

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL AS CHEMISTRY (9620)

Unit 1: Inorganic 1 and Physical 1

Wednesday 6 January 2021 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each question or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	



Answer **all** questions in the spaces provided.

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0 1

This question is about atoms and ions.

0 1 . 1

Table 1 shows the relative charge and the relative mass for each of the fundamental particles in an atom.

Complete **Table 1**.

[2 marks]

Table 1

	Relative charge	Relative mass
Electron	-1	1/1836
Neutron	0	1
Proton	+1	1

0 1 . 2

Complete **Table 2** to show the number of protons, electrons and neutrons in the selenium atom and the selenium ion shown.

[2 marks]

Table 2

	Number of protons	Number of electrons	Number of neutrons
^{76}Se	34	34	42
$^{77}\text{Se}^{2-}$	34	36	43



0 1 . 3

A sample of selenium contains four isotopes.

Table 3 shows the relative abundances of the isotopes in this sample of selenium.

Table 3

	^{76}Se	^{77}Se	^{78}Se	^{80}Se
Relative abundance	1.2	1.0	3.1	10.8

Calculate the relative atomic mass of this sample of selenium.

Give your answer to 1 decimal place.

[2 marks]

$$A_r = \Sigma(\text{mass} \times \text{abundance}) \div \Sigma \text{abundance}$$

$$= [(1.2 \times 76) + (1.0 \times 77) + (3.1 \times 78) + (10.8 \times 80)] \div 16.1$$

$$= (91.2 + 77 + 241.8 + 864) \div 16.1$$

$$= 1274 \div 16.1 = 79.13$$

Relative atomic mass 79.1

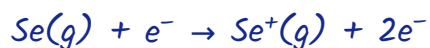
A sample of selenium is analysed using a time of flight (TOF) mass spectrometer.

0 1 . 4

The selenium atoms are ionised by electron impact.

Write an equation, including state symbols, to show this ionisation.

[1 mark]



0 1 . 5

Describe how the selenium ions are accelerated in the TOF mass spectrometer.

[1 mark]

the positive ions are attracted towards a negatively charged plate

(accelerated by an electric field)

Turn over ►



A different sample of selenium contains a fifth isotope.

01.6

After acceleration, the selenium ion has a kinetic energy of $4.742 \times 10^{-14} \text{ J}$
The ion takes $2.572 \times 10^{-6} \text{ s}$ to travel 2.260 m along a flight tube.

Calculate the mass, in kg, of this ion.

$$v = \sqrt{\frac{2 KE}{m}}$$

v = velocity (m s^{-1})

KE = kinetic energy of the ion (J)

m = mass of the ion (kg)

[3 marks]

$$v = d \div t = 2.260 \div 2.572 \times 10^{-6} = 878\,700 \text{ m s}^{-1}$$

$$m = 2KE \div v^2$$

$$m = (2 \times 4.742 \times 10^{-14}) \div (878\,700)^2$$

$$m = 1.228 \times 10^{-25} \text{ kg}$$

Mass of ion 1.228×10^{-25} kg

01.7

Use your answer to Question **01.6** to calculate the mass number of the ion.

(If you could not answer Question **01.6** you should use the value $1.179 \times 10^{-25} \text{ kg}$
This is **not** the correct answer.)

The Avogadro constant, $L = 6.022 \times 10^{23} \text{ mol}^{-1}$

[2 marks]

$$\text{mass of 1 mol} = 1.228 \times 10^{-25} \times 6.022 \times 10^{23} = 0.07395 \text{ kg}$$

$$= 73.95 \text{ g, so mass number} = 74$$

Mass number 74



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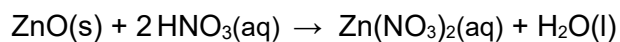
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0 2

Zinc nitrate can be formed by the reaction



0 2 . 1

An excess of zinc oxide is added to 150 cm³ of 1.25 mol dm⁻³ nitric acid.Calculate the maximum mass, in g, of zinc nitrate ($M_r = 189.4$) formed.**[3 marks]**

$$n(\text{HNO}_3) = 150 \times 10^{-3} \times 1.25 = 0.1875 \text{ mol}$$

$$n(\text{Zn(NO}_3)_2) = \frac{1}{2} \times 0.1875 = 0.09375 \text{ mol}$$

$$\text{mass} = 0.09375 \times 189.4 = 17.76 \text{ g}$$

$$\text{mass} = 17.8 \text{ g}$$

Mass 17.8 g

0 2 . 2

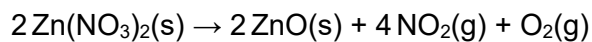
State how pure zinc nitrate can be obtained from the reaction mixture after the excess of zinc oxide is removed.

[1 mark]

crystallisation: heat the solution to evaporate some of the water, leave
to cool and crystallise, then filter off and dry the crystals



0 2 . 3 Zinc nitrate decomposes when heated



Calculate the total volume, in m^3 , of gas formed when 1.20 g of zinc nitrate ($M_r = 189.4$) are decomposed.

The volume of gas is measured at a temperature of 200°C and a pressure of 100 kPa

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[5 marks]

$$T = 200 + 273 = 473 \text{ K} \quad p = 100 \text{ kPa} = 100\,000 \text{ Pa}$$

$$n(\text{Zn}(\text{NO}_3)_2) = 1.20 \div 189.4 = 6.34 \times 10^{-3} \text{ mol}$$



$$n(\text{gas}) = 5/2 \times 6.34 \times 10^{-3} = 1.59 \times 10^{-2} \text{ mol}$$

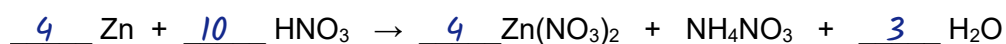
$$V = nRT \div p = (1.59 \times 10^{-2} \times 8.31 \times 473) \div 100\,000$$

$$V = 6.23 \times 10^{-4} \text{ m}^3$$

Total volume of gas 6.23×10^{-4} m^3

0 2 . 4 Complete the equation for the reaction of zinc with concentrated nitric acid.

[1 mark]



10

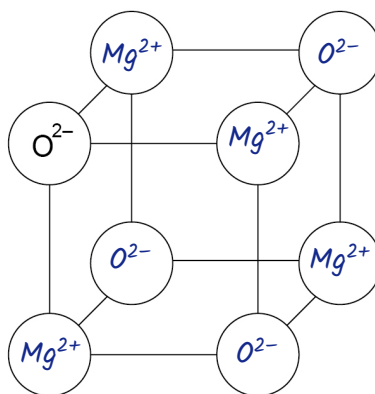
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0 3

This question is about structure and bonding.

0 3 . 1

Figure 1 shows part of the structure of magnesium oxide.Complete **Figure 1** by writing the formula of the appropriate ion in each circle.**[1 mark]****Figure 1**

0 3 . 2

State why molten magnesium oxide conducts electricity.

[1 mark]

*the ions are free to move (mobile ions), so they can carry charge
through the liquid*

0 3 . 3

Name and explain the shape of the nitrogen trichloride (NCl_3) molecule.

Suggest the value of the bond angle.

[4 marks]Name of shape *triangular pyramidal*

Explanation of shape *N has 3 bonding pairs and 1 lone pair of electrons,
which repel to get as far apart as possible
the lone pair repels more strongly than the bonding pairs (lp to bp >
bp to bp repulsion), so the angle is less than 109.5°*

Bond angle *107°* 

0 3 . 4 Table 4 gives some data about the F_2 molecule and the CH_3F molecule.

Table 4

	F_2	CH_3F
Relative molecular mass	38.0	34.0
Boiling point / °C	-188	-78

Explain why the boiling point of CH_3F is much higher than that of F_2

[3 marks]

between F_2 molecules there are only weak van der Waals forces

(induced dipole to dipole forces)

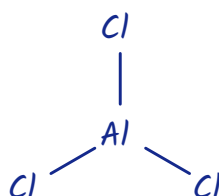
CH_3F is polar (C-F bond), so between CH_3F molecules there are

permanent dipole to dipole forces as well as van der Waals forces

permanent dipole to dipole forces are stronger than van der Waals forces, so more energy is needed to separate the CH_3F molecules

0 3 . 5 Draw the structure of an $AlCl_3$ molecule.

[1 mark]

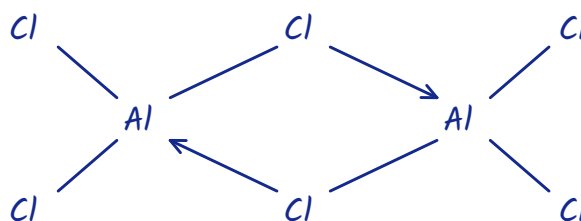


0 3 . 6 Al_2Cl_6 is produced when co-ordinate bonds form between two molecules of $AlCl_3$

Draw the structure of an Al_2Cl_6 molecule.

You should show covalent bonds as a line (—) and co-ordinate bonds as an arrow (→).

[2 marks]



0 4

This question is about enthalpy changes.

0 4 . 1

Define standard enthalpy of combustion.

[2 marks]

*the enthalpy change when 1 mole of a substance is burned completely
in excess oxygen*

*with all reactants and products in their standard states (under standard
conditions, 100 kPa and 298 K)*

0 4 . 2

The equation for the formation of one mole of ethanol from its elements is shown.

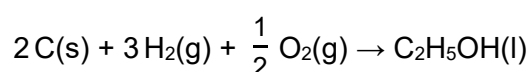


Table 5 shows some enthalpy of combustion data.

Table 5

	C(s)	H ₂ (g)	C ₂ H ₅ OH(l)
$\Delta_c H^\ominus / \text{kJ mol}^{-1}$	-394	-286	-1371

Use data from Table 5 to calculate a value for the standard enthalpy of formation, in kJ mol^{-1} , of ethanol.

[2 marks]

$$\Delta_f H = \Sigma \Delta_c H(\text{reactants}) - \Sigma \Delta_c H(\text{products})$$

$$\Delta_f H = 2(-394) + 3(-286) - (-1371)$$

$$\Delta_f H = -788 - 858 + 1371$$

$$\Delta_f H = -275 \text{ kJ mol}^{-1}$$

Standard enthalpy of formation -275 kJ mol^{-1}



0 4 . 3 Ethanol vapour burns in oxygen.

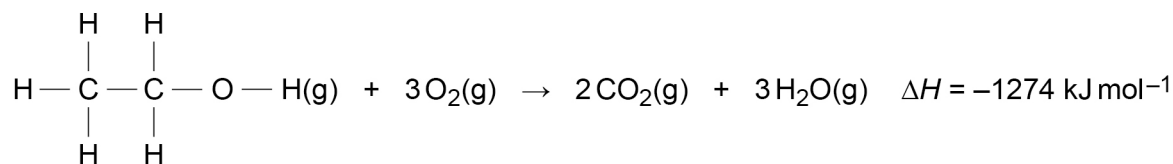


Table 6 shows some mean bond enthalpy data.

Table 6

	C-C	C-H	C-O	O=O	C=O
Mean bond enthalpy / kJ mol ⁻¹	348	412	360	496	805

Use the equation and the data in **Table 6** to calculate a value for the mean bond enthalpy of the O-H bond.

[3 marks]

$$\text{bonds broken} = 348 + 360 + 5(412) + (\text{O-H}) + 3(496)$$

$$= 4256 + (\text{O-H})$$

$$\text{bonds made} = 4(805) + 6(\text{O-H}) = 3220 + 6(\text{O-H})$$

$$\Delta H = \text{broken} - \text{made}: 4256 + (\text{O-H}) - 3220 - 6(\text{O-H}) = -1274$$

$$1036 - 5(\text{O-H}) = -1274$$

$$5(\text{O-H}) = 2310$$

$$\text{O-H} = 462 \text{ kJ mol}^{-1}$$

Bond enthalpy 462 kJ mol⁻¹

7

Turn over ►



0 5

This question is about elements in Group 7 and their compounds.

Iodine reacts with bromine to form the compound IBr
Iodine and bromine have different electronegativities.

0 5 . 1

Complete the diagram to show the polarity of the I–Br bond.

[1 mark]



0 5 . 2

Explain why iodine and bromine have different electronegativities.

[2 marks]

*an iodine atom is larger than a bromine atom; it has more electron
shells and more shielding
so the bonding pair of electrons is further from the nucleus and is
attracted less strongly by the iodine nucleus, so iodine is less
electronegative*

0 5 . 3

When a few drops of concentrated sulfuric acid are added to solid sodium bromide, sulfur dioxide forms.

Write an ionic equation for this reaction.

State the role of sulfuric acid in this reaction.

[2 marks]

Equation



Role of sulfuric acid *oxidising agent (electron acceptor)*



A student tests a solution **X** to find out if halide ions are present.

Method

Step 1 Add acidified silver nitrate solution to **X**.

Step 2 Add an excess of dilute aqueous ammonia to the mixture formed in **Step 1**.

0 5 . 4

Explain why the silver nitrate solution is acidified.

[1 mark]

*to react with and remove any carbonate ions (or other ions) that would
form other insoluble silver salts and interfere with the test*

0 5 . 5

State what would be observed in **Step 1** and in **Step 2** if **X** contained chloride ions as the **only** halide ion.

[2 marks]

Observation in **Step 1**

white precipitate forms

Observation in **Step 2**

the precipitate dissolves to give a colourless solution

0 5 . 6

State why dilute hydrochloric acid is **not** suitable to acidify the silver nitrate solution.

[1 mark]

*it contains chloride ions, which would form a white precipitate of AgCl
with the silver nitrate, giving a false positive result*

Turn over ►



0 5 . 7

Write an equation to show the reaction between chlorine and water in the absence of sunlight.

[1 mark]



0 5 . 8

Chlorine is added to water supplied for drinking.

State **one** advantage and **one** disadvantage of adding chlorine to water supplies.

[2 marks]

Advantage it kills bacteria (so prevents diseases such as typhoid)

Disadvantage chlorine is toxic, and it can react with organic compounds in the water to form carcinogenic chlorinated hydrocarbons

0 5 . 9

Chlorine reacts with hot concentrated sodium hydroxide.



Identify the element that is oxidised in this reaction.

Explain your answer using oxidation states.

[2 marks]

Element oxidised chlorine (Cl)

Explanation the oxidation state of Cl increases from 0 in Cl_2 to +5 in NaClO_3 , so chlorine is oxidised (some Cl is also reduced to -1 in NaCl)



Turn over for the next question

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0 6

This question is about the Period 2 elements lithium to nitrogen.

The elements in Period 2 show periodic trends similar to those in Period 3.

0 6 . 1

State why carbon is classified as a p block element.

[1 mark]

its outer (highest energy) electrons are in a 2p orbital (sub-shell)

0 6 . 2

Explain, in terms of structure and bonding, why the melting point of carbon (graphite) is very high.

[3 marks]

graphite is macromolecular (giant covalent) with layers of carbon atoms

each carbon atom is joined to 3 others by strong covalent bonds

many strong covalent bonds must be broken, which needs a lot of

energy

0 6 . 3

Explain why there is a general increase in first ionisation energy from lithium to nitrogen.

[2 marks]

the number of protons increases, so the nuclear charge increases

the outer electrons are in the same shell with similar shielding, so there

is a stronger attraction between the nucleus and the outer electrons

0 6 . 4

Identify the element, from lithium to nitrogen, that does **not** follow the trend of increasing first ionisation energy.

Explain why this element does **not** follow the trend.

[3 marks]

Element *boron (B)*

Explanation *the B electron is removed from a 2p orbital, but in Be from a 2s orbital*

2p is higher in energy than 2s, so the electron is more easily lost



0 6 . 5

Identify the element, from lithium to nitrogen, that has the largest atomic radius.

[1 mark]

lithium (Li)

0 6 . 6

Identify the element, from lithium to nitrogen, that has the largest **third** ionisation energy.

[1 mark]

beryllium (Be)

0 6 . 7

The nitride ion has the formula N^{3-} Give the electron configuration of the N^{3-} ion.

Give the formula of beryllium nitride.

[2 marks]

Electron configuration *$1s^2 2s^2 2p^6$* Formula *Be_3N_2*

0 6 . 8

An oxide of lithium contains 30.0% lithium by mass.

What is the empirical formula of this oxide of lithium?

Tick (✓) one box.

[1 mark]

 Li_2O ☐ LiO ☒ LiO_2 ☐

14

END OF QUESTIONS



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