InkChemistry

ANSWER BOOK

Group 7: trends down the group and displacement reactions

Group 2 and Group 7 · Unit C13

AQA 3.2.3.1 · OCR A 3.1.3

18 questions · 61 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 GTDG-Q10

B1 the chlorine atom carries the partial negative charge, δ-. **B1** chlorine is more electronegative than iodine, being a smaller atom, so it attracts the bonding pair more strongly. [2]

SECTION B · Standard, 3 to 5 marks

B1 GTDG-Q1

B1 chlorine is a pale green gas; allow yellow-green. **B1** bromine is a red-brown (dark orange-brown) liquid. **B1** iodine is a grey-black solid; allow shiny black. **B1** iodine vapour is purple; allow violet. [4]

B2 GTDG-Q2

B1 the molecules get larger, with more electrons, down the group. **B1** so the van der Waals forces between molecules get stronger; accept induced dipole–dipole, London or dispersion forces. **B1** more energy is needed to overcome these forces between molecules. **B1** boiling separates whole Br_2 molecules from one another, and the covalent bond within each molecule is far stronger than the forces between them. [4]

B3 GTDG-Q3

B1 atomic radius increases down the group because each element has one more occupied shell than the one above. **B1** so the bonding pair of electrons is further from the nucleus. **B1** there are more inner shells, so the bonding pair is more shielded from the nucleus. **B1** the attraction between the nucleus and the bonding pair is weaker, so electronegativity decreases; reject an answer about attracting a single electron to form an ion. [4]

B4 GTDG-Q5

B1 $Cl_2(aq) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$; reject equations that show potassium ions. **B1** reduction: $Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)$. **B1** oxidation: $2Br^-(aq) \rightarrow Br_2(aq) + 2e^-$; allow electrons subtracted on the left. **B1** bromide ions are oxidised, from -1 to 0, and chlorine is the oxidising agent. [4]

B5 GTDG-Q9

B1 astatine is a solid, because At_2 molecules have more electrons than I_2, so the van der Waals forces are stronger still. **B1** it is black or very dark, continuing the darkening of colour down the group. **B1** its electronegativity is lower than iodine's. **B1** the bonding pair is further from the nucleus and more shielded in the larger astatine atom, so it is attracted less strongly. [4]

B6 GTDG-Q4

B1 an oxidising agent gains electrons, and the electron gained by a halogen enters its outer shell. **B1** in chlorine that shell is closer to the nucleus and less shielded than in iodine. **B1** so an incoming electron is more strongly attracted, and chlorine gains electrons more readily. [3]

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B7 GTDG-Q6 **B1** the solution turns brown as iodine forms. **B1** after shaking with cyclohexane the upper organic layer is purple. **B1** iodine is non-polar and dissolves far better in non-polar cyclohexane than in water, so it moves into the organic layer. [3]

B8 GTDG-Q11 **B1** fluorine is the strongest oxidising agent of the halogens, too reactive and toxic to store or handle in a school. **B1** it oxidises water itself, releasing oxygen, so a solution of fluorine in water cannot be made. **B1** $2F_2(g) + 2H_2O(l) \rightarrow 4HF(aq) + O_2(g)$. [3]

B9 GTDG-Q12 **B1** in water bromine is orange (yellow when dilute) and iodine is brown (yellow when dilute), so they look similar. **B1** in cyclohexane bromine is orange and iodine is purple, which are clearly different. **B1** so shaking with cyclohexane shows which halogen has been formed when the colour in water is ambiguous. [3]

B10 GTDG-Q13 **M1** amount of I^- = 25.0 ÷ 1000 × 0.100 = 2.50×10^{-3} mol. **M1** $Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$, so amount of I_2 = $2.50 \times 10^{-3} \div 2 = 1.25 \times 10^{-3}$ mol. **A1** mass = $1.25 \times 10^{-3} \times 253.8 = 0.317$ g, to three significant figures; error carried forward from M2. [3]

B11 GTDG-Q14 **M1** amount of Br^- = 50.0 ÷ 1000 × 0.200 = 1.00×10^{-2} mol. **M1** Cl_2 reacts with Br^- in a 1 : 2 ratio, so amount of Cl_2 = 5.00×10^{-3} mol. **A1** volume = $5.00 \times 10^{-3} \times 24.0 = 0.120$ dm^3 = 120 cm^3, to three significant figures. [3]

B12 GTDG-Q16 **B1** the orange colour is that of the bromine water added, diluted, not evidence of a product. **B1** bromine is a weaker oxidising agent than chlorine, so it cannot oxidise chloride ions and no reaction is expected. **B1** the conclusion is not valid; a control of bromine water with pure water would show the same colour. [3]

B13 GTDG-Q19 **B1** from chlorine to iodine the atoms get larger, so the bonding pair is further from the nuclei and the bond weakens. **B1** fluorine atoms are very small, so the F–F bond is very short and the lone pairs on the two atoms are close together. **B1** the lone pairs repel each other strongly, which offsets much of the attraction of the bonding pair, so the bond is weak. [3]

B14 GTDG-Q20 **M1** bonds broken: H–H + F–F = 436 + 158 = 594 kJ mol^{-1}. **M1** bonds made: 2 × H–F = 2 × 562 = 1124 kJ mol^{-1}. **A1** ΔH = 594 - 1124 = -530 kJ mol^{-1}, to three significant figures; the minus sign is needed for the mark. [3]

B15 GTDG-Q21 **B1** the H–I bond (298 kJ mol^{-1}) is much weaker than the H–Cl bond (432 kJ mol^{-1}), because the larger iodine atom holds the shared pair further from its nucleus. **B1** the hot wire supplies enough energy to break H–I bonds, so hydrogen iodide decomposes to hydrogen and purple iodine vapour, but not enough to break H–Cl bonds. **B1** $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$; allow a single arrow. [3]

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B16 GTDG-Q22 **B1** chlorine is a stronger oxidising agent than either bromine or iodine, so it displaces either halide; the colour of the halogen formed decides which halide was present. **B1** iodine is brown in water and purple in cyclohexane, whereas bromine would be orange in water and orange-red in cyclohexane, so the two colours identify iodine. **B1** $Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$, the iodide ions being oxidised; the cyclohexane layer is the deciding observation because dilute iodine and bromine in water can look alike. [3]

SECTION C · Long, 6 marks or more

C1 GTDG-Q18 **Indicative content** [6]

B1 chlorine water turns potassium bromide orange and potassium iodide brown, so chlorine oxidises both bromide and iodide ions. **B1** bromine water turns potassium iodide brown, so bromine oxidises iodide, but it causes no colour change with potassium chloride. **B1** iodine solution reacts with neither chloride nor bromide, and the mixtures stay the colour of the iodine solution added. **B1** a halogen displaces only the halogens below it, so oxidising power decreases in the order $Cl_2 > Br_2 > I_2$. **B1** a correct ionic equation with state symbols, such as $Cl_2(aq) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$, with no potassium ions shown. **B1** the trend arises because the electron gained enters a shell further from the nucleus and more shielded down the group, so it is less strongly attracted.

Levels

Level 3 (5–6 marks) all the observations are given for the three halogens with the three halide solutions, including where nothing happens, the order of oxidising power is deduced from them, a correct ionic equation is written, and the trend is explained through the distance and shielding of the electron gained.

Level 2 (3–4 marks) the chlorine and bromine results are given and the order deduced with an equation; the iodine results, the state symbols, or the reason the oxidising power falls down the group is absent.

Level 1 (1–2 marks) chlorine is said to displace bromide or iodide with a colour change; the trend is usually explained by the halogen losing electrons more easily down the group.

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