2.9 A-Level Chemistry: Required Practicals and Practical Skills: Test Pack

Total Marks

AQA 7405 · Calculator allowed · about 50 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student is given an unknown white crystalline solid X and instructed to identify the cation and anion present using standard qualitative tests. The results are shown below.

Test 1: A small sample of X was dissolved in distilled water, then dilute nitric acid was added, followed by aqueous silver nitrate. Observation: a cream precipitate formed. The precipitate did not dissolve in dilute ammonia solution but dissolved slowly in concentrated ammonia solution.

Test 2: A separate sample of X was dissolved in water. Aqueous barium chloride, acidified with dilute hydrochloric acid, was added. Observation: no precipitate formed.

Test 3: A sample of solid X was heated gently with aqueous sodium hydroxide. Observation: a pungent gas was produced, which turned damp red litmus paper blue.

(a) Identify the halide ion present in X, using the result of Test 1. Give the ionic equation for the reaction between this ion and silver ions. **(3)**

(b) Explain why dilute nitric acid is added before the silver nitrate solution in Test 1. **(2)**

(c) State the conclusion that can be drawn from the result of Test 2, and explain why the hydrochloric acid is added before the barium chloride solution. **(2)**

(d) Identify the gas produced in Test 3 and write an ionic equation for its formation. Explain the result observed with the damp litmus paper. **(4)**

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(e) Using your answers to Tests 1-3, deduce the identity of solid X, giving its name and formula. **(2)**

(Total for Question 1 is 13 marks)

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2 A student carried out an experiment to determine the enthalpy change of combustion of a fuel, using the following apparatus and measurements:

- A digital thermometer, reading to the nearest 0.1°C, was used to measure the temperature rise of the water, dT = 18.5°C (found from an initial and a final reading).
- A two-decimal-place balance (resolution 0.01 g) was used to find the mass of fuel burned, by weighing the burner before and after burning, giving a mass burned of 0.83 g.
- A measuring cylinder, with a resolution uncertainty of ±0.5 cm^3, was used to measure out 100 cm^3 of water.

(a) Calculate the percentage uncertainty in the temperature rise, dT. (The uncertainty in a single thermometer reading is half the smallest scale division.) **(2)**

(b) Calculate the percentage uncertainty in the mass of fuel burned. **(2)**

(c) Calculate the percentage uncertainty in the volume of water measured. **(1)**

(d) State which single measurement contributes the greatest percentage uncertainty to the final result, and suggest a change to the method or apparatus that would reduce this uncertainty. **(2)**

(e) Calculate the total percentage uncertainty in the calculated enthalpy change, by summing the percentage uncertainties from parts (a) to (c). Hence calculate the absolute uncertainty, in kJ mol-1, in an experimental enthalpy value of -650 kJ mol-1. **(3)**

(Total for Question 2 is 10 marks)

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3 A student set up an electrochemical cell to measure its EMF, using a zinc half-cell (a zinc electrode in 1.00 mol dm-3 $ZnSO_4(aq)$) connected via a salt bridge to a copper half-cell (a copper electrode in 1.00 mol dm-3 $CuSO_4(aq)$). The two electrodes were connected through a high-resistance voltmeter.

Standard electrode potentials:
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ E DEG = +0.34 V
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ E DEG = -0.76 V

(a) State the half-equation for the reaction occurring at the zinc electrode and identify whether it is oxidation or reduction. **(2)**

(b) Calculate the standard EMF of the cell. **(2)**

(c) Write the conventional cell diagram (cell notation) for this cell, including state symbols and the given concentrations. **(2)**

(d) State two conditions that must be met for the values of E DEG given above to be valid standard electrode potentials. **(2)**

(e) Explain the function of the salt bridge in this cell. **(2)**

(f) When the student measured the EMF experimentally, they obtained a value of +1.05 V rather than the +1.10 V calculated in part (b). Suggest two reasons for this difference. **(2)**

(Total for Question 3 is 12 marks)

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Mark scheme · 2.9 A-Level Chemistry: Required Practicals and Practical Skills: Test Pack

Question 1

(a) identifies bromide ion, $Br^-(aq)$ (cream precipitate, dissolves only in concentrated ammonia - distinguishes from chloride and iodide) **B1**

(a) correct ionic equation $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ **B1**

(a) fully balanced with correct state symbols (cao) **B1**

(a) Answer: Bromide ion, $Br^-(aq)$; $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

(b) removes/reacts with any carbonate (or hydroxide/sulfite) ions present as impurities **B1**

(b) which would otherwise also form a precipitate with Ag^+ (e.g. Ag_2CO_3), giving a false positive result **B1**

(b) Answer: To remove carbonate (or similar) ions that would otherwise also precipitate with silver ions and give a misleading (false positive) result.

(c) no sulfate (SO_4^{2-}) ions are present in X **B1**

(c) the dilute HCl prevents carbonate/sulfite ions from also giving a precipitate with Ba^{2+}, so the test is specific for sulfate **B1**

(c) Answer: No sulfate ions present; acidifying first removes carbonate/sulfite so only sulfate would give a precipitate.

(d) ammonia, NH_3 **B1**

(d) correct ionic equation $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$ **B1**

(d) ammonia gas dissolves in the water present on the damp litmus paper **B1**

(d) forming an alkaline solution (ammonium hydroxide/OH^-(aq)), which turns red litmus blue **B1**

(d) Answer: Ammonia, NH_3; $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$; ammonia dissolves in the damp litmus paper forming an alkaline solution, turning it blue.

(e) ammonium bromide **B1**

(e) correct formula NH_4Br (cao) **B1**

(e) Answer: Ammonium bromide, NH_4Br

Question 2

(a) uncertainty per reading = ±0.05°C; since dT is found from two readings (initial and final), total uncertainty = 2 x 0.05 = ±0.1°C **M1**

(a) % uncertainty = (0.1/18.5) x 100 = 0.54% (awrt 0.5%) **A1**

(a) Answer: 0.54%

(b) uncertainty per reading = ±0.01 g; mass burned is found by difference (two readings), so total uncertainty = 2 x 0.01 = ±0.02 g **M1**

(b) % uncertainty = (0.02/0.83) x 100 = 2.41% (awrt 2.4%) **A1**

(b) Answer: 2.41%

(c) (0.5/100) x 100 = 0.5% **B1**

(c) Answer: 0.5%

(d) the mass of fuel burned (2.41%) contributes the greatest percentage uncertainty (ecf from (a)-(c)) **B1**

(d) e.g. use a balance that reads to 3 or more decimal places (0.001 g resolution), or burn a greater mass of fuel (achieve a larger temperature rise) so the fixed absolute uncertainty becomes a smaller percentage of a larger mass **B1**

(d) Answer: Mass of fuel burned; use a more precise balance or burn a larger mass of fuel.

(e) total % uncertainty = 0.54 + 2.41 + 0.5 = 3.45% (awrt 3.4-3.5%, ecf from (a)-(c)) **M1**

(e) absolute uncertainty = 3.45% of 650 = (3.45/100) x 650 **M1**

(e) = 22 kJ mol-1 (awrt 22-22.5), so the enthalpy value can be quoted as -650 ± 22 kJ mol-1 **A1**

(e) Answer: ±22 kJ mol-1 (total % uncertainty = 3.45%)

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Question 3

(a) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ **B1**

(a) oxidation (loss of electrons) **B1**

(a) Answer: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$; oxidation.

(b) E(cell) = E(more positive/reduced electrode) - E(more negative/oxidised electrode) = 0.34 - (-0.76) **M1**

(b) +1.10 V (cao) **A1**

(b) Answer: +1.10 V

(c) $Zn(s) \mid Zn^{2+}(aq, 1.00 \text{ mol dm-3}) \parallel Cu^{2+}(aq, 1.00 \text{ mol dm-3}) \mid Cu(s)$ **B1**

(c) correct convention: single line = phase boundary, double line = salt bridge, more negative electrode (Zn) on the left (oe correct equivalent format) **B1**

(c) Answer: $Zn(s) \mid Zn^{2+}(aq, 1.00 \text{ mol dm-3}) \parallel Cu^{2+}(aq, 1.00 \text{ mol dm-3}) \mid Cu(s)$

(d) temperature of 298 K (25°C) **B1**

(d) ion concentration(s) of 1.00 mol dm-3 (and, for any gases, a pressure of 100 kPa); accept: platinum electrode used where no solid metal is present in the half-cell **B1**

(d) Answer: 298 K; 1.00 mol dm-3 ion concentrations (and 100 kPa for any gases).

(e) allows ions to flow between the two half-cells, completing the circuit **B1**

(e) maintains electrical neutrality in each half-cell as electrons flow through the external circuit, without allowing the two solutions to mix directly **B1**

(e) Answer: Completes the circuit by allowing ion flow while maintaining charge neutrality and keeping the solutions from mixing.

(f) the concentrations of $ZnSO_4$/$CuSO_4$ used were not exactly 1.00 mol dm-3, or the temperature was not exactly 298 K **B1**

(f) resistance in the wires/salt bridge/connections causes a small voltage drop (the voltmeter is not perfectly infinite resistance); accept: oxide layer/impurities on the electrode surfaces affecting the electrode potential **B1**

(f) Answer: Non-standard concentrations/temperature; resistance in the circuit/salt bridge causing a voltage drop.

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