InkChemistry

ANSWER BOOK

The four crystal structures and their properties

Bonding and structure · Unit C03

AQA 3.1.3.4 · OCR A 2.2.2, 3.1.1

20 questions · 59 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 FCS-Q1

B1 magnesium is metallic and sodium chloride is ionic. **B1** ice is molecular and silicon dioxide is macromolecular, also called giant covalent. [2]

A2 FCS-Q2

B1 in diamond each carbon is bonded to four others, at 109.5°. **B1** in graphite each carbon is bonded to three others, at 120°. [2]

A3 FCS-Q4

B1 a low melting point, because only weak intermolecular forces are overcome on melting. **B1** it does not conduct electricity, because its molecules are uncharged and there are no delocalised electrons. [2]

A4 FCS-Q14

B1 I_2 and hexane are both non-polar and form induced dipole–dipole forces with each other of similar strength to those broken. **B1** iodine can form only weak induced dipole–dipole forces with water, which cannot make up for the hydrogen bonds between water molecules that would have to be broken. [2]

A5 FCS-Q19

B1 the delocalised electrons can move only round their own C_{60} cage. **B1** there are no bonds between neighbouring molecules, only weak intermolecular forces, so electrons cannot pass from one molecule to the next through the solid. [2]

SECTION B · Standard, 3 to 5 marks

B1 FCS-Q5

B1 in graphite each carbon atom forms only three covalent bonds. **B1** the fourth outer electron of each atom is delocalised across the layer. **B1** the delocalised electrons can move along the layers and carry charge. **B1** in diamond all four outer electrons of each carbon are used in covalent bonds, so no electrons are free to move. [4]

B2 FCS-Q8

B1 in ice each water molecule is hydrogen bonded to four others. **B1** the hydrogen bonds hold the molecules in a rigid, open tetrahedral lattice with empty space inside it. **B1** on melting some hydrogen bonds break and the open lattice collapses. **B1** the molecules in the liquid pack more closely, so the same mass occupies a smaller volume. [4]

B3 FCS-Q12

B1 P is metallic, because it conducts as a solid, so it has delocalised electrons. **B1** Q is molecular, because its low melting point shows only weak intermolecular forces are overcome. **B1** R is ionic, because it conducts only when molten, when its ions are free to move. **B1** S is macromolecular, because its very high melting point and lack of conduction show a network of covalent bonds with no delocalised electrons. [4]

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B4 FCS-Q15 **B1** both are macromolecular forms of carbon with strong covalent bonds between the atoms. **B1** in diamond each carbon is bonded to four others tetrahedrally in a three-dimensional network. **B1** in graphite each carbon is bonded to three others in flat hexagonal layers held together by weak forces. **B1** graphite has one delocalised electron per atom; diamond has none. [4]

B5 FCS-Q3 **B1** a macromolecular, giant covalent, structure. **B1** each silicon atom is covalently bonded to four oxygen atoms arranged tetrahedrally. **B1** each oxygen atom is bonded to two silicon atoms, so the network extends throughout the crystal in a 1:2 ratio. [3]

B6 FCS-Q6 **B1** the forces between the layers are weak. **B1** so the layers slide over each other easily, which makes graphite soft. **B1** melting requires breaking the strong covalent bonds within the layers, which needs a great deal of energy. [3]

B7 FCS-Q7 **B1** iodine is a molecular crystal of I_2 molecules. **B1** melting only overcomes the weak induced dipole–dipole forces between molecules, which needs little energy. **B1** the covalent I–I bonds within the molecules are not broken. [3]

B8 FCS-Q9 **B1** diamond is macromolecular: each carbon is covalently bonded to four others in a network throughout the crystal. **B1** melting requires breaking many strong covalent bonds, which needs a great deal of energy. **B1** the rigid three-dimensional network of strong bonds resists any change of shape, so diamond is hard. [3]

B9 FCS-Q10 **M1** amount of carbon = 0.600 ÷ 12.0 = 0.0500 mol, which is $0.0500 \times 6.022 \times 10^{23} = 3.011 \times 10^{22}$ atoms. **M1** each atom forms three bonds, each shared by two atoms, so 1.5 bonds per atom: $1.5 \times 3.011 \times 10^{22}$. **A1** 4.52×10^{22} C–C bonds, to three significant figures. [3]

B10 FCS-Q11 **M1** volume of water = 1000 ÷ 1.00 = 1000 cm^3. **M1** volume of ice = 1000 ÷ 0.917 = 1090.5 cm^3. **A1** increase = 90.5 cm^3, to three significant figures. [3]

B11 FCS-Q13 **B1** like graphite it is macromolecular, with strong covalent bonds within the layers. **B1** nitrogen is more electronegative than boron, so the remaining electrons are held on the nitrogen atoms rather than delocalised across the layer. **B1** with no delocalised electrons there is nothing free to move and carry charge. [3]

B12 FCS-Q16 **B1** the claim is not supported: sodium chloride, which is ionic, melts higher than magnesium, which is metallic. **B1** tungsten shows some metallic bonding is stronger than the ionic bonding in sodium chloride, so neither type is always stronger. **B1** the strength of each depends on the charges and sizes of the particles, so comparisons must be made compound by compound rather than by bonding type. [3]

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B13 FCS-Q18

B1 C_{60} is molecular: separate C_{60} molecules, with covalent bonds only within each cage. **B1** turning it to vapour overcomes only the induced dipole–dipole forces between the molecules. **B1** diamond is macromolecular, so turning it to vapour means breaking many strong covalent bonds, which needs far more energy. [3]

B14 FCS-Q20

M1 amount of water = 45.0 ÷ 18.0 = 2.50 mol. **M1** energy = 2.50 × 40.7. **A1** 102 kJ, to three significant figures. [3]

B15 FCS-Q21

B1 on melting the molecules stay in contact and only some of the hydrogen bonds are broken, enough to collapse the open lattice of ice. **B1** on boiling the molecules are separated completely, so all the remaining hydrogen bonds must be broken. **B1** far more intermolecular attractions are overcome per mole on boiling, so more energy is needed; no O–H bonds are broken in either change. [3]

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