InkChemistry

ANSWER BOOK

Group 2 compounds: solubility, uses and the sulfate test

Group 2 and Group 7 · Unit C13

AQA 3.2.2 · OCR A 3.1.2 (e); 3.1.4

19 questions · 67 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 GCS-Q11

B1 barium hydroxide is soluble, so it would give a high concentration of hydroxide ions, a strongly alkaline solution that would damage the gut. **B1** it would release toxic Ba^{2+} ions into solution, to be absorbed into the blood. [2]

A2 GCS-Q21

B1 Li^+ is a very small ion with a high charge density, so it polarises the nitrate ion strongly, as a Group 2 ion does, and the nitrate decomposes to the oxide, brown nitrogen dioxide and oxygen. **B1** Na^+ is larger, so it polarises the nitrate ion less and sodium nitrate only loses oxygen, forming sodium nitrite with no nitrogen dioxide. [2]

SECTION B · Standard, 3 to 5 marks

B1 GCS-Q2

B1 magnesium hydroxide treats indigestion: it neutralises excess stomach acid, and is sparingly soluble so the hydroxide concentration stays low. **B1** calcium hydroxide treats acidic soil: it is a base that neutralises the acid and raises the pH. **B1** calcium oxide removes sulfur dioxide from flue gases: it is a basic oxide that reacts with the acidic gas. **B1** barium sulfate is the barium meal: it is insoluble, so toxic Ba^{2+} is not absorbed, and barium absorbs X-rays. [4]

B2 GCS-Q3

B1 barium sulfate is insoluble, so it cannot form a solution and is swallowed as a suspension of solid. **B1** because it does not dissolve, barium ions are not released and are not absorbed into the blood; reject 'barium sulfate is not toxic'. **B1** barium absorbs X-rays strongly, so the gut lined with barium sulfate shows up on the X-ray. **B1** magnesium sulfate is soluble and dissolves, and magnesium ions are not toxic at that dose. [4]

B3 GCS-Q4

B1 add dilute hydrochloric acid (or dilute nitric acid) to the solution first; reject sulfuric acid. **B1** then add a few drops of barium chloride solution; allow barium nitrate. **B1** a white precipitate shows that sulfate ions are present; ignore 'cloudy' unless a precipitate is named. **B1** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$. [4]

B4 GCS-Q5

B1 the acid removes carbonate ions, reacting with them to form carbon dioxide and water. **B1** otherwise carbonate ions would form a white precipitate of barium carbonate, giving a false positive; reject 'removes impurities'. **B1** sulfuric acid contains sulfate ions, so a white precipitate would form whether or not the sample contained sulfate. **B1** fizzing shows that carbonate was present; once it has been removed, a white precipitate still shows sulfate. [4]

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B5 GCS-Q15 [4]

B1 both react with sulfur dioxide to form calcium sulfite, so both remove it. **B1** calcium carbonate releases carbon dioxide at the scrubber: $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$. **B1** calcium oxide is made by heating calcium carbonate, which releases the same carbon dioxide at the kiln and uses energy. **B1** so calcium carbonate is cheaper and releases no more carbon dioxide overall, which makes it the better choice.

B6 GCS-Q22 [4]

B1 heat the same amount in moles of each carbonate in identical boiling tubes, with a delivery tube leading into limewater. **B1** use the same Bunsen flame at the same height and the same volume of limewater for each. **B1** time how long it takes for the limewater to turn milky; the shorter the time, the less stable the carbonate. **B1** lift the delivery tube out of the limewater before removing the flame, so cold limewater is not drawn back into the hot tube.

B7 GCS-Q23 [4]

B1 hydrogen: a lighted splint at the mouth of the tube gives a squeaky pop. **B1** oxygen: a glowing splint placed in the gas relights. **B1** chlorine: damp blue litmus paper turns red and is then bleached white; allow damp litmus is bleached. **B1** sulfur dioxide: acidified aqueous potassium manganate(VII) turns from purple to colourless; allow acidified potassium dichromate(VI) turning from orange to green.

B8 GCS-Q24 [4]

B1 warm the solution with sodium hydroxide alone and test for ammonia with damp red litmus, so that ammonia from any ammonium ions is detected and driven off first. **B1** then add aluminium foil, or Devarda's alloy, and warm again. **B1** a gas that turns damp red litmus paper blue is ammonia, and shows that nitrate ions were present. **B1** aluminium reduces the nitrogen from +5 in NO_3^- to −3 in NH_3, so the ammonia can only have come from nitrate.

B9 GCS-Q27 [4]

M1 Mr of $BaSO_4$ = 137.3 + 32.1 + 4 × 16.0 = 233.4. **M1** $n(BaSO_4) = 0.583 \div 233.4 = 2.50 \times 10^{-3}$ mol. **M1** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$, and barium chloride is in excess, so $n(SO_4^{2-})$ in the 25.0 cm³ sample = 2.50×10^{-3} mol. **A1** concentration = $2.50 \times 10^{-3} \div 0.0250 = 0.100$ mol dm^{-3}, with the working shown in full because the answer is given.

B10 GCS-Q8 [3]

M1 $Mr(Mg(OH)_2) = 58.3$, so amount of $Mg(OH)_2 = 0.350 \div 58.3 = 6.003 \times 10^{-3}$ mol. **M1** $Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$, so amount of HCl = $2 \times 6.003 \times 10^{-3} = 1.201 \times 10^{-2}$ mol. **A1** volume = $1.201 \times 10^{-2} \div 0.0500 = 0.240$ dm³ = 240 cm³, to three significant figures.

B11 GCS-Q9 [3]

M1 $Mr(SO_2) = 64.1$, so amount of $SO_2 = 2.50 \times 10^6$ g ÷ 64.1 = 3.900×10^4 mol. **M1** $CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$ is 1 : 1, and Mr(CaO) = 56.1, so mass = $3.900 \times 10^4 \times 56.1$ g. **A1** 2.19×10^6 g, which is 2.19 tonnes to three significant figures.

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B12 GCS-Q13 [3]

B1 water from a limestone area contains carbonate (or hydrogencarbonate) ions. **B1** these form a white precipitate of barium carbonate, so the result does not show sulfate. **B1** repeat the test after adding dilute hydrochloric acid until fizzing stops; a white precipitate then shows sulfate.

B13 GCS-Q14 [3]

B1 with sodium hydroxide, magnesium chloride gives a white precipitate but barium chloride gives no change. **B1** with dilute sulfuric acid, barium chloride gives a white precipitate but magnesium chloride gives no change. **B1** the results are opposite because hydroxide solubility increases down the group while sulfate solubility decreases.

B14 GCS-Q19 [3]

B1 the Ba^{2+} ion is larger than the Mg^{2+} ion and has the same charge, so its charge density is lower. **B1** Ba^{2+} polarises (distorts) the electron cloud of the carbonate ion less, so the C–O bonds in the anion are weakened less. **B1** more energy is needed to break the carbonate ion into an oxide ion and carbon dioxide, so a higher temperature is needed.

B15 GCS-Q20 [3]

M1 $Mr(Mg(NO_3)_2) = 24.3 + 2 \times (14.0 + 3 \times 16.0) = 148.3$, so amount $= 1.48 \div 148.3 = 9.980 \times 10^{-3}$ mol. **M1** $2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$, so amount of $O_2 = 9.980 \times 10^{-3} \div 2 = 4.990 \times 10^{-3}$ mol. **A1** volume $= 4.990 \times 10^{-3} \times 24.0 = 0.120\ dm^3 = 120\ cm^3$, to three significant figures.

B16 GCS-Q26 [3]

B1 chlorine reacts with the water on the paper to give hydrochloric acid and chloric(I) acid, which turn the litmus red. **B1** chloric(I) acid is an oxidising agent and bleaches the dye, so the paper turns white. **B1** sulfur dioxide dissolves to give sulfuric(IV) acid, which is acidic and turns the litmus red but does not oxidise the dye, so it stays red.

SECTION C · Long, 6 marks or more

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

B1 add sodium hydroxide solution dropwise to a sample of each solution, and dilute sulfuric acid to a fresh sample of each. **B1** with sodium hydroxide, Mg^{2+} gives a white precipitate, Ca^{2+} a slight white precipitate, and Sr^{2+} and Ba^{2+} little or none. **B1** with dilute sulfuric acid, Ba^{2+} gives a dense white precipitate, Sr^{2+} a white precipitate, Ca^{2+} a slight one and Mg^{2+} none. **B1** the hydroxide results follow because hydroxide solubility increases down the group, so magnesium hydroxide precipitates most. **B1** the sulfate results follow because sulfate solubility decreases down the group, so barium sulfate precipitates most. **B1** a correct ionic equation, such as $Mg^{2+}(aq) + 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)$ or $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$.

Levels

Level 3 (5–6 marks) both reagents are used on separate samples, the observations for all four ions with each reagent are given, both trends in solubility are used to explain them, and a correct ionic equation is written; the answer would let a student tell the four solutions apart.

Level 2 (3–4 marks) the observations with both reagents are mostly right and one solubility trend explains them; the other trend or the ionic equation is not there.

Level 1 (1–2 marks) a white precipitate is mentioned for one ion; the two solubility trends are often run the same way, with barium hydroxide called the least soluble.

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