3.2 Structure and bonding

01. 0620_p20_qp_40 Q: 1

The following table gives information about six substances.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	–188	–42	poor	poor
C	776	1497	poor	good
D	–117	78	poor	poor
E	1607	2227	poor	poor
F	–5	102	poor	good

(a) Which substance could be a metal?

..... [1]

(b) State **all** the substances that are liquid at room temperature.

..... [1]

(c) Which substance could have a macromolecular structure similar to that of silicon(IV) oxide?

..... [1]

(d) Which substance could be propane?

..... [1]

(e) Which substance could be sodium chloride?

..... [1]

[Total: 5]

02. 0620_p20_qp_40 Q: 3

Kinetic theory explains the properties of matter in terms of the arrangement and movement of particles.

(a) Nitrogen is a gas at room temperature. Nitrogen molecules, N_2, are spread far apart and move in a random manner at high speed.

(i) Draw the electronic structure of a nitrogen molecule.
Show only the outer electron shells.

[2]

(ii) Compare the movement and arrangement of the molecules in solid nitrogen to those in nitrogen gas.

.....

.....

.....

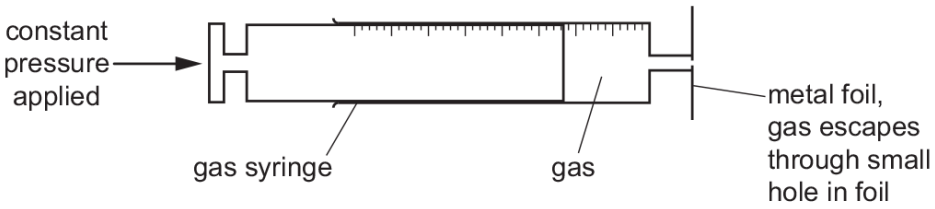
..... [3]

(b) A sealed container contains nitrogen gas. The pressure of the gas is due to the molecules of the gas hitting the walls of the container.
Use the kinetic theory to explain why the pressure inside the container increases when the temperature is increased.

.....

..... [2]

The following apparatus can be used to measure the rate of diffusion of a gas.



The following results were obtained.

gas	temperature / °C	rate of diffusion in cm^3 / min
nitrogen	25	1.00
chlorine	25	0.63
nitrogen	50	1.05

(c) (i) Explain why nitrogen gas diffuses faster than chlorine gas.

.....

..... [2]

(ii) Explain why the nitrogen gas diffuses faster at the higher temperature.

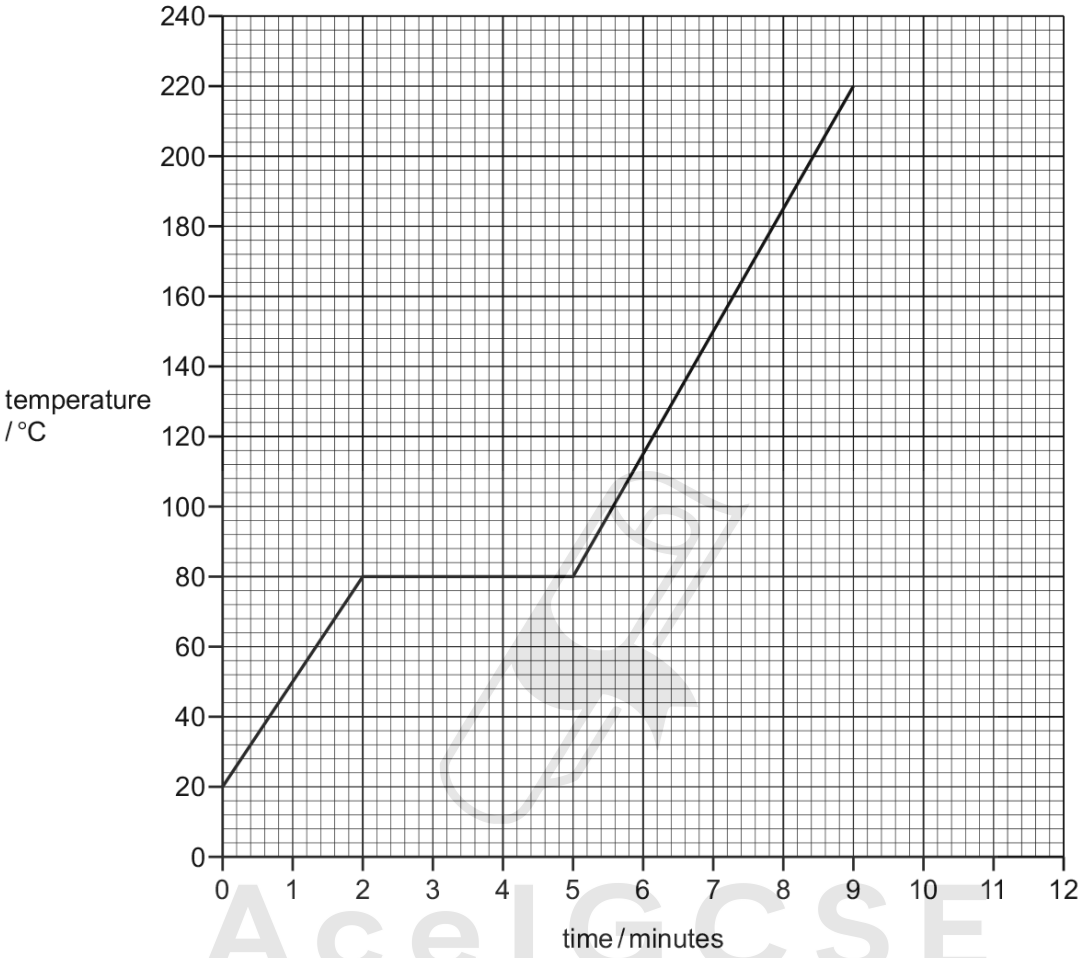
..... [1]

[Total: 10]

03. 0620_s19_qp_41 Q: 2

Z is a covalent substance. In an experiment, a sample of pure solid **Z** was continually heated for 11 minutes.

The graph shows how the temperature of the sample of pure **Z** changed during the first 9 minutes.



(a) What is the melting point of pure **Z**?

..... °C [1]

(b) The sample of pure **Z** began to boil at 9 minutes. It was boiled for 2 minutes.

Use this information to sketch on the grid how the temperature of the sample of pure **Z** changed between 9 minutes and 11 minutes. [1]

(c) The sample of pure **Z** was continually heated between 2 minutes and 5 minutes.

Explain, in terms of attractive forces, why there was no increase in the temperature of the sample of pure **Z** between 2 minutes and 5 minutes.

.....

.....

..... [2]

(d) Describe how the motion of particles of pure **Z** changed from 0 minutes to 2 minutes.

.....

..... [2]

(e) The experiment was repeated using a solid sample of **impure Z**.

Suggest the differences, if any, in the melting point and boiling point of the sample of impure **Z** compared to the sample of pure **Z**.

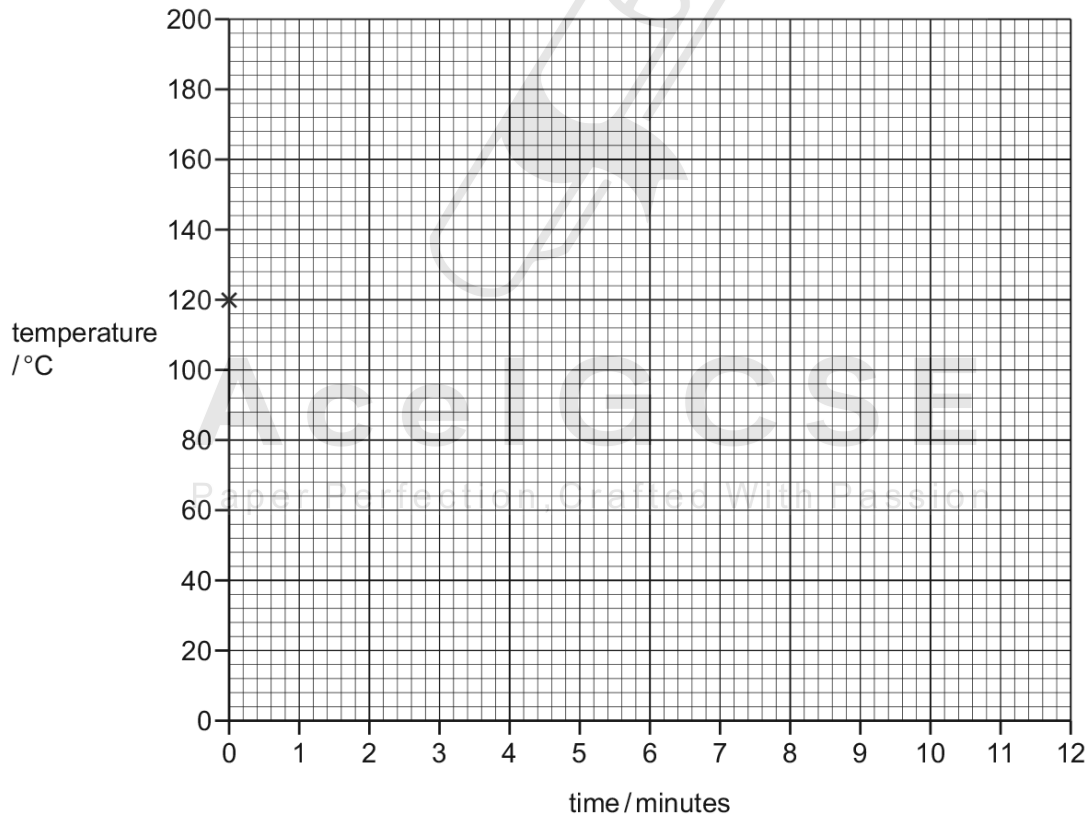
melting point .....

boiling point .....

[2]

(f) A sample of pure **Z** was allowed to cool from 120 °C to 20 °C. The total time taken was 8 minutes.

Starting from point ×, sketch on the grid how the temperature of the sample of pure **Z** changed between 0 minutes and 8 minutes.



[2]

[Total: 10]

04. 0620_w16_qp_41 Q: 1

The table gives some information about five substances.

substance	melting point /°C	boiling point /°C	solubility in water	electrical conductivity when molten	electrical conductivity when solid
F	–97	65	very soluble	does not conduct	does not conduct
G	1600	2230	insoluble	does not conduct	does not conduct
H	801	1413	soluble	conducts	does not conduct
I	–57	126	insoluble	does not conduct	does not conduct
J	1085	2562	insoluble	conducts	conducts

(a) Which substance in the table has ionic bonding?

..... [1]

(b) Which substance in the table has a giant covalent structure?

..... [1]

(c) Name a method you could use to separate a mixture of substance **J** and water.

..... [1]

(d) Name a method you could use to obtain substance **F** from a mixture of substance **F** and water.

..... [2]

(e) Describe how you could obtain a solid sample of substance **H** from a mixture of substance **H** and substance **G**.

.....

.....

.....

.....

.....

..... [3]

(f) Substance **J** is a metal.

Describe how substance **J** is able to conduct electricity when it is a solid.

.....

.....

..... [2]

[Total: 10]

05. 0620_w16_qp_43 Q: 1

(a) Complete the table.

particle	charge	relative mass
proton	+1	
neutron		1
electron		

[2]

(b) The following are isotopes of carbon.

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

(i) In terms of numbers of protons, neutrons and electrons, how are these **three** isotopes the same and how are they different?

They are the same because .....

.....

They are different because .....

.....

[3]

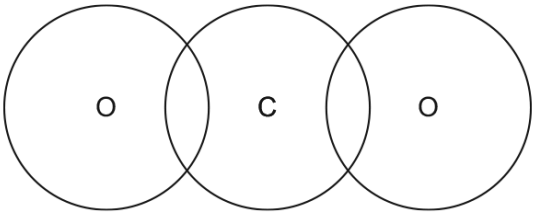
(ii) Why do all isotopes of carbon have the same chemical properties?

..... [1]

(c) Name **two** forms of the element carbon which have giant covalent structures.

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

(d) Complete the diagram to show the electron arrangement in a carbon dioxide molecule. Show the outer shell electrons only.



[2]

[Total: 9]

06. 0620_s15_qp_32 Q: 2

The table shows the melting points, boiling points and electrical properties of five substances, **A** to **E**.

substance	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of liquid
A	–7	59	poor	poor
B	1083	2567	good	good
C	755	1387	poor	good
D	43	181	poor	poor
E	1607	2227	poor	poor

Choose a substance from the table above to match each of the following descriptions. A substance may be used once, more than once or not at all. Justify each choice with evidence from the table.

One has been completed as an example.

This substance is covalent and is a solid at room temperature (25 °C). .....**D**.....

evidence *Its melting point is above room temperature. It has a low melting point and it does not conduct as a liquid, so it is covalent.*

(a) This substance has a giant covalent structure. .....

evidence .....

..... [3]

(b) This substance is a metal. .....

evidence .....

..... [2]

(c) This substance is a liquid at room temperature (25 °C). .....

evidence .....

..... [3]

(d) This substance is an ionic solid. .....

evidence .....

..... [3]

[Total: 11]

07. 0620_w15_qp_31 Q: 6

Carbon and silicon are elements in Group IV. They both form oxides of the type XO_2.

(a) Silicon(IV) oxide, SiO_2, has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide.

.....

.....

.....

.....

..... [3]

(ii) State **three** properties which silicon(IV) oxide and diamond have in common.

.....

.....

..... [3]

(iii) How could you show that silicon(IV) oxide is acidic and not basic or amphoteric?

.....

.....

..... [2]

(b) Explain why the physical properties of carbon dioxide are different from those of diamond and silicon(IV) oxide.

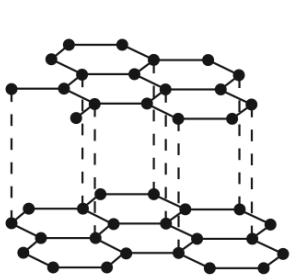
.....

..... [1]

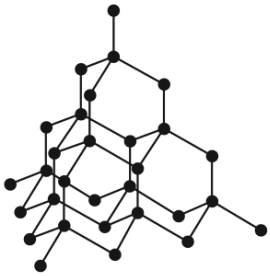
[Total: 9]

08. 0620_w14_qp_31 Q: 2

Two macromolecular forms of carbon are graphite and diamond. The structures of graphite and diamond are given below.



graphite



diamond

(a) Explain in terms of its structure why graphite is soft and is a good conductor of electricity.

.....

.....

.....

.....

..... [3]

(b) State **two** uses of graphite which depend on the above properties.

It is soft .....

.....

It is a good conductor of electricity .....

..... [2]

(c) Silicon(IV) oxide also has a macromolecular structure.

(i) Describe the macromolecular structure of silicon(IV) oxide.

.....

..... [1]

(ii) Predict **two** physical properties which diamond and silicon(IV) oxide have in common.

.....

..... [2]

[Total: 8]

09. 0620_s13_qp_31 Q: 8

There are three types of giant structure - ionic, metallic and giant covalent.

(a) In an ionic compound, the ions are held in a lattice by strong forces.

(i) Explain the term *lattice*.

.....

..... [2]

(ii) Explain how the ions are held together by strong forces.

.....

..... [1]

(b) Describe the bonding in a typical metal.

.....

.....

..... [3]

(c) The electrical conductivities of the three types of giant structure are given in the following table.

type of structure	conductivity of solid	conductivity of liquid
ionic	poor	good
metallic	good	good
giant covalent	poor	poor

Explain the differences in electrical conductivity between the three types of giant structure and the difference, if any, between the solid and liquid states of the same structure.

.....

.....

.....

.....

..... [5]

[Total: 11]

10. 0620_s13_qp_33 Q: 1

Substances can be classified as:

elements mixtures compounds

Elements can be divided into:

metals non-metals

(a) Define each of the following terms.

(i) *element*

.....

..... [2]

(ii) *compound*

.....

..... [2]

(iii) *mixture*

.....

..... [1]

(b) Classify each of the following as either an element, compound or mixture.

(i) brass ..... [1]

(ii) carbon dioxide ..... [1]

(iii) copper ..... [1]

(c) Which physical property is used to distinguish between metals and non-metals? It is possessed by all metals but by only one non-metal.

..... [1]

[Total: 9]

11. 0620_w13_qp_32 Q: 1

The table gives the melting points, the boiling points and the electrical properties of six substances A to F.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	–210	–196	does not conduct	does not conduct
B	777	1627	does not conduct	good conductor
C	962	2212	good conductor	good conductor
D	–94	63	does not conduct	does not conduct
E	1410	2355	does not conduct	does not conduct
F	1064	2807	good conductor	good conductor

(a) Which **two** substances could be metals? ..... [1]

(b) Which substance could be nitrogen? ..... [1]

(c) Which substance is an ionic solid? ..... [1]

(d) Which substance is a liquid at room temperature? ..... [1]

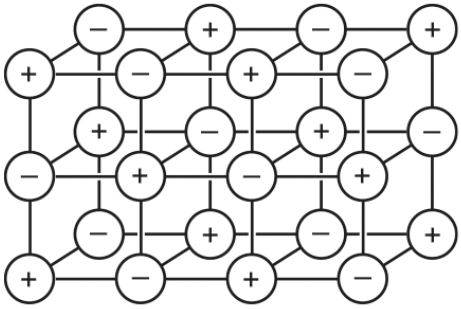
(e) Which substance has a giant covalent structure similar to that of diamond? ..... [1]

(f) Which **two** substances could exist as simple covalent molecules? ..... [1]

[Total: 6]

12. 0620_w13_qp_33 Q: 2

(a) The diagram shows the lattice of a typical ionic compound.



(i) Explain the term *ionic lattice*.

.....

..... [2]

(ii) In this lattice, the ratio of positive ions to negative ions is 1:1.
In the lattice of a different ionic compound, the ratio of positive ions to negative ions is 1:2.
Suggest why this ratio varies in different ionic compounds.

..... [1]

(iii) Give **three** physical properties of ionic compounds.

.....

.....

..... [3]

(b) Strontium oxide is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the **valency** electrons around the negative ion.
The electron distribution of a strontium atom is 2 + 8 + 18 + 8 + 2.

Use o to represent an electron from a strontium atom.
Use x to represent an electron from an oxygen atom.

[3]

[Total: 9]

13. 0620_s12_qp_32 Q: 2

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]

01. 0620_p20_ms_40 Q: 1

(a) A [1]

(b) D and F note: both needed for mark [1]

(c) E [1]

(d) B [1]

(e) C [1]

---

02. 0620_p20_ms_40 Q: 3

(a) (i) 6e between two nitrogen atoms; note: can be any combination of dots or crosses [1]
1 lone pair on each nitrogen atom; [1]

(ii)

	solid	gas	
pattern:	regular / lattice	random / irregular / no pattern;	[1]
distance:	close	far apart / spread out;	[1]
movement:	vibrate / fixed position	moving;	[1]

note: comparison must be made

(b) particles have more energy / move faster; [1]
collide harder / collide more frequently / more collisions / collide with more force; [1]
allow: molecules instead of particles

(c) (i) nitrogen has smaller M_r; [1]
nitrogen (molecules) move faster (than chlorine molecules) / ora; [1]
note: comparison must be made

(ii) (at higher temperature) molecules move faster / have more energy [1]

---

03. 0620_s19_ms_41 Q: 2

(a)	80(°C) (1)	1
(b)	horizontal line from end of graph at minute 9 to minute 11 (1)	1
(c)	energy is used to break bonds / overcome attraction (1) between molecules (1)	2

(d)	vibrations (1) increase (1)	2
(e)	melting point decreases (1) boiling point increases (1)	2
(f)	decrease from 120 °C to 80 °C and horizontal line at 80 °C (1) decrease from horizontal line to finish at 20 °C at 8 mins (1)	2

04. 0620_w16_ms_41 Q: 1

(a)	**H**	1
(b)	**G**	1
(c)	filtration	1
(d)	fractional distillation	1 1
(e)	add / mix / stir / dissolve / shake / heat with water filter / decant heat (filtrate) or (leave filtrate to) evaporate	1 1 1
(f)	electrons (electrons) move / flow (throughout structure)	1 1

05. 0620_w16_ms_43 Q: 1

(a)	<table><tr><td>proton</td><td>+1</td><td>1</td></tr><tr><td>neutron</td><td>0</td><td>1</td></tr><tr><td>electron</td><td>–1</td><td>$^1/_{1840}$</td></tr></table>	**2**
(b)(i)	(same) number of protons and electrons / 6 protons and six electrons (different) neutron (number) / 6,7 and 8 neutrons	**2** **1**
(b)(ii)	same <u>number</u> of electrons / electron configuration	**1**
(c)	diamond *and* graphite	**1**
(d)	two double bonds with no extra electrons on the carbon atoms both oxygen atoms with four non-bonding electrons	**1** **1**

06. 0620_s15_ms_32 Q: 2

(a)	E; high melting point / mp / mpt **OR** high boiling point / bp / bpt; poor / non conductor (when liquid and / or solid);	**3**	**I** mpt/bpt above room temp
(b)	B; (good) conductor when <u>solid</u> (and liquid);	**2**	**A** (good) conductor in any state / both states **I** high melting point/boiling point **R** low melting point/boiling point
(c)	A; melting point / –7 (°C) is below room temperature / 25 (°C) / RTP ora; boiling point / 59 (°C) is above room temperature / 25 (°C) / RTP ora;	**3**	**I** low melting point / boiling point / conductivity 25 (°C) / room temperature / RTP is in between –7 (°C) and 59 (°C) **OR** 25 (°C) / room temperature / RTP is between mpt and bpt would both score the 2 evidence marks
(d)	C; high melting point / mp / mpt **OR** high boiling point / bp / bpt; **BOTH** poor / non conductor when solid **and** good conductor when liquid **OR** molten / only conduct when liquid;	**3**	**A** melting point **and** boiling point both above room temp / 25 °C / RTP **I** conducts when aqueous or in solution **I** conducts in liquid due to free electrons

07. 0620_w15_ms_31 Q: 6

(a)(i)	any three from: • each oxygen is joined to two silicons / atoms; • each silicon is joined to four oxygens / atoms; • tetrahedral (around silicon) / similar to diamond; • linear around oxygen;	**3**
(a)(ii)	any three from: • high melting point / boiling point; • hard; • strong; • (colourless) crystalline (solid); • brittle / not malleable; • poor / non-conductor (of electricity) / insulator; • insoluble (in water);	**3**
(a)(iii)	SiO_2 reacts with or dissolves in or neutralises an acid or acidic oxide; SiO_2 does not react or dissolve in or neutralise an alkali or base or basic oxide;	**1** **1**
(b)	carbon dioxide has a simple molecular structure;	**1**

08. 0620_w14_ms_31 Q: 2

(a) soft because weak forces between layers/sheets/rows [1]

layers can slip/slide [1]

good conductor because electrons can move/mobile [1]

(b) it is soft: pencils **or** lubricant **or** polish [1]
good conductor: electrodes **or** brushes (in electric motors) [1]

(c) **(i)** every silicon atom is bonded/attached to 4 oxygen atoms or every oxygen bonded/attached to two silicon atoms [1]

(ii) Any **two** from:
high melting point/boiling point
hard
colourless crystals/shiny
poor/non-conductor of electricity/insulator
insoluble in water [2]

[Total: 8]

---

09. 0620_s13_ms_31 Q: 8

(a) **(i)** regular arrangement / repeating pattern **NOT** structure [1]
cond: ions [1]
not molecules / atoms

(ii) attraction between opposite charges / electrostatic attraction [1]

(b) delocalised / mobile / free / sea of electrons [1]
positive ions / cations
not atoms / protons / nuclei [1]
attraction between these electrons and ions [1]

(c) **giant covalent**
no ions [1]
no delocalised / free / mobile / sea of electrons **or** all electrons [1]

ionic
in ionic solid ions cannot move [1]
liquid ionic compound ions can move [1]

metallic
(both solid and liquid) metals have delocalised (**or** alternative term) electrons [1]

[Total: 11]

---

10. 0620_s13_ms_33 Q: 1

(a) (i) *element*
cannot be broken into anything simpler [1]
by chemical means [1]
OR made up of one type of atom only [2]

(ii) *compound*
two **or** more different elements [1]
chemically bonded together [1]

(iii) *mixture*
two **or** more substances not chemically joined together [1]

(b) (i) mixture [1]

(ii) compound [1]

(iii) element [1]

(c) conductivity (of heat or electricity) [1]

[Total: 9]

---

11. 0620_w13_ms_32 Q: 1

(a) C **and** F [1]

(b) A [1]

(c) B [1]

(d) D [1]

(e) E [1]

(f) A **and** D [1]

[Total: 6]

---

12. 0620_w13_ms_33 Q: 2

(a) (i) positive **and** negative ions [1]
regular pattern / opposite charges closer than the same charge [1]

(ii) so that charges cancel / ions may not have the same charge [1]

(iii) Any **three** of:
high melting point or boiling point
hard
brittle
soluble in water / insoluble in organic solvents
conduct (electricity) in liquid state **or** in aqueous solution / non-conductors or poor conductor (when solid) [3]

(b) correct formula [1]
correct charges [1]
6x and 2o around oxygen [1]

[Total: 9]

---

13. 0620_s12_ms_32 Q: 2

(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]
