InkChemistry

ANSWER BOOK

Formulae, equations and state symbols

Working in the laboratory · Unit C00

AQA 3.1.2.5 · OCR A 2.1.2, 2.1.4

20 questions · 66 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 FE-Q2

B1 hydrogen H_2, nitrogen N_2 and oxygen O_2. **B1** the halogens F_2, Cl_2, Br_2 and I_2. [2]

A2 FE-Q15

B1 calcium carbonate, because carbonates other than those of Group 1 and ammonium are insoluble. **B1** $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$. [2]

A3 FE-Q22

B1 the crystals hold five molecules of water of crystallisation for each $CuSO_4$, joined to the formula by the raised dot. **B1** heating drives the water off as steam, leaving white anhydrous $CuSO_4$: $CuSO_4{\cdot}5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O(g)$. [2]

SECTION B · Standard, 3 to 5 marks

B1 FE-Q3

B1 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$, with the coefficients 5, 3 and 4; allow multiples. **B1** state symbols (g) for oxygen and carbon dioxide and (l) for water; allow $H_2O(g)$. **B1** $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$. **B1** 2 iron atoms, 3 carbon atoms and 6 oxygen atoms on each side of the iron equation. [4]

B2 FE-Q4

B1 the subscripts are part of a formula and fix which substance it represents. **B1** H_2O_2 is hydrogen peroxide, which the reaction does not produce; the product is water. **B1** the equation is balanced with coefficients only: $2H_2 + O_2 \rightarrow 2H_2O$. **B1** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$, with state symbols; allow $H_2O(g)$. [4]

B3 FE-Q5

B1 (s) means solid and (l) means liquid. **B1** (g) means gas and (aq) means dissolved in water. **B1** (aq) is different from (l): pure ethanol is $C_2H_5OH(l)$, and only ethanol dissolved in water is (aq). **B1** water cannot be dissolved in water, so as a pure liquid it is always (l); reject $H_2O(aq)$. [4]

B4 FE-Q8

B1 the ionic equation for both strong-acid reactions is $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$. **B1** the other ions are spectators, so the same chemical change happens in both and releases the same energy per mole of water. **B1** ethanoic acid is weak and mostly un-ionised, so it stays whole: $CH_3COOH(aq) + OH^-(aq) \rightarrow CH_3COO^-(aq) + H_2O(l)$. **B1** that is a different reaction, in which some energy goes into ionising the acid, so less energy is released overall. [4]

B5 FE-Q10

B1 both mixtures give a white precipitate of barium sulfate. **B1** both ionic equations are $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$. **B1** the full equations differ only in the spectator ions, Na^+ and Cl^- in one and K^+ and NO_3^- in the other. **B1** any soluble barium salt with any soluble sulfate is the same reaction, which is the basis of the sulfate test. [4]

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B6 FE-Q13

B1 $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$. **B1** $Ag^+(aq) + e^- \rightarrow Ag(s)$. **B1** the silver half-equation is doubled so that two electrons are gained for the two that zinc loses. **B1** $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$, with the electrons cancelled; ignore nitrate shown on both sides. [4]

B7 FE-Q1

B1 calcium hydroxide is $Ca(OH)_2$; reject $CaOH_2$. **B1** aluminium sulfate is $Al_2(SO_4)_3$. **B1** ammonium carbonate is $(NH_4)_2CO_3$. [3]

B8 FE-Q6

B1 sodium chloride is soluble, so the sodium and chloride ions stay dissolved after mixing. **B1** they are present on both sides of the equation unchanged, so they are spectator ions. **B1** spectator ions are cancelled, leaving $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$. [3]

B9 FE-Q7

B1 $Ag^+ + Br^- \rightarrow AgBr$, with the species in the right places. **B1** state symbols $Ag^+(aq)$, $Br^-(aq)$ and $AgBr(s)$. **B1** the spectator ions are the potassium ion, K^+, and the nitrate ion, NO_3^-. [3]

B10 FE-Q9

B1 potassium salts and nitrates are always soluble, so the precipitate must be lead(II) iodide. **B1** lead(II) iodide has the formula PbI_2, because Pb^{2+} needs two I^- ions. **B1** $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$; state symbols required. [3]

B11 FE-Q11

B1 split every aqueous ionic compound and strong acid into its ions, keeping the coefficients. **B1** leave solids, liquids, gases and covalent molecules whole. **B1** cancel ions that appear unchanged on both sides, then check that atoms and total charge balance. [3]

B12 FE-Q16

B1 the equation is balanced in atoms and in charge, and the state symbols are correct. **B1** it is not a complete ionic equation, because $Cl^-(aq)$ appears unchanged on both sides and is a spectator. **B1** cancelling it gives $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$. [3]

B13 FE-Q18

B1 the Roman numeral shows the iron ion is Fe^{3+}, and sulfate is SO_4^{2-}. **B1** two Fe^{3+} ions give 6+ and three SO_4^{2-} ions give 6-, the lowest whole numbers for which the charges cancel. **B1** more than one sulfate ion is needed, so the sulfate is written in brackets with the 3 outside. [3]

B14 FE-Q19

B1 potassium sulfate is K_2SO_4. **B1** ammonium nitrate is NH_4NO_3. **B1** sodium ethanoate is CH_3COONa; allow CH_3CO_2Na. [3]

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B15 FE-Q20

B1 sodium carbonate is soluble, so in solution it is split into $Na^+(aq)$ and $CO_3^{2-}(aq)$, and Na^+ cancels as a spectator, giving $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$. **B1** calcium carbonate is an insoluble solid, so it has no free ions in solution and is left whole. **B1** its calcium ions appear as a product: $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$. [3]

B16 FE-Q21

B1 sodium salts are soluble, so the solid must be copper(II) hydroxide, a precipitate. **B1** its formula is $Cu(OH)_2$, because Cu^{2+} needs two OH^- ions. **B1** $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$. [3]

SECTION C · Long, 6 marks or more

C1 FE-Q14

Indicative content [6]

B1 magnesium oxide dissolves to give a colourless solution with no gas: $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$. **B1** the oxide is an insoluble solid, so it stays whole in the ionic equation, $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$. **B1** magnesium carbonate fizzes and dissolves: $MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$, the gas giving the fizz. **B1** the carbonate is insoluble, so its ionic equation keeps it whole: $MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l) + CO_2(g)$. **B1** sodium hydroxide shows no visible change, only warming, because both reactants and products are in solution: $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$. **B1** its ionic equation is $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$; in all three reactions H^+ is what reacts and chloride is a spectator.

Levels

Level 3 (5–6 marks) all three observations are given and matched to what the full equations show, all three ionic equations are correct with the insoluble solids kept whole, and the answer draws the common conclusion that H^+ reacts in every case and chloride is a spectator.

Level 2 (3–4 marks) the observations and full equations are right; one ionic equation splits the oxide or carbonate into ions, or the spectator conclusion is not drawn.

Level 1 (1–2 marks) fizzing with the carbonate is noted, with one equation; magnesium oxide is commonly written as separate Mg^{2+} and O^{2-} ions, and chloride is kept in the ionic equations.

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