

CIE A-Level Chemistry 9701 Paper 3 Practice Paper (Advanced Practical Skills)

Total: 40 marks · 2 h · 2 questions · 11 parts

Data and formulae

Quantity	Value
Gas constant R	8.31 J K ⁻¹ mol ⁻¹
Avogadro constant L	6.02 x 10 ²³ mol ⁻¹
Planck constant h	6.63 x 10 ⁻³⁴ J s
Speed of light c	3.00 x 10 ⁸ m s ⁻¹
Elementary charge e	1.60 x 10 ⁻¹⁹ C
Relative atomic masses H, C, O, Na, S	1.0, 12.0, 16.0, 23.0, 32.1

Q 1 · Titration: purity of the iron(II) salt FA 1 using potassium manganate(VII) [14]

(a) A student titrates 25.0 cm³ of FA 1 (iron(II) sulfate solution acidified with dilute sulfuric acid) with 0.0200 mol dm⁻³ KMnO₄(aq). The burette readings are shown. Calculate the titre of each titration and state which one must be rejected.

Titration	Initial reading / cm ³	Final reading / cm ³
rough	0.00	24.20
1	0.15	24.85
2	0.00	24.10
3	0.00	24.15

[2]

(b) Calculate the mean titre from the concordant readings (cm³, 2 decimal places). [2]

(c) Calculate the number of moles of KMnO_4 in the mean titre. [1]

(d) Write the ionic equation for the reaction between MnO_4^- and Fe^{2+} , and calculate the moles of Fe^{2+} in 25.0 cm^3 of FA 1. [2]

(e) FA 1 was made by dissolving 9.45 g of the hydrated salt in water and making the volume up to 250 cm^3 . Calculate the moles of Fe^{2+} in 250 cm^3 and hence the relative molecular mass M_r of the salt. [2]

(f) Calculate the mass of iron in FA 1 and the percentage by mass of iron in the sample. [2]

(g) The salt is $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$, $M_r = 392.1$, containing 14.23% iron. Compare your answers with these values, comment on the purity of the sample and suggest one improvement to increase accuracy. [3]

Q 2 · Qualitative analysis: identifying the ions in the unknown salt FA 4 [12]

(a) FA 4 is a hydrated salt. Complete the table with the observations for each test (colour, precipitate, solubility, gas).

Test	Observation
1. Dissolve FA 4 in distilled water	
2. Add a little $\text{NaOH}(\text{aq})$, then excess, then warm	
3. Add $\text{BaCl}_2(\text{aq})$, then excess dilute HCl	
4. Add a little aqueous ammonia, then excess ammonia	

[4]

(b) From the observations, state which three ions FA 4 contains and justify each one. [3]

(c) FA 4 is $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$. Using A_r : N 14.0, H 1.0, Al 27.0, S 32.1, O 16.0, calculate its M_r and the percentage by mass of water of crystallisation. [3]

(d) Explain how test 4 distinguishes Al^{3+} from Zn^{2+} . [2]

Q 3 · Calorimetry: enthalpy change of neutralisation of sodium hydroxide with hydrochloric acid [14]

(a) 25.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid and 25.0 cm³ of 1.00 mol dm⁻³ sodium hydroxide are mixed in an insulated cup and the temperature is recorded every 30 s, as shown. State the maximum temperature and the temperature rise, and explain why the maximum, not the last reading, is used.

Time / s	0	30	60	90	120	150	180	210	240	270
Temperature / °C	20.0	20.0	20.5	24.0	26.0	26.7	26.7	26.6	26.5	26.4

[3]

(b) Assuming the solution density is 1.00 g/cm³ and its specific heat capacity is 4.18 J g⁻¹ K⁻¹, calculate the energy released by the reaction in J. [3]

(c) Calculate the moles of water formed and hence the enthalpy change of neutralisation ΔH in kJ/mol, with its sign. [3]

(d) State two reasons why the experimental value is not accurate. [2]

(e) Suggest two improvements and explain why your value (-56.0 kJ/mol) is smaller in magnitude than the Data Booklet value of -57.3 kJ/mol. [3]