Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

STEM | Exam Builder

Chemical bonding

Time allowed: 1 hour 25 minutes

Subject code **0620**

Chemistry

Questions from Paper 3 and Paper 4

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 90

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 90 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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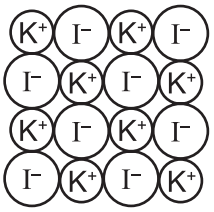
Print at 100% (Actual size) so diagrams keep their real measurements.

1 The list describes five types of chemical structures.

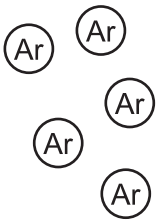
giant covalent
giant ionic
metallic
simple atomic
simple molecular

(a) The diagrams below show four types of chemical structures.

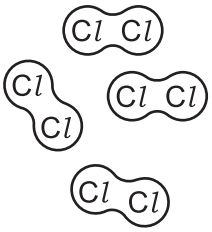
A



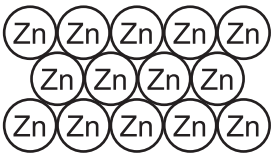
B



C



D



(i) Use the list to match these structures with the diagrams.

structure **A** is ..... [1]

structure **B** is ..... [1]

structure **C** is ..... [1]

structure **D** is ..... [1]

(ii) Which **two** of the structures **A**, **B**, **C** or **D** have low melting points?

..... and ..... [1]

(b) Sodium chloride is an ionic solid.
Complete the following sentences using words from the list.

electrons **ionic** **molecular** **molten** **solid**

Sodium chloride does not conduct electricity when it is a .....
because the ions cannot move. When it is ..... sodium chloride does
conduct electricity because the ions are free to move. [2]

[Total: 7]

Ionic bonding Click for more variations

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1 **(a)** **(i)** A: giant ionic [1]
B: simple atomic [1]
C: simple molecular [1]
D: metallic [1]

(ii) B and C (both needed for mark) [1]

(b) solid; molten; [2]

2 Nitrogen molecules are diatomic.

(a) (i) State the meaning of the term diatomic.

..... [1]

(ii) State the percentage of nitrogen in clean, dry air.

..... [1]

(b) Ammonia has a simple molecular structure.

Complete Fig. 2.1 to show the dot-and-cross diagram for a molecule of ammonia.
Show outer shell electrons only.

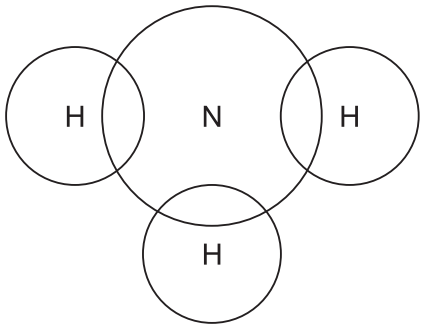


Fig. 2.1

[2]

(c) Sodium chloride has a giant ionic structure of positive and negative ions.

(i) State the general name given to any positive ion.

..... [1]

(ii) State **one** physical property of an ionic compound.

..... [1]

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(d) Graphite is used as an electrode.

(i) State one **other** use of graphite.

..... [1]

(ii) Choose the correct statement that describes the structure and bonding in graphite.

Tick (✓) **one** box.

simple covalent molecule	☐
giant ionic	☐
simple ionic	☐
giant covalent	☐

[1]

[Total: 8]

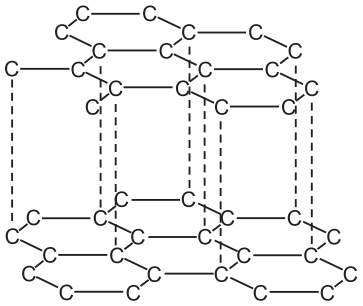
Covalent bonding and simple molecules Click for more variations

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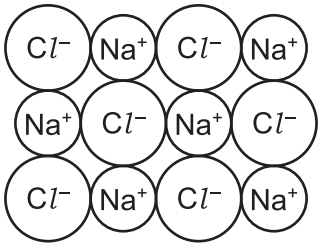
2(a)(i)	has two atoms (in a molecule)	**1**
2(a)(ii)	78 (%)	**1**
2(b)	3 bonding pairs between each H and N **AND** no extra electrons on H atoms (1) two non-bonding electrons on N atom (1)	**2**
2(c)(i)	cation	**1**
2(c)(ii)	high melting point / high boiling point **OR** (good) electrical conductivity when molten **OR** (good) electrical conductivity in aqueous solution	**1**
2(d)(i)	lubricant	**1**
2(d)(i)	4th box down ticked (giant covalent)	**1**

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3 The structures of graphite and sodium chloride are shown below.



graphite



sodium chloride

(a) Describe the similarity and differences in these structures.

.....

.....

.....

.....

.....

..... [4]

(b) Graphite is a form of carbon.
Carbon is an element.

(i) What is meant by the term *element*?

.....

..... [1]

(ii) Write a symbol equation for the complete combustion of carbon.

[2]

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(c) The table shows some properties of four substances, **A**, **B**, **C** and **D**.

substance	melting point / °C	boiling point / °C	electrical conductivity
A	–7	+59	does not conduct
B	–157	–152	does not conduct
C	+769	+1930	conducts when molten but not when solid
D	+1410	+2355	does not conduct

Which **one** of these substances, **A**, **B**, **C** or **D**,

(i) is a liquid at room temperature, ... [1]

(ii) is a giant ionic structure, ... [1]

(iii) is a noble gas, ... [1]

(iv) is a giant covalent structure? ..... [1]

[Total: 11]

Giant covalent structures: diamond, graphite and silicon dioxide Click for more variations

3 **(a)** Any **four** from: [4]

- both giant structures
- both have layered structures
- graphite covalent
- sodium chloride ionic
- graphite macromolecule / giant covalent structure
- graphite has layers which are separated / further apart (than C-C bonds)
- sodium chloride has ions touching
- graphite has only one type of particle / graphite is an element / only has C atoms
- sodium chloride has two types of particles / sodium chloride is a compound
- graphite has hexagonal arrangement (of atoms)
- sodium chloride has cubic arrangement **allow**: square arrangement
- graphite has atoms all of one size
- sodium chloride has different sized particles / ions

ignore: properties / weak or strong bonding

(b) **(i)** substance containing only one type of atom [1]
allow: substance that cannot be split up (by chemical means)

(ii) $C + O_2 \rightarrow CO_2$ [2]

(c) **(i)** A [1]

(ii) C [1]

(iii) B [1]

(iv) D [1]

[Total: 11]

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4 The diagrams below show the electron arrangement in two compounds.



(a) In a water molecule, each hydrogen atom is bonded to the oxygen atom by sharing a pair of electrons.
Why does an oxygen atom share two pairs of electrons rather than just one pair?

.....

..... [1]

(b) Describe how a potassium atom becomes a potassium ion.

..... [1]

(c) Why is there a bond between the ions in potassium chloride?

.....

..... [1]

(d) Solid potassium chloride is a poor conductor of electricity. When dissolved in water it is a good conductor. Explain.

.....

..... [2]

[Total: 5]

Ionic bonding Click for more variations

4 **(a)** to complete the outer shell (of oxygen) / full outer or valence shell / 8 (electrons) in outer shell / Noble gas structure / to complete outer shell / to complete the octet
ignore reference to hydrogen atoms / reference to accepting / sharing or gaining electrons [1]

(b) loses (one) electron [1]
not loses electron**s**

(c) opposite charges attract / electrostatic attraction / positive attracts negative / + and – attract [1]

(d) in solid ions cannot move / flow / no free ions / ions in a lattice [1]
in solution ions can move / flow / mobile ions / ions free (to move) [1]

[Total: 5]

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5 Table 2.1 shows the melting points, boiling points and electrical conductivities of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

Table 2.1

substance	melting point / °C	boiling point / °C	electrical conductivity when solid	electrical conductivity when molten
A	1600	2230	poor	poor
B	–219	–183	poor	poor
C	770	1420	poor	good
D	–39	357	good	good
E	–7	58	poor	poor
F	44	280	poor	poor
G	1085	2562	good	good

(a) Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, is:

(i) a gas at 25 °C

..... [1]

(ii) a solid consisting of simple molecules at 25 °C

..... [1]

(iii) a metal which is liquid at 25 °C.

..... [1]

(b) **(i)** Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, has a giant covalent structure.

Use the information in Table 2.1 to give **two** reasons for your choice.

substance .....

reason 1 .....

reason 2 .....

[3]

(ii) Identify which substance, **A**, **B**, **C**, **D**, **E**, **F** or **G**, is an ionic compound.

Use the information in Table 2.1 to give **one** reason for your choice.

substance .....

reason .....

[2]

[Total: 8]

Ionic bonding Click for more variations

STEM Exam Builder

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5(a)(i)	**B**	**1**
5(a)(ii)	**F**	**1**
5(a)(iii)	**D**	**1**
5(b)(i)	**M1 A** **M2** high melting point **AND/OR** high boiling point **M3** poor conductor of electricity when solid **AND** molten	**3**
5(b)(ii)	**M1 C** **M2** only conducts electricity when molten	**2**

6 Diamond and graphite are different forms of the same element, carbon.
Explain the following in terms of their structure.

(a) Graphite is a soft material which is used as a lubricant.

.....

..... [2]

(b) Diamond is a very hard material which is used for drilling and cutting.

.....

..... [2]

(c) Graphite is a good conductor of electricity and diamond is a poor conductor.

.....

.....

..... [2]

[Total: 6]

Giant covalent structures: diamond, graphite and silicon dioxide Click for more variations

6 **(a)** weak forces between layers or between (hexagonal) rings / weak bonds between layers or between (hexagonal) rings / Van der Waals forces between layers or between (hexagonal) rings; [1]
(layers/rings) slip/slide (over each other) / move over each other [1]

(b) strong bonds (between atoms) / covalent bonds (between atoms); [1]
all bonds are covalent/strong / each atom covalently bonded / carbon (atoms) is bonded to four others / bonds are directional / (atoms are arranged) tetrahedrally; [1]
accept: carbon has four bonds

(c) graphite has delocalised / mobile / free electrons; [1]
diamond (outer shell) electrons used / fixed / localised in bonding / no delocalised electrons / no mobile electrons / no free electrons; [1]

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7 The table below includes information about some of the elements in Period 2.

element	carbon	nitrogen	fluorine	neon
symbol	C	N	F	Ne
structure	macromolecular	simple molecules N_2	simple molecules F_2	single atoms Ne
boiling point / °C	4200	–196	–188	–246

(a) Why does neon exist as single atoms but fluorine exists as molecules?

.....

..... [2]

(b) What determines the order of the elements in a period?

..... [1]

(c) When liquid nitrogen boils the following change occurs.

$$N_2(l) \rightarrow N_2(g)$$

The boiling point of nitrogen is very low even though the bond between the atoms in a nitrogen molecule is very strong. Suggest an explanation.

.....

..... [2]

(d) Draw a diagram showing the arrangement of the outer shell (valency) electrons in a molecule of nitrogen.

[2]

[Total: 7]

Noble gases Click for more variations

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7 **(a)** neon has full outer shell / energy level / valency shell / octet / 8 (electrons) in outer shell / neon does not need to lose or gain electrons; [1]
fluorine atoms have 7 electrons / needs 1 to fill / has incomplete shell / forms bonds with other fluorine atoms / fluorine (atoms) form covalent bonds / shares electrons; [1]

(b) atomic number / proton number / number of protons (in one atom); [1]

(c) weak intermolecular (or between molecules) forces / Van der Waals forces between molecules / low amount of energy required to break bonds between molecules; [1]
strong bonds don't break / covalent bonds don't break / (unnamed) bonds within molecules / between atoms don't break; [1]

(d) 1 non-bonding pair on each nitrogen atom; [1]
6 electrons between nitrogen atoms; [1]

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8 Magnesium forms ionic compounds.

(a) Magnesium reacts with fluorine to form the ionic compound magnesium fluoride.
The electronic configurations of an atom of magnesium and an atom of fluorine are shown in Fig. 3.1.

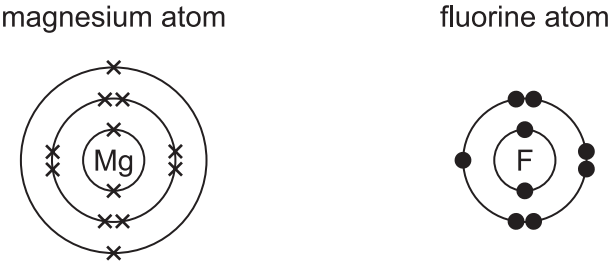


Fig. 3.1

(i) Ions are formed by the transfer of electrons from magnesium atoms to fluorine atoms.

Complete the dot-and-cross diagrams in Fig. 3.2 to show the electronic configurations of **one** magnesium ion and **one** fluoride ion. Show the charges on the ions.

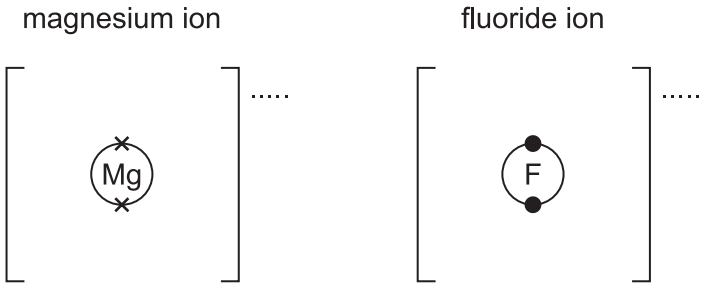


Fig. 3.2

[3]

(ii) Deduce the formula of magnesium fluoride.

..... [1]

(iii) When solid magnesium fluoride is dissolved in water it forms a solution that conducts electricity.

State one other change that can be made to solid magnesium fluoride to allow it to conduct electricity.

..... [1]

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(b) Silicon tetrachloride, $SiCl_4$, and silicon(IV) oxide, SiO_2, are covalent compounds.

Complete the dot-and-cross diagram in Fig. 3.3 to show the electronic configuration in a molecule of silicon tetrachloride. Show outer shell electrons only.

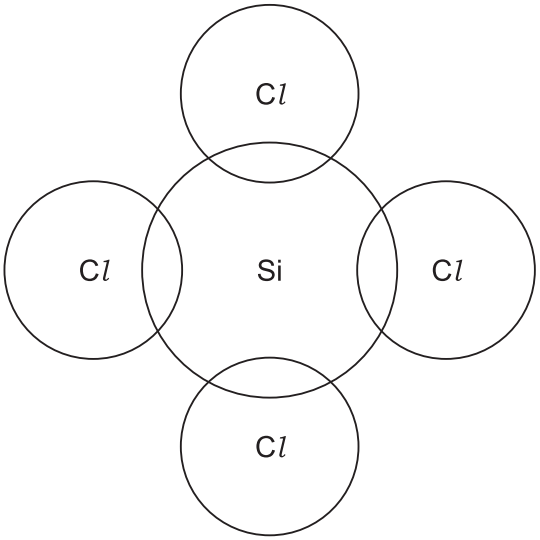


Fig. 3.3

[2]

(c) The melting points of silicon tetrachloride and silicon(IV) oxide are shown in Table 3.1.

Table 3.1

	melting point / °C
silicon tetrachloride	–69
silicon(IV) oxide	1710

(i) Silicon tetrachloride has a low melting point because it has weak forces of attraction between particles.

Name the type of particles that are held together by these weak forces of attraction.

..... [1]

(ii) Explain, in terms of structure and bonding, why silicon(IV) oxide has a high melting point.

.....

.....

.....

..... [2]

[Total: 10]

Ionic bonding Click for more variations

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8(a)(i)	**M1** eight crosses in second shell of Mg **M2** 7 dots and 1 cross in second shell of F **M3** '2+' charge on Mg ion on correct answer line **and** '–' charge on F ion on correct answer line	**3**
8(a)(ii)	MgF_2	**1**
8(a)(iii)	melting	**1**
8(b)	**M1** 4 dot and cross single bonds **M2** 3 pairs of non-bonding e on each Cl and no non-bonding e on Si	**2**
8(c)(i)	molecule(s)	**1**
8(c)(ii)	**M1** covalent bonds **M2** strong bonds **and** giant (covalent) structure	**2**

9 Magnesium is a metal.

(a) Describe the structure and bonding in magnesium.

.....

.....

.....

..... [3]

(b) Why can magnesium conduct electricity when solid?

.....

.....

.....

..... [2]

(c) Why is magnesium malleable?

.....

.....

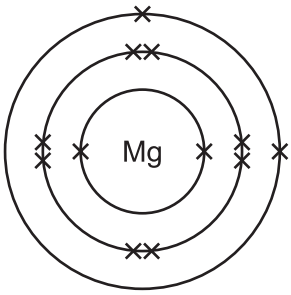
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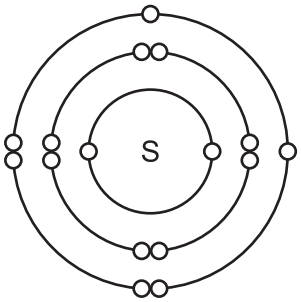
..... [2]

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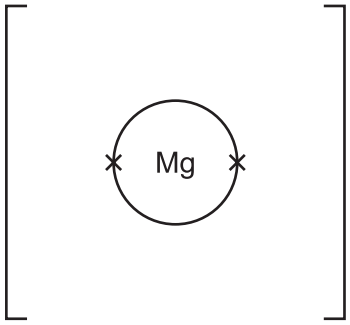
(d) Magnesium reacts with sulfur to form the ionic compound magnesium sulfide, MgS.

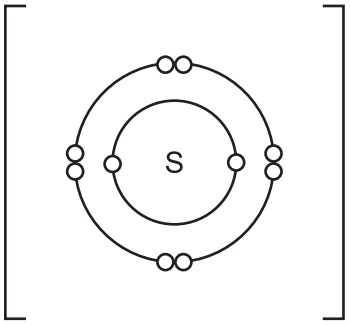
The diagrams show the electronic structures of atoms of magnesium and sulfur.





(i) Complete the diagrams to show the electronic structures of the ions in magnesium sulfide. Show the charges on the ions.





[3]

(ii) Ionic compounds, such as magnesium sulfide, do **not** conduct electricity when solid.
Magnesium sulfide does **not** dissolve in water.
Magnesium sulfide **does** conduct electricity under certain conditions.

State the conditions needed for magnesium sulfide to conduct electricity. Explain why magnesium sulfide conducts electricity under these conditions.

.....

.....

.....

..... [2]

[Total: 12]

Metallic bonding Click for more variations

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9(a)	regular arrangement / lattice of positive ions / magnesium ions / Mg^{2+} ions	**1**
	sea of electrons **OR** delocalised electrons	**1**
	attraction between (positive) ions and (delocalised / sea of) electrons	**1**
9(b)	electrons	**1**
	move / flow (throughout / through the structure)	**1**
9(c)	layers (of atoms or ions)	**1**
	layers / atoms / ions can slide / slip / glide (over each other) (without breaking the metallic bonds)	**1**
9(d)(i)	magnesium shown as (2, 8) using crosses	**1**
	sulfide shown as (2, 8, 8), with the two gained electrons in the outer shell of sulfur shown as crosses and all other electrons on sulfur shown as dots	**1**
	magnesium ion charge as 2^+ **AND** sulfide charge as 2^-	**1**
9(d)(ii)	melt / fused	**1**
	ions can move **OR** are mobile	**1**

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10 This question is about covalent compounds.

(a) State what is meant by a covalent bond.

.....

..... [2]

(b) Chlorine(I) oxide, Cl_2O, is a simple molecule with covalent bonds.

(i) State what is meant by (I) in the name chlorine(I) oxide.

..... [2]

(ii) Complete the dot-and-cross diagram in Fig. 2.1 of a molecule of chlorine(I) oxide.

Show outer electrons only.

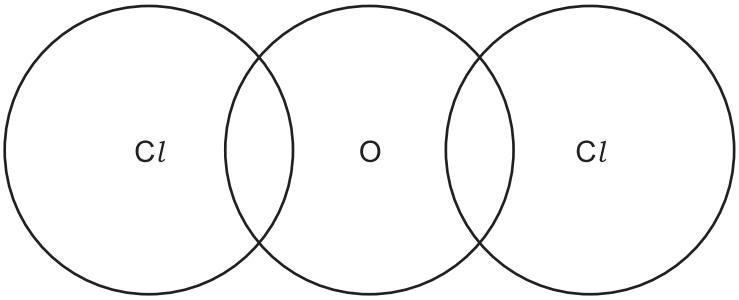


Fig. 2.1

[3]

(iii) Explain, in terms of structure and bonding, why Cl_2O boils at a low temperature and does **not** thermally decompose into its constituent elements, Cl_2 and O_2.

.....

.....

.....

..... [3]

(iv) Give **two** reasons why liquid Cl_2O is a poor conductor of electricity.

1 .....

2 .....

[2]

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(c) Carbon and silicon(IV) oxide both exist as giant covalent structures.

(i) Name a giant covalent structure of carbon which conducts electricity.

..... [1]

(ii) Identify the particles responsible for the conduction of electricity in this covalent structure of carbon.

..... [1]

(iii) Silicon(IV) oxide contains silicon atoms, Si, and oxygen atoms, O.

Fig. 2.2 shows part of the giant covalent structure of silicon(IV) oxide.

Complete the diagram in Fig. 2.2 by adding the symbol for each of the 9 atoms shown.

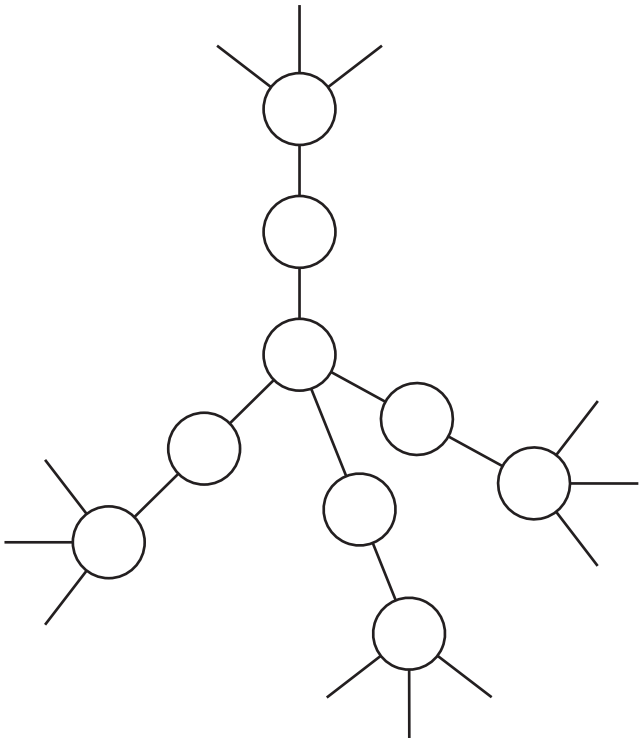


Fig. 2.2

[2]

[Total: 16]

Covalent bonding and simple molecules Click for more variations

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10(a)	M1 **pair** of electrons M2 electron(s) shared between **two** atoms	**2**
10(b)(i)	M1 the oxidation number of chlorine / Cl M2 (oxidation number) is +1	**2**
10(b)(ii)	M1 O with 1 dot-cross bonding pair with each Cl M2 4 non-bonding dots for O M3 6 non-bonding crosses for each Cl	**3**
10(b)(iii)	M1 (forces of) attraction between molecules are broken (during boiling) M2 covalent bonds (between Cl and O atoms) are broken (during thermal decomposition) M3 weak attraction between molecules and strong covalent bonds / bonding between atoms correctly applied	**3**
10(b)(iv)	M1 no ions M2 no mobile electrons	**2**
10(c)(i)	graphite	**1**
10(c)(ii)	electrons	**1**
10(c)(iii)	M1 5 correct Si atoms M2 4 correct O atoms	**2**

STEM | Exam Builder