4. States of matter

4.2 Bonding and structure

Paper 2

Question Paper

1 **(d)** Boron nitride is a white solid that melts above 2900 °C.

Fig. 2.2 shows part of the lattice structure of a crystal of boron nitride.

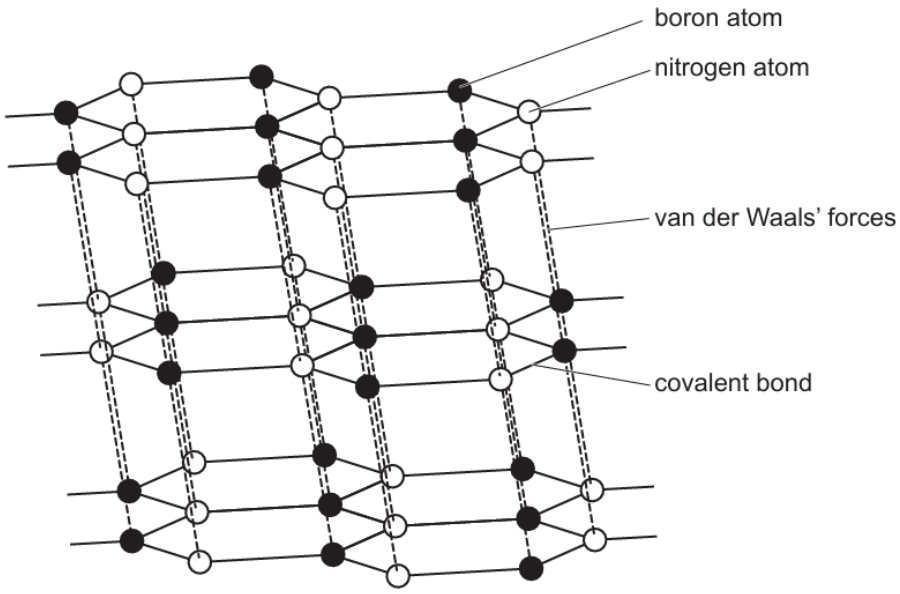

Fig. 2.2

(i) Use Fig. 2.2 to deduce the empirical formula of boron nitride.

..... [1]

(ii) Suggest the identity of another crystalline solid that has atoms arranged in layers similar to that of solid boron nitride.

..... [1]

2 The Group 14 elements show a change from non-metallic to metallic character down the group.

(a) Table 3.1 shows some properties of two Group 14 elements, C and Sn, in their standard states. The table is incomplete.

Table 3.1

	C (graphite)	Sn
state and appearance in standard state	grey shiny solid	silvery solid
electrical conductivity		good
type of bonding		metallic
type of structure	giant	

(i) Complete Table 3.1. [3]

(ii) Identify the lattice structure shown by graphite.

..... [1]

(iii) Explain why Sn has good electrical conductivity.

.....

..... [1]

3 **(e)** A form of solid nitrogen has a lattice structure similar to solid iodine.

Identify the type of lattice structure of solid nitrogen.

..... [1]

4 The melting points of some solids are shown in Table 1.1.

Table 1.1

solid	melting point/K
magnesium	923
phosphorus	317
sodium chloride	1074
sulfur	392

(a) (i) State the type of bonding present in magnesium and in sodium chloride.

bonding in magnesium .....

bonding in sodium chloride .....
[1]

(ii) Explain the difference in the melting points of magnesium and sodium chloride.

.....

..... [1]

(iii) Explain the difference in the melting points of phosphorus and sulfur in terms of structure and bonding.

.....

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..... [2]

5 **(d)** $POCl_3$ shows similar chemical properties to PCl_5.

$POCl_3$ has a melting point of 1°C and a boiling point of 106 °C.

$POCl_3$ reacts vigorously with water, forming misty fumes and an acidic solution.

(i) Explain how the information in **(d)** suggests the structure and bonding of $POCl_3$ is simple covalent.

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.....

..... [2]

6 **(a)** Magnesium has a melting point of 650 °C and high electrical conductivity.

Explain these properties of magnesium by referring to its structure and bonding.

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..... [2]

7 Radium, Ra, is an element found in Group 2 of the Periodic Table. It is a crystalline solid at room temperature and conducts electricity.

Radium chloride, $RaCl_2$, has a melting point of 900 °C and is soluble in water.

(a) Predict the lattice structure of $RaCl_2$(s) based on the properties described.

..... [1]

8 The strength of interaction between particles determines whether the substance is a solid, liquid or gas at room temperature.

(a) Lithium sulfide, Li_2S, is a crystalline solid with a melting point of 938 °C. It conducts electricity when it is molten.

(i) Give the formulae of the particles present in solid lithium sulfide.

..... [1]

(ii) Explain, in terms of the structure of the crystalline solid, why lithium sulfide has a high melting point.

.....

..... [2]

9 Sulfides are compounds that contain sulfur but not oxygen.

(a) Carbon disulfide, CS_2, is a volatile liquid at room temperature and pressure.

(i) State the meaning of *volatile*.

..... [1]

10 Phosphorus is a reactive Period 3 element.

(a) Phosphorus has several allotropes. Details of two allotropes are given.

allotrope of phosphorus	formula	melting point / °C
white	P_4	44
red	P	590

(i) White phosphorus and red phosphorus both have covalent bonding.

Suggest the types of structure shown by white phosphorus (P_4) and red phosphorus (P).

Explain why red phosphorus (P) has a higher melting point than white phosphorus (P_4).

structure of P_4 .....

structure of P .....

explanation .....

.....

.....

[3]

11 **(a)** Table 1 gives physical data for some of the Period 3 elements.

Table 1

atomic number, *Z*	11	12	13	14	15	16	17
bonding present in element	M						C
first ionisation energy / kJ mol^{-1}	494	736	577	786	1060	1000	1260
maximum oxidation number							+7
anionic radius / nm	–	–	–	0.271	0.212	0.184	0.181

(i) Complete the row in the table labelled 'bonding present in element'.

Use C = covalent, I = ionic, M = metallic, as appropriate. [1]

12 Phosphorus, sulfur and chlorine can all react with oxygen to form oxides.

(a) Phosphorus reacts with an excess of oxygen to form phosphorus(V) oxide.

(iii) State the structure and bonding of solid phosphorus(V) oxide.

..... [1]

13 Phosphorus, sulfur and chlorine can all react with oxygen to form oxides.

(e) Element **E** is a Period 5 element.

E reacts with oxygen to form an insoluble white oxide that has a melting point of 1910 °C. The oxide of **E** conducts electricity only when liquid.

E also reacts readily with Cl_2(g) to form a white solid that reacts exothermically with water. The resulting solution reacts with aqueous silver nitrate to form a white precipitate that dissolves in dilute ammonia.

(i) Suggest the type of bonding shown by the **oxide** of **E**. Explain your answer.

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..... [2]

(ii) Suggest the type of bonding shown by the **chloride** of **E**. Explain your answer.

.....

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..... [2]

14 The Period 3 elements, Na to S, all react with oxygen to form oxides.

(d) Explain why phosphorus(V) oxide has a low melting point of approximately 300 °C but magnesium oxide has a high melting point of approximately 2850 °C.

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..... [3]

(f) Describe the lattice structure of silicon(IV) oxide.

Your answer should include reference to the arrangement of the silicon and oxygen atoms and the bonds between them.

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..... [2]

15 Magnesium silicide, Mg_2Si, is a compound made by heating magnesium with sand.

(c) Suggest, with reference to structure and bonding, why SiH_4 is a gas at room temperature.

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..... [2]

16 **(b)** **(i)** Explain why the boiling point of SiO_2 is much higher than the boiling point of SO_3.

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..... [3]