OVERALL BONDING WS 1

SECTION A

1 Which of the following exists in the solid state as a giant covalent lattice?

A ice

B iodine

C silicon(IV) oxide

D tin(IV) chloride

2 Why does copper wire conduct electricity when a potential difference is applied?

A Bonding electrons in the crystal lattice move.

B Copper(II) ions move to the cathode.

C The atoms of copper become ionised.

D The crystal lattice breaks down.

3 When heated, solid iodine readily forms iodine vapour.

What does this information suggest about the nature of the particles in these two physical states of iodine?

	solid	*vapour*
A	ionic	atomic
B	ionic	molecular
C	molecular	atomic
D	molecular	molecular

4 Which of the following solids has a simple molecular lattice?

A magnesium oxide

B sodium

C silicon(IV) oxide

D sulphur

5 Why does the exothermic reaction

$$\text{C(diamond)} \longrightarrow \text{C(graphite)} \qquad \Delta H = -3\ \text{kJ mol}^{-1}$$

not occur spontaneously?

A A tetrahedral configuration is always more stable than a planar one.

B Diamond has only strong covalent bonds whereas graphite has both covalent bonds and van der Waals' forces.

C The change from diamond to graphite has a high activation energy.

D The density of graphite is less than that of diamond.

6 A substance commonly found in the house or garden has the following properties.

- It is combustible.
- It is an electrical insulator.
- It melts over a range of temperature.

What could the substance be?

A brass

B paper

C poly(ethene)

D silicon(IV) oxide

7 Which solid exhibits more than one kind of chemical bonding?

A brass

B copper

C diamond

D ice

8 Which type of bonding is **never** found in elements?

A covalent

B ionic

C metallic

D van der Waals' forces

[W'15 2 Q1]

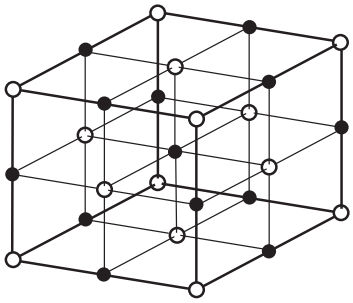
9 Three substances, *R*, *S*, *T*, have physical properties as shown.

substance	mp / °C	bp / °C	electrical conductivity	
			of solid	of liquid
R	801	1413	poor	good
S	2852	3600	poor	good
T	3550	4827	good	not known

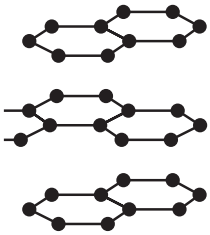
What could be the identities of *R*, *S* and *T* ?

	R	*S*	*T*
A	NaF	KC*l*	Cu
B	NaBr	BaO	SiO_2
C	NaC*l*	MgO	C [graphite]
D	NaBr	CaO	C [diamond]

10 The diagram shows part of the lattice structures of solids **X** and **Y**. [In **X**, ○ and ● represent particles of different elements.]



X



Y

What are the types of bonding present in **X** and **Y**?

	X	**Y**
A	covalent	metallic
B	ionic	covalent
C	ionic	metallic
D	metallic	ionic

11 What are the lattice structures of solid diamond, iodine and silicon(IV) oxide?

	giant molecular	simple molecular
A	diamond, silicon(IV) oxide	iodine
B	diamond, iodine	silicon(IV) oxide
C	iodine	diamond, silicon(IV) oxide
D	silicon(IV) oxide	diamond, iodine

12 Which solid has a simple molecular lattice?

A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

13 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp / °C	801	2852	3550
bp / °C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO_2
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO_2

14 Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point / °C	boiling point / °C	density / g cm^{-3}
X	–7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	**Y**	**Z**
A	Br_2	A*l*	Si
B	Br_2	Na	Mg
C	I_2	Mg	Na
D	I_2	Si	K

15 Three compounds have the physical properties shown in the table.

compound	**P**	**Q**	**R**
melting point / °C	2852	993	–119
boiling point / °C	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

	P	**Q**	**R**
A	MgO	KC*l*	NH_3
B	MgO	NaF	C_2H_5Br
C	SiO_2	KC*l*	C_2H_5Br
D	SiO_2	NaF	HC*l*

16 Which solid contains more than one kind of bonding?

A iodine

B silicon dioxide

C sodium chloride

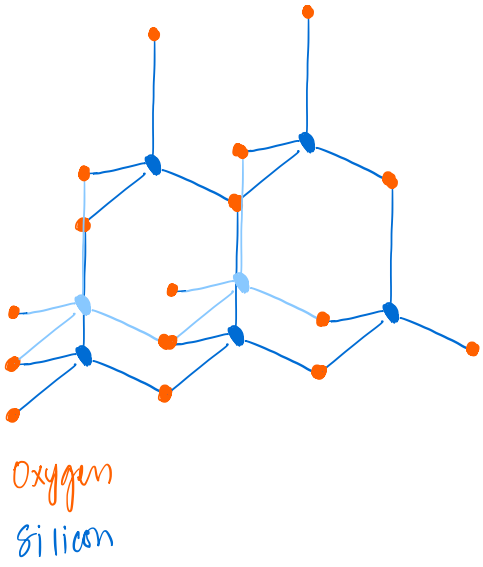
D zinc

17 Some car paints contain small flakes of silica, SiO_2.

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in this statement?



	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

18 Which pair of elements has chemical bonds of the same type between their atoms in the solid state?

A aluminium and phosphorus

B chlorine and argon

C magnesium and silicon

D sulfur and chlorine

19 Two conversions are outlined below.

NH_4^+ NH_3

C_2H_4 C_2H_6

What similar feature do these two conversions have?

A a lone pair of electrons in the product

B change in oxidation state of an element

C decrease in bond angle of the species involved

D disappearance of a π bond

20 Magnesium oxide is used to line industrial furnaces because it has a very high melting point.

Which type of bond needs to be broken for magnesium oxide to melt?

A co-ordinate

B covalent

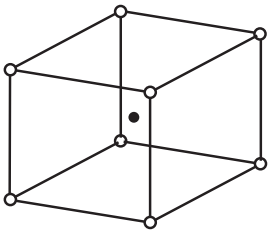
C ionic

D metallic

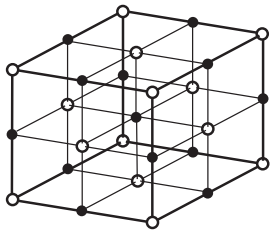
21 The table gives the radii, in pm, of some ions. [1 pm = 10^{-12} m]

ion	radii
Na^+	102
Mg^{2+}	72
Cs^+	167
Cl^-	181
O^{2-}	140

Caesium chloride, CsC*l*, has a different lattice structure from both sodium chloride, NaC*l*, and magnesium oxide, MgO.



CsC*l* lattice



NaC*l* and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

A the charge on the cation

B the ratio of the ionic charges

C the ratio of the ionic radii

D the sum of the ionic charges

22 Substances X, Y and Z are all solids. Some of their physical properties are given in the table.

substance	X	Y	Z
melting point / °C	772	114	1610
boiling point / °C	1407	183	2205
electrical conductivity of the liquid state	conducts	does not conduct	does not conduct

What type of lattice could each substance have?

	X	Y	Z
A	giant molecular	simple molecular	ionic
B	ionic	giant molecular	simple molecular
C	ionic	simple molecular	giant molecular
D	simple molecular	ionic	giant molecular

23 Four substances have the physical properties shown.

Which substance is an ionic solid?

	melting point / °C	boiling point / °C	electrical conductivity of solid	electrical conductivity of molten substance	electrical conductivity of aqueous solution
A	–115	–85	poor	poor	good
B	660	2470	good	good	insoluble
C	993	1695	poor	good	good
D	1610	2230	poor	poor	insoluble

24 Which solid contains more than one kind of bonding?

A copper

B diamond

C ice

D magnesium oxide

25 $AlCl_3$ reacts with $LiAlH_4$ and $(CH_3)_3N$ to give $(CH_3)_3NAlH_3$.

Which statement about $(CH_3)_3NAlH_3$ is correct?

A It contains hydrogen bonding.

B It is dimeric.

C The Al atom has an incomplete octet of electrons.

D The bonds around the Al atom are tetrahedrally arranged.

26 Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure and properties. Carbon is in Group 14. Silica, SiO_2, is a Group 14 compound.

Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solids exist in a lattice structure.

B Both solids have a simple molecular structure.

C Both solids have atoms joined by single covalent bonds.

D Both solids change spontaneously to gas at s.t.p.

27 Which solid has a simple molecular lattice?

A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

28 Some car paints contain small flakes of silica, SiO_2.

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in these statements?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

Repeat

29 Three substances have the physical properties shown in the table.

substance	melting point / °C	boiling point / °C	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	–70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	V	W
A	Na	KCl	$SiCl_4$
B	Na	NaF	C_2H_5Br
C	Zn	KCl	HCl
D	Zn	NaF	$SiCl_4$

30 Which solid contains more than one type of bonding?

A iodine

B silicon dioxide

C sodium chloride

D zinc

[S'18 1 Q6]

31 Which element shows the greatest tendency to form covalent compounds?

A boron

B magnesium

C neon

D potassium

[W'16 2 Q13]

32 Repeat

Solid carbon dioxide, CO_2, is similar to solid iodine, I_2, in its structure and properties. Carbon is in Group 14. Silica, SiO_2, is a Group 14 compound.

Which statement about solid CO_2 and solid SiO_2 is correct?

A Both solids exist in a lattice structure.

B Both solids have a simple molecular structure.

C Both solids have atoms joined by single covalent bonds.

D Both solids change spontaneously to gas at s.t.p.

[M'16 Q8]

SECTION B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

1 Which of the following are features of the structure of metallic copper?

1 ionic bonds

2 delocalised electrons

3 lattice of ions

2 Silicon tetrachloride, $SiCl_4$, is a liquid of low boiling point. In the presence of water it decomposes to form silicon(IV) oxide and hydrogen chloride.

What types of bonding occur in $SiCl_4$(l)?

1 co–ordinate bonding

2 covalent bonding

3 van der Waals forces

3 Which of the following statements are correct for the sequence of compounds below considered from left to right?

NaF MgO AlN SiC

1 The electronegativity difference between the elements in each compound increases.

2 The formula-units of these compounds are isoelectronic (have the same number of electrons).

3 The bonding becomes increasingly covalent.

4 Which pairs of compounds contain one that is giant ionic and one that is simple molecular?

1 Al_2O_3 and Al_2Cl_6

2 SiO_2 and $SiCl_4$

3 P_4O_{10} and PCl_3

5 Which of the following solids contain more than one type of chemical bond?

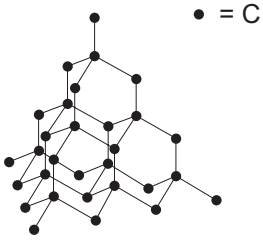
1 brass (an alloy of copper and zinc)

2 graphite

3 ice

6 Which diagrams represent part of a giant molecular structure?

1



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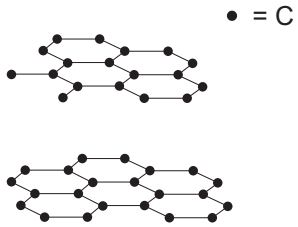

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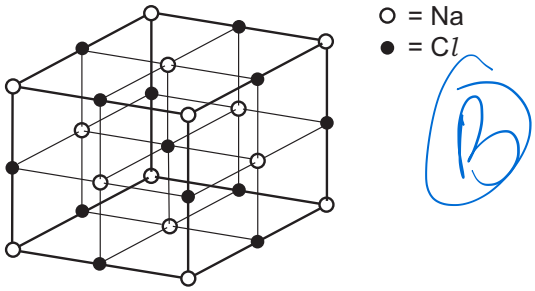


7 Boron is a non-metallic element which is placed above aluminium in Group III of the Periodic Table. It forms a compound with nitrogen known as boron nitride which has a graphite structure.

Which of the following conclusions can be drawn from this information?

1 The empirical formula of boron nitride is BN.

2 The boron and nitride atoms are likely to be arranged alternately in a hexagonal pattern.

3 Boron nitride has a layer structure with van der Waals' forces between the layers.

8 The Group IV elements carbon, silicon and germanium all exist in a diamond structure. The bond lengths in these structures are given below.

element *X*	C	Si	Ge
bond length *X*–*X*/nm	0.154	0.234	0.244

Why does the bond length increase down the group?

1 Orbital overlap decreases down the group.

2 Atomic radius increases down the group.

3 Nuclear charge increases down the group.

9 Which of these substances have a giant structure?

1 silicon(IV) oxide

2 baked clay found in crockery

3 phosphorus(V) oxide

10 Which substances have a giant structure?

1 calcium oxide

2 calcium

3 baked clay found in crockery

11 Which compounds contain covalent bonds?

1 aluminium chloride

2 ammonia

3 calcium fluoride

12 Which substances contain delocalised electrons?

1 cyclohexene

2 graphite

3 sodium

C

[S'13 2 Q33]

OVERALL BONDING WS 2

1 **(a)** Give the full electron configuration of the following.

(i) Mg $1s^2\ 2s^2\ 2p^6\ 3s^2$

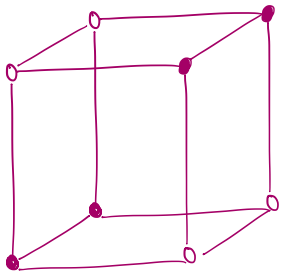
(ii) Mg^{2+} $1s^2\ 2s^2\ 2p^6$

(iii) O $1s^2\ 2s^2\ 2p^4$

(iv) O^{2-} $1s^2\ 2s^2\ 2p^2$

[2]

(b) **(i)** Describe, with the aid of a diagram, the lattice structure of magnesium oxide.



- Mg^{2+}
- O^{2-}

(ii) Use your diagram to interpret and explain **two** physical properties of magnesium oxide.

It has high melting point and does not conduct electricity

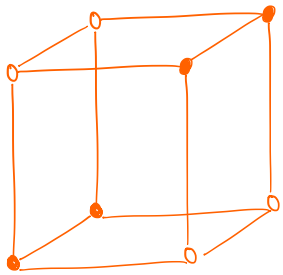
(iii) State **two** large scale uses of magnesium oxide.

Lining the insides of blast furnaces.
Used in spark plugs.

[5]

- Electrical insulators.
- Ceramics.

2 **(a)** Salt, sodium chloride, forms transparent colourless crystals. Describe the bonding in sodium chloride crystals, give the formula of each particle and sketch part of the crystal structure.



[3]

(b) Explain why crystals of sodium chloride do not conduct electricity, but molten sodium chloride does.

In liquid form the ions are free to move and carry the charge.

[2]

[W'03 Q1]

3 Drawing diagrams where appropriate, suggest in terms of structure and bonding, explanations for the following.

(i) the high melting point and boiling point of Al_2O_3

Al_2O_3 has a giant structure of ions that are held together by strong ionic bonds. These make it very difficult to break the lattice, so Al_2O_3 has a high melting and boiling point.

(ii) the low boiling point of SO_3

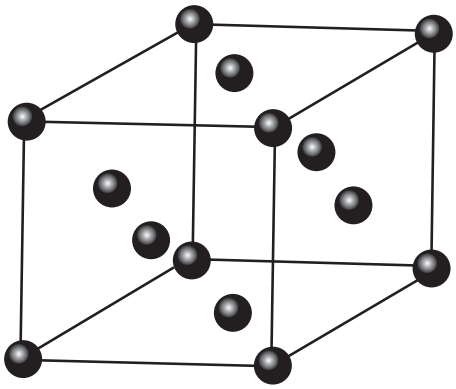
SO_3 exists as a simple covalent molecule and is held together by weak intermolecular forces caused by induced-dipoles. The energy required to overcome these bonds is less hence its boiling point is low.

(iii) the melting point of SiO_2 is much higher than that of P_4O_{10}

SiO_2 exists as a macromolecule and is held together by strong covalent bonds. Large amounts of energy is required to overcome these bonds compared to P_4O_{10} which is a simple covalent structure with weak IMF.

[7]

4 Copper and iodine are both solids which have different physical and chemical properties. Each element has the same face-centred crystal structure which is shown below.



The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ● .

(a) Which type of particles are present in the iodine crystal? Give their formula.

particle ..... molecules. .....

formula ..... I_2 ..... [2]

(b) When separate samples of copper or iodine are heated to 50 °C, the copper remains as a solid while the iodine turns into a vapour.

(i) Explain, in terms of the forces present in the solid structure, why copper remains a solid at 50 °C.

Copper is held together in a metallic lattice, cations surrounded by electrons. Where as I_2 has is held together by weak vandr waals forces.

(ii) Explain, in terms of the forces present in the solid structure, why iodine turns into a vapour when heated to 50°C.

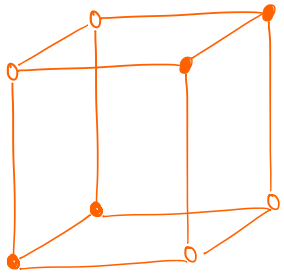
I_2 is held together by weaker van der waals' forces that are overcome at 50°C.

[4]

5 Suggest, in terms of the structure and bonding, explanations for the following. You should draw diagrams where you think they will help your answer.

(i) the high melting point of sodium chloride

NaCl is held together by strong ionic bonds that require a lot of energy to be overcome.



(ii) the low melting point of silicon tetrachloride

SiCl4 is a simple covalent structure with weak vdw der Waals' forces between the molecules.

[4]

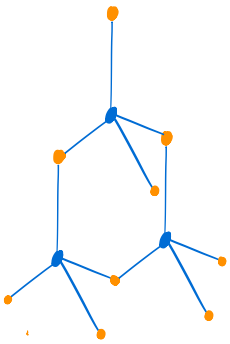
6 The elements carbon and silicon are both in Group IV of the Periodic Table.
Carbon is the second most abundant element by mass in the human body and silicon is the second most common element in the Earth's crust.

Carbon and silicon each form an oxide of general formula XO_2.
At room temperature, CO_2 is a gas while SiO_2 is a solid with a high melting point.

(a) Briefly explain, in terms of the chemical bonds and intermolecular forces present in **each** compound, why CO_2 is a gas and SiO_2 is a solid at room temperature.

SiO_2 exists as macromolecule in which covalent bonds need to be overcome for it to melt, requiring lots of energy. CO_2 is a simple covalent molecule with weak van der Waals' forces that are easily overcome at r.t.p. [3]

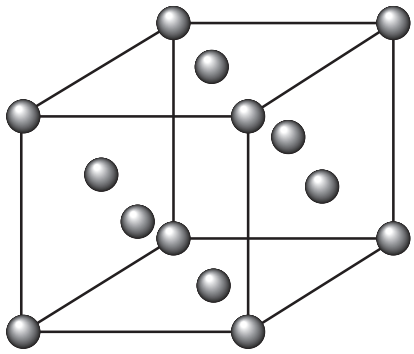
(b) Draw a simple diagram to show the structure of SiO_2. Your diagram should contain at least **two** silicon atoms **and** show clearly how many bonds each atom forms.



• Silicon
• Oxygen.

Key point here is that each silicon is 'connected' to 4 oxygens and each oxygen to 2 silicons. [2]

7 Copper, proton number 29, and argon, proton number 18, are elements which have different physical and chemical properties.
In the solid state, each element has the same face-centred cubic crystal structure which is shown below.



The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ●.

(a) Which types of particle are present in the copper and argon crystals?
In each case, give their formula.

element	particle	formula
copper	Catims	Cu^{2+}
argon	atoms	Ar.

[2]

At room temperature, copper is a solid while argon is a gas.

(b) Explain these observations in terms of the forces present in **each** solid structure.

In the solid state, Coppur has catims held firmly in a sea of delocalised electrons by strong metallic bonds. This gives it a stable structure with high MP. Argon, on the other hand, has weak IMF caused by induced dipoles. These forces are easily overcome by the energy at room temperature. [4]

8 Separate samples of the oxides MgO and SiO_2 are melted.
Each molten sample is then tested to see whether or not it conducts electricity.

Suggest what would be the results in **each** case. Explain your answers.

MgO : ionic compound, will have free moving ions when molten.

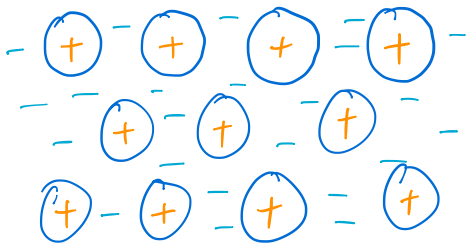
SiO_2 Not ionic, no ions.

[4]

9 **(c)** Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of cerium's compounds contain Ce^{3+} or Ce^{4+} ions.

(i) Cerium shows the same structure and bonding as a typical metal.

Draw a labelled diagram to show the structure and bonding in cerium.



[2]

(ii) Cerium(IV) oxide, CeO_2, is a ceramic.

Suggest **two** physical properties of cerium(IV) oxide.

1. High Melting Point
2. Electrical insulator.

[2]

10 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.

Sodium would react rapidly with chlorine, giving bright yellow/orange light. The yellow/green gas disappears and white solid forms. [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 NaCl has a giant lattice structure with strong ionic bonds holding the ions in place.

$SiCl_4$ structure **and** bonding Simple molecular structure with covalent bonding and induced dipoles btw molecules.

explanation Large difference in electronegativities in NaCl leads to a transfer of electrons to form ions. These are then held together by strong electrostatic force of attraction giving NaCl a high melting point. For $SiCl_4$, the small difference in electronegativity and symmetry in shape leads to induced dipoles as IMF that don't require a lot of energy to break, resulting in low M.P and B.P. [4]

11 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.

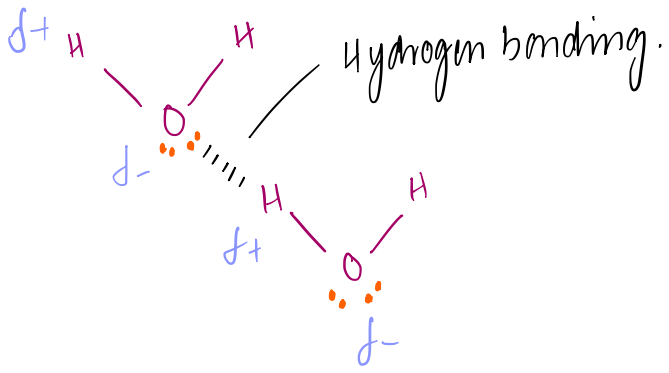
crystalline solid	type of bonding	type of lattice structure
copper	Metallic	Metallic lattice
ice	Covalent	hydrogen bonded simple molecular
silicon(IV) oxide	covalent	macromolecular
iodine	covalent	Simple molecular
sodium chloride	Ionic	Giant ionic lattice

[5]

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

Hydrogen bonding [1]

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



[3]