04-05 Chemical Bonding and Materials

Set B Exam practice

Name	Time 65 minutes	Total 40 marks	Score ____ / 40

Use a copy of the Periodic Table where you need one.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
2 Why Do Atoms Combine?	2	1	1	
3 Ionic Bonding	1, 3, 10, 14	6	4	
4 Covalent Bonding	9, 11	7	5	
5 Giant Covalent Structures	7, 8	13	8	
6 Metallic Bonding and Alloys	4, 5, 6, 12	10	6	
7 Structure and Properties	13	3	2	

A Multiple choice

6 MARKS

1 Oxygen reacts with a metal X to form an ionic compound XO. Which statement about oxygen is correct when forming this compound?

A one atom of oxygen gives away one electron to an atom of X
B one atom of oxygen gives away two electrons to an atom of X
C one atom of oxygen receives one electron from an atom of X
D one atom of oxygen receives two electrons from an atom of X

/1

Answer ☐ [1]

Source: 2023 GESS Sec 3 End-of-Year P1 Q10

2 Which of the following elements would be expected to form the largest ion (most number of electron shells) with a noble gas configuration?

A oxygen **B** fluorine **C** potassium **D** magnesium

/1

Answer ☐ [1]

Source: 2023 XMS Sec 3 WA2 Q1

3 Element P has an electronic configuration of 2.8.8.2. Element Q has an electronic configuration of 2.8.7. What is the likely chemical formula of the compound containing only P and Q?

A P_7Q_2 **B** PQ_2 **C** P_2Q **D** PQ

/1

Answer [1]

Source: 2023 XMS Sec 3 WA2 Q2

4 Which particles enable the conduction of electricity through metals?

A positive ions and electrons

B positive ions and negative ions

C positive ions only

D electrons only

/1

Answer [1]

Source: 2023 XMS Sec 3 WA2 Q4

5 Iron is a metal. Its structure consists of a giant lattice of positive ions in a 'sea of electrons'. Which statements about solid iron are correct?

1 Iron conducts electricity because the electrons are free to move.
2 Iron conducts heat because the positive metal ions are free to move.
3 Iron has a high melting point due to the strong ionic bonds.
4 Iron is malleable because the layers of atoms can slide over one another.

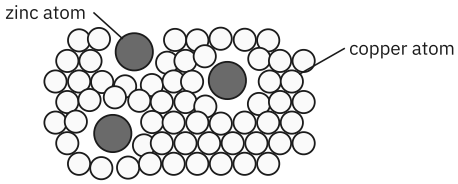
A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 1, 2 and 4

/1

Answer [1]

Source: 2023 PLMGS Sec 3 End-of-Year P1 Q6

6 The diagram shows the structure of brass.



Why is brass harder than pure copper?

A The zinc atoms form strong covalent bonds with copper atoms.

B The zinc atoms prevent layers of copper atoms from slipping over each other easily.

C The zinc atoms prevent the 'sea of electrons' from moving freely in the lattice.

D Zinc atoms have more electrons than copper atoms.

/1

Answer [1]

Source: 2024 Dunman Sec 4 Prelim P1 Q29

B Structured questions

34 MARKS

7 Carbon has many allotropes, including diamond, buckyball, graphite and single-walled carbon nanotubes (SWCNT). Carbon atoms have four valence electrons and prefer to share electrons rather than transfer them. A buckyball is a molecule made of 60 carbon atoms. SWCNT is one flat sheet of carbon atoms rolled into a cylinder, and graphite is a stack of such sheets. Each carbon atom in buckyball, SWCNT and graphite is bonded to three other carbon atoms, so these structures have one delocalised electron per carbon atom. Each carbon atom in diamond is bonded to four other atoms. The table shows some properties.

property	diamond	buckyball	graphite	SWCNT
electrical conductivity / S per cm	0.001	0.00001	4000	1 000 000

relative electron movement speed	low	very low	high	very high
melting point / °C	4030	600	3600	3550
relative cost	high	very high	low	high
solubility in organic solvents	no	yes	no	no
flexibility	no	yes	no	yes

(a) Explain, in terms of electronic configuration, why carbon has a tendency to form molecules but not ions.

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[1]

(b)

(i) With reference to the table, state the relationship between the relative electron movement speed and electrical conductivity.

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[1]

(ii) With reference to their structures, explain why SWCNT is a much better conductor of electricity than diamond.

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[3]

(c) Scientists consider buckyball to have a simple molecular structure.

(i) Give two pieces of evidence from the table that support this.

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[2]

(ii) Using information from the passage, suggest the chemical formula of buckyball.

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[1]

(d) Suggest and explain which of the four carbon allotropes will be most suitable to be used in flexible solar cells.

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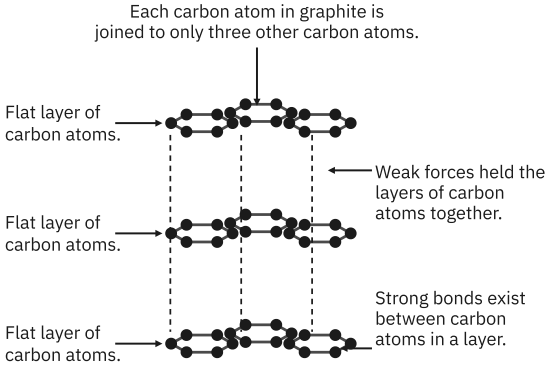
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[2]

/10

Source: 2022 XMS Sec 3 WA2 B4, adapted

8 Carbon is a highly versatile element that exists in different forms such as diamond, graphite and fullerene. Figure 1 shows the structure of graphite and Figure 2 shows the structure of a buckyball, C_{60}, which has 60 carbon atoms covalently bonded in a cage-like structure.



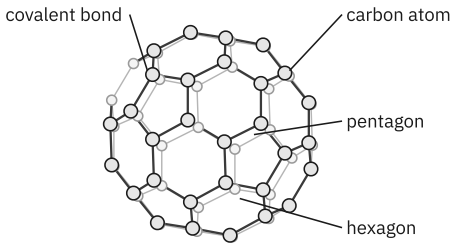


Figure 1 (left) and **Figure 2** (right)

(a) State a physical property of graphite.

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[1]

(b) By comparing the structures of graphite and buckyball, predict if buckyball can conduct electricity. Explain your answer.

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[2]

/3

Source: 2023 XMS Sec 3 WA2 Q8

9 Oxygen and chlorine combine to form a brownish-yellow gas, dichlorine monoxide (Cl_2O). Oxygen and chlorine also combine with aluminium to form aluminium oxide and aluminium chloride respectively.

(a) Draw a dot-and-cross diagram to show the bonding in dichlorine monoxide. Show only the valence electrons.

[2]

(b) Aluminium oxide has a melting point of 2072 °C while aluminium chloride has a melting point of 192.4 °C. Using your understanding of bonding and structure, put a tick in one box in each row to show whether each statement is true or false.

statement	true	false
(i) The ionic bonding in aluminium oxide is much stronger than in aluminium chloride.		
(ii) Aluminium chloride has a simple molecular structure while aluminium oxide has a giant ionic lattice structure.		
(iii) Both aluminium oxide and aluminium chloride can conduct electricity when molten.		

/5

[3]

Source: 2024 SMSS Sec 3 End-of-Year P2 Q4

10 Sodium hydride, NaH, is an ionic compound formed between sodium and hydrogen.

(a) Draw a dot-and-cross diagram to show the bonding in sodium hydride. Show all electrons.

/2

[2]

Source: 2024 SMSS Sec 3 End-of-Year P2 Q5(a)

11 Ethanedioic acid, $H_2C_2O_4$, is a colourless crystalline solid with a melting point of 103 °C. A student tested the electrical conductivity of the acid. The colourless crystals did not conduct electricity but the aqueous solution of the acid did.

Explain why the pure acid does not conduct electricity but can do so when dissolved in water.

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[2]

Source: 2024 SMSS Sec 3 End-of-Year P2 Q6(a)

12 The SAE system gives each steel a four-digit designation. The first two digits show the type of steel and the last two digits show the percentage of carbon by weight. For example, 1060 is a plain carbon steel with 0.60 % carbon. Chromium steel is written 50XX.

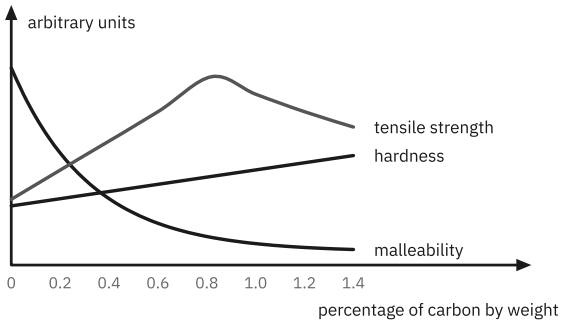
steel	carbon (%)	melting point / °C	use
low carbon	0.05 to 0.30	1464	car bodies
medium carbon	0.30 to 0.60	1427	machinery
high carbon	0.60 to 1.00	1353	bridge cables

(a) Write the SAE designation for a chromium steel containing 0.65 % by weight of carbon.

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[1]

(b) Use relevant data from the table and the graph to explain why low carbon steel and high carbon steel are suitable for their respective uses.



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[2]

(c)

(i) Identify which carbon steel in the table is the hardest.

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[1]

(ii) Explain with reference to the structure of the carbon steel why your answer in (i) is harder than the other carbon steels.

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[3]

/7

Source: 2024 SMSS Sec 3 End-of-Year P2 Q11, adapted

13 Flerovium, Fl, has atomic number 114. It has been suggested that flerovium is a typical metal.

Predict whether flerovium will have a higher or lower melting point than oxygen. Explain your answer in terms of bonding and structure.

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/3 **[3]**

Source: 2024 CHS Sec 3 End-of-Year Section B Q5(c)

14 Draw the dot-and-cross diagram for calcium oxide. Show outer electrons.

/2 **[2]**

Source: 2022 XMS Sec 3 WA2 B3(b)