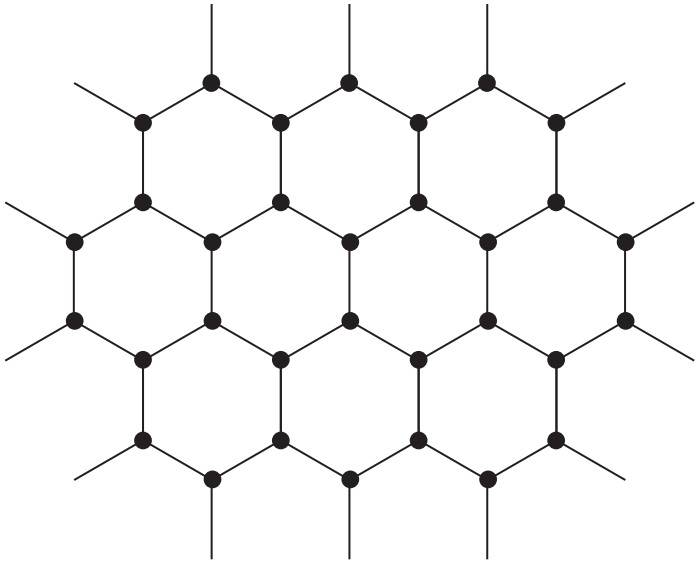
4 (a) Graphene is a new material made from carbon atoms. It is the thinnest and strongest material known. Graphene has a very high melting point and is an excellent conductor of electricity.
Part of the structure of graphene is illustrated in the diagram.



4 (a) (i) Deduce the type of crystal structure shown by graphene.

.....

(1 mark)

4 (a) (ii) Suggest why graphene is an excellent conductor of electricity.

.....

.....

.....

.....

(2 marks)

4 (a) (iii) Explain, in terms of its structure and bonding, why graphene has a high melting point.

.....

.....

.....

.....

(2 marks)

Do not write outside the box

4 (b) Titanium is also a strong material that has a high melting point. It has a structure similar to that of magnesium.

4 (b) (i) State the type of crystal structure shown by titanium.

.....

(1 mark)

4 (b) (ii) Explain, in terms of its structure and bonding, why titanium has a high melting point.

.....

.....

.....

.....

(2 marks)

4 (c) Titanium can be hammered into objects with different shapes that have similar strengths.

4 (c) (i) Suggest why titanium can be hammered into different shapes.

.....

.....

(1 mark)

4 (c) (ii) Suggest why these objects with different shapes have similar strengths.

.....

.....

(1 mark)

4 (d) Magnesium oxide (MgO) has a melting point of 3125 K.
Predict the type of crystal structure in magnesium oxide and suggest why its melting point is high.

Type of crystal structure .....

Explanation .....

.....

.....

.....

(3 marks)

13

Question	Marking Guidance	Mark	Comments
4(a)(i)	Macromolecular / giant covalent / giant molecular / giant atomic	1	If covalent, molecular, giant, lattice, hexagonal or blank mark on. If metallic, ionic or IMF chemical error CE = 0 for 4(a)(i), 4(a)(ii) and 4(a)(iii).
4(a)(ii)	Delocalised electrons / free electrons Able to move / flow (through the crystal)	1 1	 Allow M2 for electrons can move / flow. Ignore electrons can carry a current / charge.
4(a)(iii)	Covalent bonds Many /strong / hard to break / need a lot of energy to break	1 1	 M2 dependent on M1. Ignore van der Waals' forces.
4(b)(i)	(Giant) metallic / metal (lattice)	1	If FCC or BCC or HCP or giant or lattice, mark on. If incorrect 4(b)(i), chemical error CE for 4(b)(ii) and 4(c)(ii).
4(b)(ii)	Nucleus / protons / positive ions and delocalised electrons (are attracted) Strong attraction	1 1	QWC Must be delocalised electrons – not just electrons. Chemical error = 0/2 for 4(b)(ii) if other types of bonding or IMF mentioned. Allow strong metallic bonding for one mark if M1 and M2 are not awarded.
4(c)(i)	Layers of atoms/ions slide (over one another)	1	Do not allow just layers.

4(c)(ii)	(Strong) (metallic) bonding re-formed / same (metallic) bonding / retains same (crystal) structure / same <u>bond strength</u> / same attraction between protons and delocalised electrons as before being hammered or words to that effect	1	If IMF, molecules, chemical error CE = 0/1 for 4(c)(ii). If metallic not mentioned in 4(b)(i) or 4(b)(ii) it must be mentioned here in 4(c)(ii) to gain this mark. Do not allow metallic bonds broken alone. Ignore same shape or same strength.
4(d)	(giant) Ionic Between + and – ions / oppositely charged ions or Mg^{2+} and O^{2-} <u>Strong attraction</u>	1 1 1	If not ionic, chemical error CE = 0/3 If molecules mentioned in explanation lose M2 and M3 Allow one mark for a strong attraction between incorrect charges on the ions.