Cambridge AS & A Level

CHEMISTRY

Paper 2

Topical Past Paper Questions

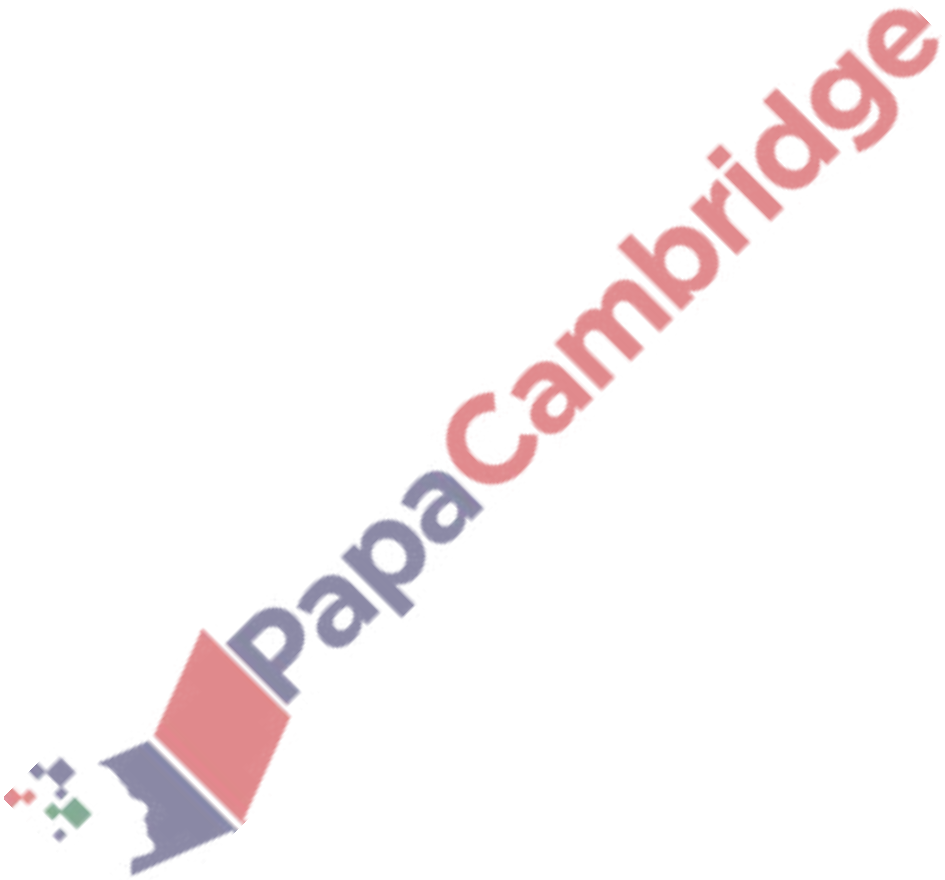
+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 3

Chemical bonding



3.1 Ionic bonding

11. 9701_S15_qp_21 Q: 1

(a) Chemists recognise that atoms are made of three types of particle.

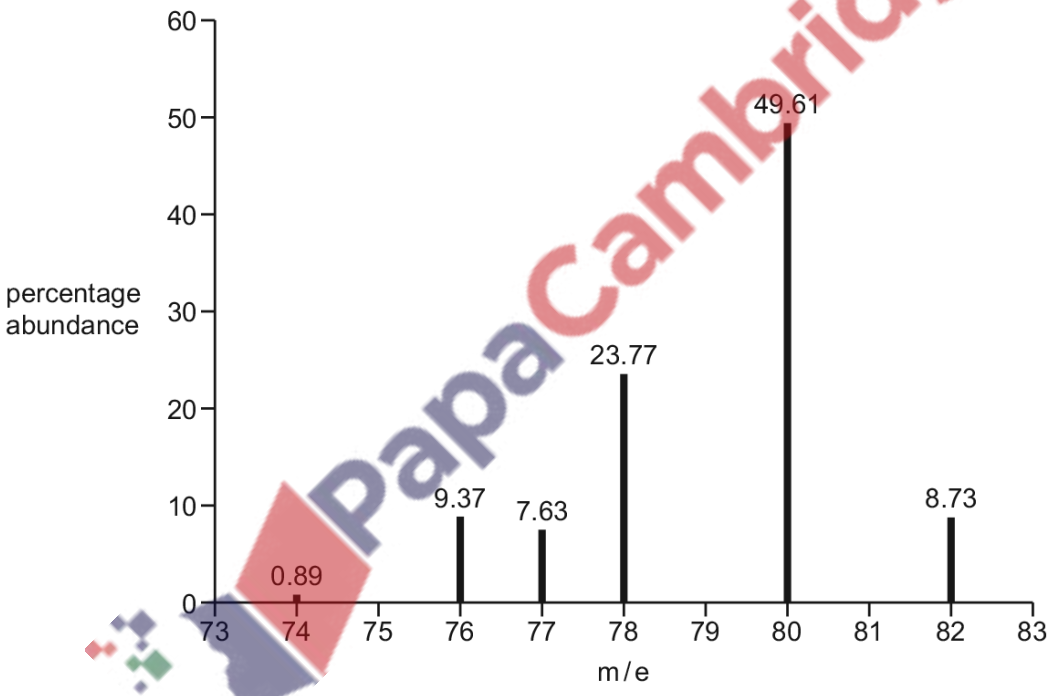
Complete the following table with their names and properties.

name of particle	relative mass	relative charge
		0
	1/1836	

[3]

(b) The relative atomic mass of an element can be determined using data from its mass spectrum.

The mass spectrum of element **X** is shown, with the percentage abundance of each isotope labelled.



(i) Define the terms *relative atomic mass* and *isotope*.

relative atomic mass .....

.....

.....

isotope .....

.....

[3]

(ii) Use the data in the mass spectrum to calculate the relative atomic mass, A_r, of **X**.
Give your answer to **two** decimal places and suggest the identity of **X**.

A_r of **X** .....

identity of **X** .....
[2]

(c) The element tellurium, Te, reacts with chlorine to form a single solid product, with a relative formula mass of 270. The product contains 52.6% chlorine by mass.

(i) Calculate the molecular formula of this chloride.

molecular formula ..... [3]

(ii) This chloride melts at 224 °C and reacts vigorously with water.

State the type of bonding **and** structure present in this chloride and explain your reasoning.

.....

.....

.....

..... [2]

(iii) Suggest an equation for the reaction of this chloride with water.

..... [1]

(d) Sodium and silicon also react directly with chlorine to produce the chlorides shown.

chloride	melting point / °C	difference between the electronegativities of the elements
NaCl	801	2.2
$SiCl_4$	–69	1.3

(i) Describe what you would **see** during the reaction between sodium and chlorine.

.....

.....

..... [2]

(ii) Explain the differences between the melting points of these two chlorides in terms of their structure **and** bonding. You should refer to the difference between the electronegativities of the elements in your answer.

NaCl structure **and** bonding .....

.....

$SiCl_4$ structure **and** bonding .....

.....

explanation .....

.....

.....

.....

.....

..... [4]

[Total: 20]

3.2 Covalent and co-ordinate bonding including shapes of simple molecules

12. 9701_w17_qp_22 Q: 1

The elements sodium to sulfur react with chlorine. The melting points of some of the chlorides formed are shown.

chloride	$NaCl$	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3	SCl_2
melting point/K	1074	987	463	203	161	195

(a) Predict the shapes of $AlCl_3$ and PCl_3.

Draw diagrams to show the shapes, name the shapes and state the bond angles.

$AlCl_3$	PCl_3
shape	shape .....
angle	angle .....

[4]

(b) (i) Explain, in terms of structure and bonding, why the melting point of $SiCl_4$ is much lower than that of $NaCl$.

.....

.....

.....

.....

..... [3]

(ii) Explain why the melting point of $SiCl_4$ is higher than that of PCl_3.

.....

.....

..... [2]

(iii) Draw the 'dot-and-cross' diagram of a molecule of $SiCl_4$.
Show outer electrons only.

[1]

[Total: 10]

3.3 Intermolecular forces, electronegativity and bond properties

13. 9701_s17_qp_21 Q: 2

Structure and bonding can be used to explain many of the properties of substances.

(a) Copper, ice, silicon(IV) oxide, iodine and sodium chloride are all crystalline solids.

Complete the table with:
- the name of a type of bonding found in each crystalline solid,
- the type of lattice structure for each crystalline solid.

crystalline solid	type of bonding	type of lattice structure
copper		
ice		
silicon(IV) oxide		
iodine		
sodium chloride		

[5]

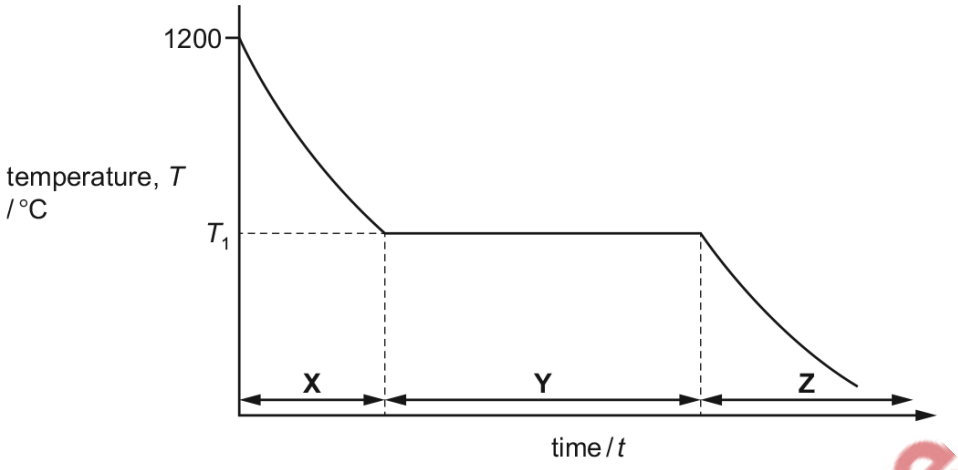
(b) (i) Name the strongest type of intermolecular force in ice.

..... [1]

(ii) Draw a fully labelled diagram of two water molecules in ice, showing the force in **(i)** and how it forms.

[3]

(c) The graph represents how the temperature of a sample of copper (melting point 1085 °C) changes as it is gradually cooled from 1200 °C.



(i) Identify the state(s) of matter present during each stage of the process shown in the graph.

X .....

Y .....

Z .....

[2]

(ii) State what is happening to the energy and movement of the particles in the copper during stage **X**.

.....

.....

..... [2]

(iii) Explain why the temperature stays constant at T_1 during stage **Y**.

.....

.....

.....

..... [2]

[Total: 15]

14. 9701_s16_qp_23 Q: 1

An experiment was carried out to determine the percentage of iron in a sample of iron wire.

(a) A 3.35 g piece of the wire was reacted with dilute sulfuric acid, in the absence of air, so that all of the iron atoms were converted to iron(II) ions. The resulting solution was made up to 250 cm^3.

(i) Write a balanced equation for the reaction between the iron in the wire and the sulfuric acid.

..... [1]

A 25.0 cm^3 sample of this solution was acidified and titrated with 0.0250 mol dm^{-3} potassium dichromate(VI). 32.0 cm^3 of the potassium dichromate(VI) solution was required for complete reaction with the iron(II) ions in the sample.

The relevant half-equations are shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

(ii) Use the half-equations to write an equation for the reaction between the iron(II) ions and the acidified dichromate(VI) ions.

..... [1]

(iii) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(iv) Calculate the amount, in moles, of iron(II) ions in the 25.0 cm^3 sample of solution.

amount = ... mol [1]

(v) Calculate the amount, in moles, of iron in the 3.35 g piece of wire.

amount = ... mol [1]

(vi) Calculate the mass of iron in the 3.35 g piece of wire.

mass = ... g [1]

(vii) Calculate the percentage of iron in the iron wire.

percentage = ... % [1]

(b) Some electronegativity values are shown.

element	electronegativity
aluminium	1.5
chlorine	3.0
iron	1.8

(i) Use the data to suggest the nature of the bonding in iron(III) chloride. Explain your answer.

.....

.....

..... [2]

(ii) Suggest an equation for the reaction between iron(III) chloride and water.

..... [1]

[Total: 10]

15. 9701_S15_qp_23 Q: 1

Neon is a noble gas.

(a) Complete the full electronic configuration of neon.

$1s^2$ ..... [1]

(b) **(i)** Explain what is meant by the term *first ionisation energy*.

.....

.....

..... [3]

(ii) Explain why the first ionisation energy of neon is greater than that of fluorine.

.....

..... [2]

(c) Neon has three stable isotopes.

isotope	mass number	percentage abundance
1		9.25
2	20	90.48
3	21	0.27

(i) Define the term *relative atomic mass*.

.....

..... [2]

(ii) Use the relative atomic mass of neon, 20.2, to calculate the mass number of isotope 1.

mass number = ... [2]

(d) A mixture of neon and argon has a mass of 0.275 g. The mixture was placed in a gas syringe at a temperature of 25 °C and a pressure of 100 kPa. Under these conditions the mixture was found to occupy a volume of 200 cm^3.

(i) Calculate the average M_r of the mixture.

average M_r = ... [2]

(ii) Use your answer to **(i)** to calculate the percentage of neon in the mixture.
Give your answer to **three** significant figures.

percentage of neon = ... % [1]

(e) Neon and argon can both be obtained by fractional distillation of liquid air as they have different boiling points.

Neon has a boiling point of 27.3 K. The boiling point of argon is 87.4 K.

(i) Name the force that has to be overcome in order to boil neon or argon and explain what causes it.

.....

.....

..... [3]

(ii) Explain why argon has a higher boiling point than neon.

.....

.....

..... [2]

[Total: 18]

3.4 Bonding and physical properties

16. 9701_w15_qp_22 Q: 1

(a) Fill the gaps in the table for each of the given particles.

name of isotope	type of particle	charge	symbol	electron configuration
carbon-13				$1s^2 2s^2 2p^2$
		–1	$^{37}_{17}Cl^-$	
sulfur-34	atom	0		
iron-54	cation			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

[5]

(b) One of the factors that determines the type of bonding present between the particles of a substance is the relative electronegativities of the bonded particles.

(i) Explain the meaning of the term *electronegativity*.

.....

.....

..... [2]

(ii) Name and describe the type of bonding you would expect to find between particles with equal electronegativities.

.....

.....

..... [2]

(iii) Name and describe the type of bonding you would expect to find between particles with very different electronegativities.

.....

.....

..... [2]

(c) The boiling points of some molecules with equal numbers of electrons are given.

substance	fluorine	argon	hydrogen chloride	methanol
formula	F_2	Ar	HCl	CH_3OH
boiling point / K	85	87	188	338

(i) Explain why the boiling points of fluorine and argon are so similar.

.....

.....

..... [2]

(ii) Explain why the boiling point of hydrogen chloride is higher than that of fluorine.

.....

.....

..... [2]

(iii) Explain why methanol has the highest boiling point of all these molecules.

.....

.....

..... [2]

[Total: 17]