InkChemistry

ANSWER BOOK

Ionic bonding and ionic lattices

Bonding and structure · Unit C03

AQA 3.1.3.1, 3.1.3.4 · OCR A 2.2.2

18 questions · 59 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 IBI-Q1

B1 a strong electrostatic attraction. **B1** between oppositely charged ions, positive and negative, acting in all directions in a lattice. [2]

A2 IBI-Q5

B1 a giant ionic lattice. **B1** each Na^+ has six Cl^- nearest neighbours and each Cl^- has six Na^+, so 6:6 coordination. [2]

A3 IBI-Q13

M1 the distance is one Cl^- radius, one Na^+ diameter and one Cl^- radius: $2 \times 0.181 + 2 \times 0.102$. **A1** 0.566 nm, to three significant figures. [2]

A4 IBI-Q14

B1 Ba^{2+} has more electron shells than Mg^{2+}, so it is a larger ion with the same charge. **B1** the ion centres in barium oxide are further apart, so the attraction between the ions is weaker and less energy is needed to melt the lattice. [2]

SECTION B · Standard, 3 to 5 marks

B1 IBI-Q9

B1 all six ions have the same number of electrons, ten, in the same arrangement $1s^2\ 2s^2\ 2p^6$. **B1** the number of protons, and so the nuclear charge, increases from 7 to 13 along the series. **B1** with the same shielding, the larger nuclear charge attracts the electrons more strongly and pulls them closer to the nucleus. **B1** down Group 1 each ion has one more occupied shell of electrons. **B1** the outer electrons are further from the nucleus, which outweighs the greater nuclear charge because of the extra shielding; ignore 'more electrons' alone. [5]

B2 IBI-Q2

B1 aluminium forms Al^{3+} and sulfur forms S^{2-}; both needed for the mark. **B1** aluminium sulfide is Al_2S_3, since two Al^{3+} (+6) balance three S^{2-} (−6). **B1** ammonium sulfate is $(NH_4)_2SO_4$; reject $NH_{42}SO_4$ without the brackets. **B1** calcium nitrate is $Ca(NO_3)_2$, two NO_3^- ions for each Ca^{2+} ion; reject $CaNO_{32}$. [4]

B3 IBI-Q7

B1 magnesium oxide contains Mg^{2+} and O^{2-} ions, with larger charges than Na^+ and Cl^-. **B1** its ions are smaller, so their centres are closer together. **B1** so the electrostatic attraction between oppositely charged ions is stronger in magnesium oxide. **B1** more energy is needed to overcome the stronger attraction and free the ions, so the melting point is higher. [4]

B4 IBI-Q16

B1 the Na^+ ion is smaller than the Na atom. **B1** because Na^+ has lost its outer shell, the 3s electron, so its outermost electrons are in a shell closer to the nucleus. **B1** the Cl^- ion is larger than the Cl atom. **B1** because the extra electron increases repulsion between the electrons while the nuclear charge is unchanged, so the electron cloud expands. [4]

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B5 IBI-Q19 **B1** the contours form a separate, nearly spherical region of electron density round each nucleus. **B1** between neighbouring sodium and chlorine centres the electron density falls almost to zero, so no electrons are shared between them. **B1** about 18 electrons surround each chlorine and about 10 each sodium, showing that one electron has transferred from sodium to chlorine. **B1** in iodine the contours of the two atoms in each I_2 molecule merge, with high density between the nuclei where the shared pair is, and fall to almost zero between molecules. [4]

B6 IBI-Q4 **B1** the magnesium ion is drawn in square brackets with a 2+ charge and an empty outer shell, or no outer electrons shown. **B1** the oxide ion is drawn in square brackets with a 2- charge and eight electrons in its outer shell. **B1** of the oxide ion's eight electrons, six are one symbol and two are the other symbol, the two transferred from magnesium. [3]

B7 IBI-Q6 **B1** in the solid the ions are held in fixed positions in the lattice and cannot move. **B1** when molten the ions are free to move. **B1** the moving ions carry the charge, Na^+ towards the negative electrode and Cl^- towards the positive electrode; there are no free electrons in either state. [3]

B8 IBI-Q8 **B1** a force can move one layer of ions relative to the next by one ion. **B1** ions of the same charge are then next to each other across the layers. **B1** the like charges repel, so the layers push apart and the crystal splits. [3]

B9 IBI-Q11 **M1** amount of NaCl = 1.00 ÷ 58.5 = 0.01709 mol. **M1** each formula unit contains two ions, so ions = $2 \times 0.01709 \times 6.022 \times 10^{23}$. **A1** 2.06×10^{22} ions, to three significant figures. [3]

B10 IBI-Q12 **M1** Mr of $CaCl_2$ = 40.1 + 2 × 35.5 = 111.1, so amount = 4.44 ÷ 111.1 = 0.03996 mol. **M1** two chloride ions per formula unit, so chloride ions = $2 \times 0.03996 \times 6.022 \times 10^{23}$. **A1** 4.81×10^{22} chloride ions, to three significant figures; allow error carried forward from a wrong Mr. [3]

B11 IBI-Q15 **B1** a purple colour spreads from the crystal towards the positive electrode. **B1** the purple colour is due to the MnO_4^- ions, which are negative and are attracted to the positive electrode. **B1** the K^+ ions move towards the negative electrode but are colourless, so the movement shows that the compound is made of ions that are free to move in solution. [3]

B12 IBI-Q17 **B1** the claim is wrong: solid sodium chloride is a giant ionic lattice of Na^+ and Cl^- ions. **B1** each Na^+ is attracted equally to six Cl^- ions around it, so no Na^+ is paired with any particular Cl^-. **B1** the formula NaCl shows only the ratio of ions in the lattice, one Na^+ for each Cl^-, not a molecule. [3]

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B13 IBI-Q20

M1 Mr of Al_2O_3 = 2 × 27.0 + 3 × 16.0 = 102.0, so amount = 2.04 ÷ 102.0 = 0.0200 mol. **M1** three oxide ions per formula unit, so oxide ions = 3 × 0.0200 × 6.022 × 10^{23}. **A1** 3.61 × 10^{22} oxide ions, to three significant figures. [3]

SECTION C · Long, 6 marks or more

C1 IBI-Q18

Indicative content [6]

B1 magnesium oxide is a giant ionic lattice of Mg^{2+} and O^{2-} ions. **B1** there are strong electrostatic attractions between oppositely charged ions in all directions, made stronger by the 2+ and 2- charges. **B1** a great deal of energy is needed to overcome these many strong attractions, so the melting point is high. **B1** as a solid it does not conduct because the ions are fixed in position and there are no delocalised electrons. **B1** when molten the ions are free to move and carry charge, so it conducts. **B1** it is brittle because a displaced layer brings ions of like charge together, they repel and the lattice splits.

Levels

Level 3 (5–6 marks) all three properties are explained from the giant ionic lattice: the strong attraction between 2+ and 2- ions giving the high melting point, the ions fixed in the solid and free when molten for conductivity, and the like charges brought together on displacement for brittleness; ions, not electrons, carry the current in the melt.

Level 2 (3–4 marks) the lattice is identified and two of the three properties are explained, or all three are tackled and one is thin, such as conductivity with nothing said about what carries the charge.

Level 1 (1–2 marks) magnesium oxide is said to be ionic with strong bonds; the molten oxide is typically said to conduct through free electrons, and brittleness is left unexplained.

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