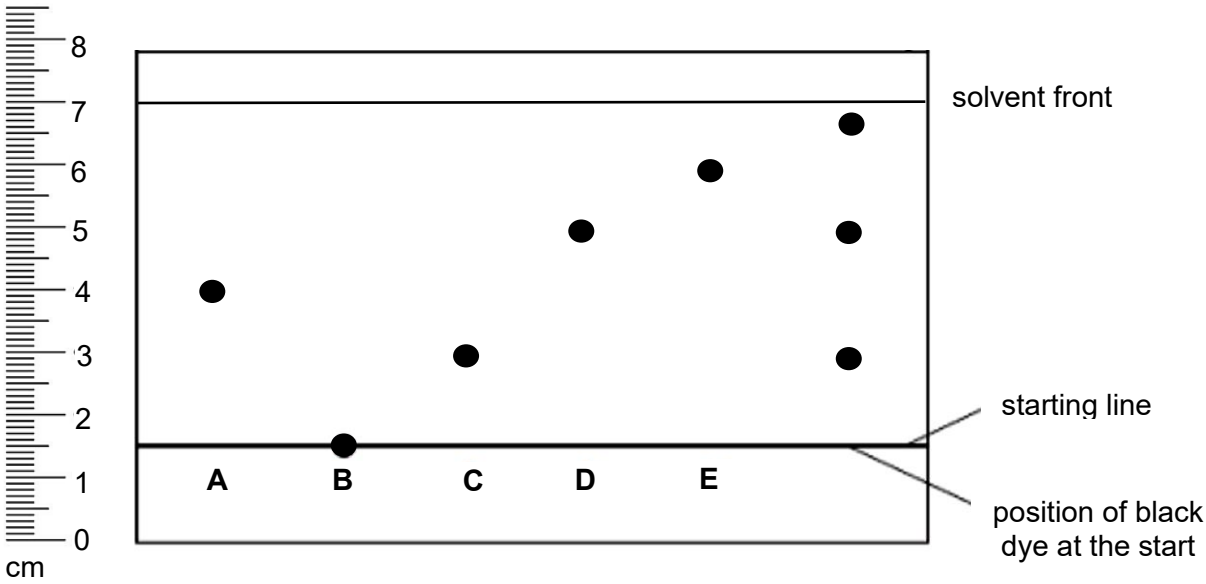


Fig. 2.1

(a) Using the results of the chromatography in Fig. 2.1, explain whether the sample of black dye is pure.

……..

…….. [1]

(b) Suggest another method that the student can use to determine whether the sample of black dye is pure. State the expected observations clearly.

……..

…….. [2]

(c) Explain why dye **B** remains on the starting line at the end of the experiment.

…….. [1]

(d) In chromatography, R_f values can be used to identify substances.

The R_f value of an industrial dye, safranin, in ethanol is 0.45.

Using the results from Fig 2.1, suggest which of the dyes, **A**, **B**, **C**, **D**, or **E** could be safranin.

Show your working clearly.

dye .....

working

[2]

[Total: 6]

3 Table 3.1 shows information about some gases in the atmosphere of the planets Mars and Earth.

Table 3.1

gas	density of pure gas at room temperature and pressure in g/dm^3	percentage composition of atmosphere on Mars (%)	percentage composition of atmosphere on Earth (%)
argon	1.67	1.9	<1
carbon dioxide	1.83	95.1	0.04
nitrogen	1.17	2.6	
oxygen		0.2	
other gases	–	<1	<1

(a) Complete the last column of Table 3.1. [1]

(b) Calculate the density of pure oxygen at room temperature and pressure in g/dm^3.

density of oxygen …… g/dm^3 [1]

(c) In Table 3.1, the term 'other gases' includes nitrogen oxides (NO_x). NO and NO_2 are examples of nitrogen oxides.

(i) Scientists have found much more nitrogen oxides in the atmosphere of Earth than on Mars.

Use the information in Table 3.1 and your knowledge about how nitrogen oxides are formed to suggest why this is so.

……..……...……....

……..……...……....

……..……...……....

……..……... [2]

(ii) The breakdown of ozone, O_3, is typically a slow process.

Nitrogen oxides such as nitrogen monoxide, NO, in the upper atmosphere can cause damage to the ozone layer by rapidly reacting with ozone in a two-step reaction.

Step 1 $NO + O_3 \rightarrow NO_2 + O_2$

Step 2 $NO_2 + O_3 \rightarrow NO + 2O_2$

Use the equations to explain how nitrogen monoxide acts as a catalyst for the breakdown of ozone.

……..……...…….....

……..……...…….....

……..……...…….... [2]

(d) Scientists predicted the surface temperature on Mars by calculating its distance from the Sun. The measured surface temperature is higher than the predicted value.

Use the information in Table 3.1 to suggest a reason why the measured surface temperature of Mars is higher than its predicted temperature.

……..……..

……..…… [1]

[Total: 7]

4 Fig. 4.1 shows an electrolysis experiment made up of two cells.

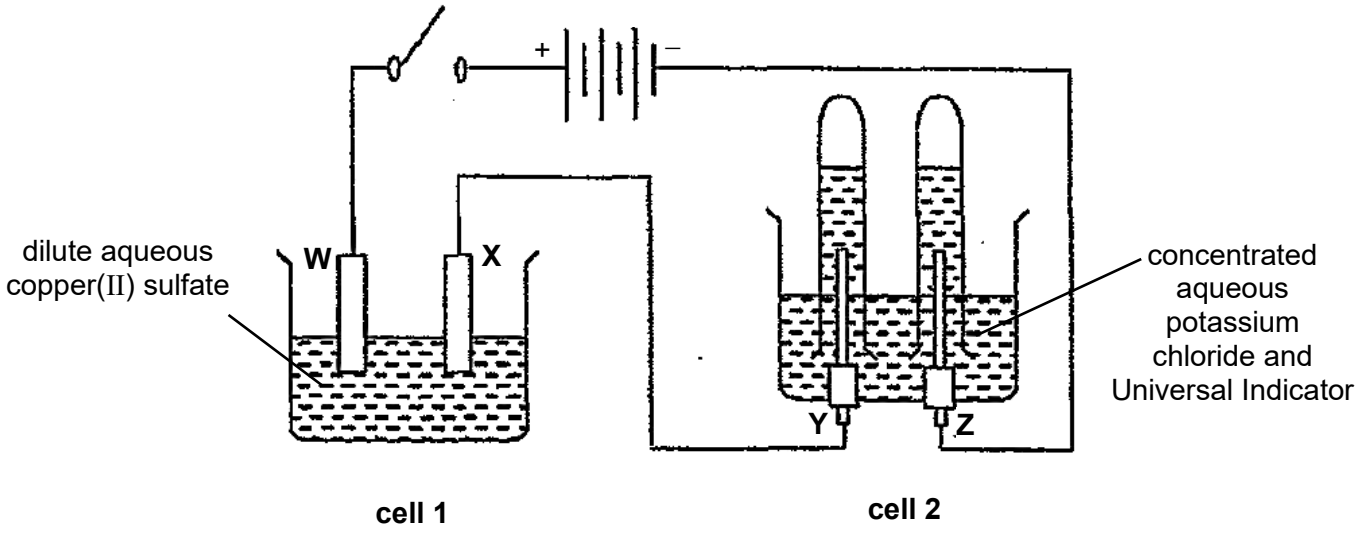


Fig. 4.1

Electrodes **W**, **X**, **Y** and **Z** are made of graphite.

(a) (i) Give the half-equations for the reactions at electrodes **Y** and **Z** in **cell 2**.

electrode **Y**: …….. [1]

electrode **Z**: …….. [1]

(ii) Describe and explain the colour change of the Universal Indicator in **cell 2** during the electrolysis.

……..……...……..…….....

……..……...……..…….....

……..……...……..…….....

……..……...……..…….... [2]

(b) Electrodes **W** and **X** are replaced with copper electrodes.

Give **one** similarity and **one** difference in the observations in **cell 1** when copper electrodes are used as compared to when graphite electrodes are used. Explain your reasoning.

……

……

……

……

……

……

……

…… [4]

[Total: 8]

5 The apparatus shown in Fig. 5.1 is used to investigate the reduction of a metal oxide by hydrogen.

Hydrogen gas is passed over the heated metal oxide in a boiling tube.

The unreacted hydrogen gas is burnt as it leaves the tube.

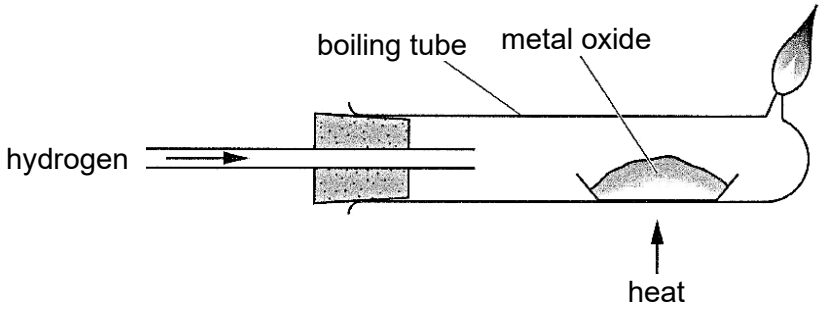


Fig. 5.1

(a) An oxide of iron is reduced by hydrogen gas using the apparatus shown in Fig. 5.1.

Table 5.1 shows the mass change when the oxide of iron is reduced.

Table 5.1

initial mass of oxide of iron / g	6.00
final mass of iron / g	4.20

Deduce the empirical formula of the oxide of iron. Show your working.

empirical formula ……

[3]

(b) The experiment is carried out with lead(II) oxide, magnesium oxide and copper(II) oxide.

(i) Complete Table 5.2 to show the observations when hydrogen gas is passed over heated magnesium oxide and heated copper(II) oxide.

Table 5.2

metal oxide	observations when hydrogen gas is passed over heated metal oxide
lead(II) oxide	yellow solid turns grey
magnesium oxide	
copper(II) oxide	

[2]

(ii) Which metal oxide, magnesium oxide, lead(II) oxide, or copper(II) oxide, takes the shortest time for complete reduction? Explain your answer.

metal oxide ……...…….

explanation ……...…….

……..……..…….....

……..……..……... [3]

[Total: 8]

6 Amines are a homologous series of organic compounds containing nitrogen atoms.

Table 6.1 shows the names, formulae and melting and boiling points of some amines.

Table 6.1

name of amine	formula	melting point/°C	boiling point/°C
methylamine	CH_3NH_2	–93	–6.3
ethylamine	$C_2H_5NH_2$	–81	16.6
propylamine	$C_3H_7NH_2$	–70	48.6
butylamine	$C_4H_9NH_2$	–49	78.0

(a) Use the information in the table to give **two** pieces of evidence that suggest that the amines are a homologous series.

……..……..

……..……..

……..……..

……..…… [2]

(b) Describe the differences in arrangement and movement of the particles in methylamine and propylamine at room temperature and pressure.

……..……..

……..……..

……..……..

……..…… [2]

(c) Amines are compounds that have similar chemical properties as ammonia.

For example, methylamine, CH_3NH_2, partially ionises when dissolved in water to form the methylammonium ion and hydroxide ion as shown in the equation below:

$$CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$$

(i) Deduce the formula of the product formed when aqueous methylamine reacts with dilute sulfuric acid.

…… [1]

(ii) Aqueous methylamine is added to a solution of copper(II) sulfate slowly with shaking, until no further change is seen.

Describe the expected observations.

……

…… [2]

[Total: 7]

7 Polylactic acid (PLA) is a polyester that is made from renewable, plant-based materials like corn and sugarcane. It is a bioplastic that can be chemically recycled by depolymerisation.

Fig. 7.1 shows the structure of PLA and how it can be depolymerised.

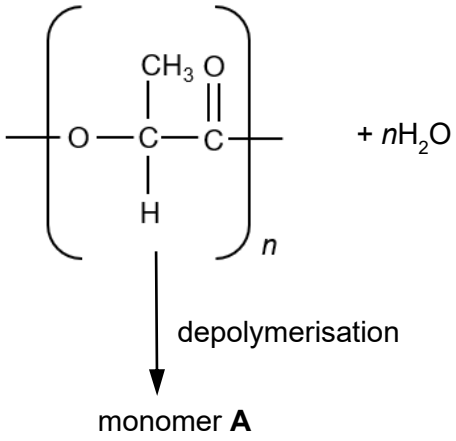


Fig. 7.1

(a) Explain how the structure of PLA shows that it is a polyester.

……..

……..…. [1]

(b) Describe the process of depolymerisation. Include names of reagents and conditions in your answer.

……..

……..…. [2]

(c) Draw the full structural formula of monomer **A**.

[1]

(d) Depolymerisation is an endothermic process that is sped up with the use of a catalyst.

Sketch a labelled energy profile diagram for the reaction.

Your diagram should show and label
- the activation energy for the uncatalysed, E_a, and catalysed reactions, E_a',
- the enthalpy change of the reaction, ΔH

[3]

(e) The use of PLA is more sustainable as compared to other plastics like polypropene due to its biodegradability. Polypropene is a non-biodegradable plastic.

(i) Polypropene is formed by the addition polymerisation of propene.

Draw the structure of the repeat unit of polypropene.

[1]

(ii) Describe **one** environmental problem caused by using non-biodegradable plastics.

……..……...…….....

……..……...…….... [1]

[Total: 9]

8 Chemical Kinetics

Chemical kinetics is the study of the rate of reactions and the factors that affect them.

In general, the rate of a reaction depends on the concentration of its aqueous reactants.

Rate Law

The rate law provides information on how the rate of a reaction depends on the concentration of all its reactants.

For example, in the reaction

$$x\mathbf{A} + y\mathbf{B} \rightarrow \text{products}$$

where **A** and **B** are the reactants, the rate law can be expressed as:

$$\text{rate} = k\,[\mathbf{A}]^m\,[\mathbf{B}]^n$$

where k is a constant;
m is the order of reaction with respect to reactant **A**;
n is the order of reaction with respect to reactant **B**.
[**A**] and [**B**] denote the concentrations of reagents **A** and **B**, respectively.

Order of Reactions

The reaction order is the extent to which the concentration of a reagent affects the rate of reaction.

For example, in the same reaction above, if the rate law is:

$$\text{rate} = k\,[\mathbf{A}]\,[\mathbf{B}]^2$$

The reaction is first-order with respect to reagent **A** and second-order with respect to reagent **B**, meaning that the rate of reaction is

- proportional to the concentration of reagent **A**: if the concentration of **A** is doubled, the rate of reaction would double.
- proportional to the square of the concentration of reagent **B**: if the concentration of **B** is doubled (×2), the rate of reaction would increase by four times ($\times 2^2 = 4$).

Bromination of Alkenes

When alkenes undergo addition reaction with halogens like bromine, they produce halogenoalkanes.

For example, in the reaction between ethene and aqueous bromine:

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

The results investigating the chemical kinetics of this reaction are shown in Table 8.1. An organic solvent was used for this reaction.

Table 8.1

experiment	concentration of C_2H_4 / moldm^{-3}	concentration of Br_2 / moldm^{-3}	rate of reaction / mol/dm^{-3}s^{-1}
1	0.10	0.20	0.10
2	0.20	0.10	0.10
3	0.20	0.20	0.20
4	0.40	0.10	0.20

Bromination of Alkynes

Alkynes are a homologous series of unsaturated hydrocarbons which contain a carbon-carbon triple bond (–C≡C–).

Alkynes can also undergo addition reaction with halogens like bromine. At high bromine concentrations, they react to produce halogenoalkanes.

For example, in the reaction between ethyne, C_2H_2, and bromine:

$$C_2H_2 + 2Br_2 \rightarrow C_2H_2Br_4$$

The results investigating the chemical kinetics of this reaction are shown in Table 8.2.

Table 8.2

experiment	concentration of C_2H_2 / moldm^{-3}	concentration of Br_2 / moldm^{-3}	rate of reaction / moldm^{-3}s^{-1}
1	0.10	0.20	0.10
2	0.10	0.40	0.40
3	0.20	0.20	0.20
4	0.20	0.40	0.80

(a) (i) Explain, in terms of collisions between reacting particles, how the rate of reaction changes with concentration.

……..

……..

……..

…….. [2]

(ii) The student looks at the data in Table 8.1 and suggests the following relationship.

$$\text{rate} = k\,[C_2H_4]\,[Br_2]$$

Use the data to show that this relationship is correct.

……..

……..

……..

……..

……..

…….. [3]

(iii) The rate of a reaction can be calculated using the following equation.

$$\text{rate of reaction} = \frac{1000}{\text{reaction time}}$$

Calculate the reaction time, in seconds, if 0.80 mol/dm^3 of ethene, C_2H_4, was reacted with 0.30 mol/dm^3 of bromine.

reaction time = ……. s [1]

(iv) Write the rate law expression for the reaction between ethyne, C_2H_2, and bromine.

rate = k

[1]

(b) **(i)** Draw a 'dot-and-cross' diagram to show the bonding in one molecule of ethyne, C_2H_2.

Show only the outer shell electrons.

[2]

(ii) State the observation you would expect when excess ethyne is reacted with bromine.

……..

……..…….. [1]

(iii) Predict the rate of reaction if 0.10 mol/dm^3 of ethyne was reacted with 0.20 mol/dm^3 of **chlorine**.

Explain your reasoning.

rate of reaction …… moldm^{-3}s^{-1}

……..

……..…….. [2]

[Total: 12]

9 Butanol reacts with ethanoic acid to form an ester.

(a) **(i)** Describe the conditions required to prepare this ester in the laboratory, and state how you would obtain the ester from the reaction mixture.

……..

……..

…….. [2]

(ii) Draw the full structural formula of the ester formed.

[1]

(b) A student carried out some experiments to compare the relative strengths of dilute ethanoic acid and dilute hydrochloric acid.

He reacts excess calcium carbonate with 1.0 mol/dm^3 of ethanoic acid and 1.0 mol/dm^3 of hydrochloric acid, separately.

(i) Write the chemical equation for the reaction between ethanoic acid and calcium carbonate.

…….. [1]

(ii) Describe the difference in the observation between the reaction of ethanoic acid with calcium carbonate and the reaction of hydrochloric acid with calcium carbonate.

Using ideas about ions, explain the difference in the observation.

……..

……..

……..

……..

…….. [3]

(iii) Describe one other method to distinguish ethanoic acid from hydrochloric acid.

……..

…….. [1]

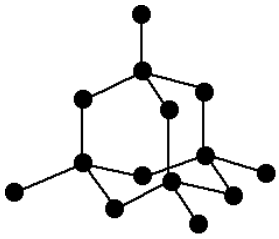
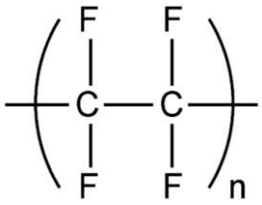
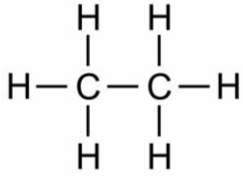
[Total: 8]

Section B

Answer **one** question from this section.

10 Table 10.1 shows the structures and melting points of three compounds, diamond, Teflon and ethane.

Table 10.1

	diamond	Teflon	ethane
melting point / °C	4500	327	–183
structure			

(a) Use ideas about bonding and structure to explain why the melting points of the three compounds differ from each other.

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……

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……

……

……

……. [4]

(b) Calculate the percentage by mass of fluorine in Teflon.

percentage by mass of fluorine = ……% [1]

(c) A sample of Teflon was found to have an average relative molecular mass of 89 000.

Calculate the number of carbon atoms that are present in an average Teflon chain.

number of carbon atoms = …… [2]

(d) A student makes the following statement:

"Teflon can be produced by reacting 1 mole of ethane with 2 moles of fluorine under UV light, then causing the resulting product to undergo addition polymerisation."

(i) Write the chemical equation for the reaction between 1 mole of ethane and 2 moles of fluorine under UV light.

…… [1]

(ii) Do you agree with the student's statement? Explain your reasoning.

……..……..

……..……..

……..……..

……..…… [2]

[Total: 10]

11 The radii of atoms and ions can be measured.

Table 11.1 shows some information about atomic radii and ionic radii of some Group 1 and Group 17 elements.

Table 11.1

element	number of electron shells in atom	atomic radius / pm	number of electron shells in ion	ionic radius / pm
lithium	2	152		68
sodium	3	185		98
potassium	4	227		133

element	number of electron shells in atom	atomic radius / pm	number of electron shells in ion	ionic radius / pm
fluorine	2	71		133
chlorine	3	99		181
bromine	4	115		196

(1×10^9 pm = 1 m)

(a) Complete the tables to show the number of electron shells in the **ions** of the Group 1 and Group 17 elements. [2]

(b) Describe the trend in **atomic radii** for Group 17 and use the data to explain this trend.

……..

……..

……..

……..…. [2]

(c) Describe the change in the radius when a lithium atom forms a lithium ion.

Suggest why the radius changes in this way.

……..

……..

……..

……..…. [2]

(d) The melting points and densities of lithium and fluorine are shown in Table 11.2.

Table 11.2

element	melting point / °C	density at room temperature and pressure / gcm^{-3}
lithium	181	0.534
fluorine	–220	0.0017

Use ideas about bonding and structure to explain why the physical properties of lithium and fluorine differ from each other.

……

……

……

……

……

……

……

…… [4]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.