Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		Add indicator, e.g., phenolphthalein or methyl orange or litmus, to the (hydrochloric) acid in the conical flask ✓ Add the sodium hydroxide (from the burette) ✓ Swirl the conical flask (after adding the sodium hydroxide) ✓ Idea of dropwise addition at the end point / until the indicator just changes colour ✓ Colour change of indicator: Phenolphthalein - colourless to pink Methyl orange - red to yellow Litmus - red to blue ✓	5 (5 x AO 1.2)	**DO NOT ALLOW** universal indicator **ALLOW** shake / mix for swirl **BUT IGNORE** stir **ALLOW** dropwise addition throughout the titration **IGNORE** clear for colourless **Examiner's Comments** It was clear that most candidates had obviously seen or done a titration and almost all candidates gained marks. Marks from marking points 2,3 and 4 were gained across a broad range of candidates. Manycandidates were able to offer a named indicator, although it was quite common for this to be universal indicator. Only the higher attaining candidates gained a mark for a correct indicator colour change. Examiners felt that most candidates had clearly performed or seen an acid/base titration with the acid in the burette and were then giving the reverse colour change.
	b	i	Results within 0.1(0) (cm^3) of each other ✓	1 (AO 1.2)	**ALLOW** Results within 0.2(0) (cm^3) of each other **IGNORE** results which are similar **Examiner's Comments** Only higher attaining candidates appreciated what is meant by concordant results. 'Results that are similar' was a common incorrect response. Some candidates gave the correct numerical tolerance but then negated their answer by stating the units as dm^3.
		ii	**First check the answer on the answer line If answer = 7.5 (cm^3) award 4 marks**	4 (4 x AO 2.2)	**ALLOW ECF** from moles of acid **ALLOW ECF** from moles of alkali i.e. volume = $\frac{\text{moles}}{0.4}$

			moles of acid = $\frac{0.12 \times 25.0}{1000}$ / 0.12 x 0.025 / 0.003 / 3.0 x 10^{-3} ✓idea that moles of alkali = moles acid / 1:1 ratio or moles of alkali =0.003 / 3.0 x 10^{-3} ✓ volume of alkali = $\frac{0.003}{0.4}$ = 0.0075 dm^3 ✓ = 7.5 cm^3 ✓		**ALLOW ECF** for conversion of dm^3 to cm^3 **Examiner's Comments** Most candidates gained 4 marks for this question. If candidates did not calculate the correct answer, the most frequently gained marks were for the 1:1 mole ratio of alkali to acid, and for the conversion of an answer in dm3to an answer in cm^3. Some candidates used the concentration in mol/dm^3 with the volume in cm^3 to calculate the moles of acid. Candidates should be encouraged to ensure units are consistent.
			Total	**10**	
2		i	Copper oxide / CuO loses oxygen or copper oxide / CuO is reduced ✓ Carbon (atoms) / C gains oxygen or carbon (atoms) / C is oxidised ✓	2 (2 x AO 2.2)	**DO NOT ALLOW** copper loses oxygen **BUT ALLOW** copper gains electrons / copper (cat)ions are reduced (to form copper atoms) **ALLOW** carbon loses electrons **Examiner's Comments** Good responses to this question explained the redox reaction in terms of copper oxide losing oxygen and carbon gaining oxygen. Examiners also saw responses in terms of loss and gain of electrons. A frequent error was stating that copper loses oxygen.
		ii	**First check the answer on the answer line** **If answer = 12 (tonnes) award 3 marks** **If answer = 12,000,000 g award 3 marks** Mass of CuO = 15 x $\frac{63.5}{79.5}$ or 15 x $\frac{127}{159}$ ✓ = 11.98 ✓ To 2 **significant figures** = 12 (tonnes) ✓	3 (2 x AO 2.2) (1 x AO 1.2)	**ALLOW ECF** marks for e.g., 15 x $\frac{79.5}{63.5}$ = 18.78 and (to 2 sig figs) 19 (tonnes) **ALLOW ECF** if significant figures are correct from an incorrect calculation of mass **Examiner's Comments** Candidates had been well prepared for reacting mass calculations, with most candidates gaining 3 marks. Some candidates did not express their answers to 2 significant figures. Errors that were made often arose from doubling only one of the A_r of Cu (from

					63.5 to 127) or the M_r of CuO (from 79.5 to 159).
		iii	**Quantitative answer:** Pure copper is twice as conductive ✓ compared to 99% pure copper ✓ **BUT** **Qualitative answer:** Pure copper is a better conductor than 99% pure / impure copper / ORA ✓	2 (2 x AO 3.2b)	**ALLOW** answers quoting 2 correct values from the graph for 2 marks e.g., 99% pure copper has relative electrical conductivity of about 49, but 100% pure copper has relative electrical conductivity of 100 **OR** e.g., copper extracted from copper oxide has a relative electrical conductivity of about 49, but when purified by electrolysis has relative electrical conductivity of 100 **ALLOW** idea that copper with less impurities is a better conductor / ORA **Examiner's Comments** Lower attaining candidates misinterpreted the question and gave answers relating to the electrolysis reaction. Many candidates identified that the graph showed that impurities in copper brought about a decrease in its electrical conductivity. Higher attaining candidates were able to give a quantitative answer in terms of pure copper being twice as conductive as 99% pure copper or quoting two values from the graph to illustrate this relationship.
			Total	**7**	
3			A ✓	1 (AO 1.1)	
			Total	**1**	
4			A ✓	1 (AO 2.1)	
			Total	**1**	
5	a		The measured volume will be greater than the actual volume. ☐ The measured volume will be smaller than the actual volume. ☑ ✓ The measured volume will be the same as the actual volume. ☐	1 (AO 3.2b)	**Examiner's Comments** 'The measured volume will be greater than the actual volume' was a commonly chosen distractor.

	b	i	**First check the answer on answer line** **If answer = 24.0 (cm^3) award 1 mark** Average titre = $\frac{24.1 + 23.9 + 24.0}{3}$ = 24.0 (cm^3) ✓	1 (AO 2.2)	**ALLOW** 24 (cm^3) **ALLOW** Average titre = $\frac{24.1 + 24.0}{2}$ = 24.05(cm^3) **ALLOW** Average titre = $\frac{23.9 + 24.0}{2}$ = 23.95(cm^3) **Examiner's Comments** Lower attaining candidates calculated the average of all 4 results, including the anomalous result in their calculation.
		ii	**First check the answer on answer line** **If answer = 4.7 / 4.70 / 4.704 / 4.71 / 4.7088 (g/dm^3) award 5 marks** Moles of KOH = $\frac{0.100 \times 24.0}{1000}$ / 0.100 x 0.024 / 0.0024 ✓ Moles of H_2SO_4 = $\frac{0.0024}{2}$ / 0.0012 ✓ Concentration of H_2SO_4 = $\frac{0.0012}{0.025}$ = 0.048 (mol/dm^3) ✓ M_r of H_2SO_4 = 98.0 / 98.1 ✓ Concentration of H_2SO_4 in g/dm^3 = 98 × 0.048 = 4.70 (g/dm^3) **or** Concentration of H_2SO_4 in g/dm^3 = 98.1 × 0.048 = 4.71 (g/dm^3) ✓ **OR for MP3, 4 & 5:** Mr of H_2SO_4 = 98.0 / 98.1 ✓ Mass of H_2SO_4 = 98.0 × 0.0012 = 0.1176 g **or** Mass of H_2SO_4 = 98.1 × 0.0012 = 0.1177 g ✓ Concentration of H_2SO_4 in g/dm^3 = 0.1176 ÷ 0.025	5 (5 × AO 2.2)	**ALLOW ECF** from average titre in part **(i)** **ALLOW ECF** from moles of KOH unit not needed **ALLOW ECF** from moles of alkali i.e., concentration = $\frac{\text{moles}}{0.025}$ / $\frac{\text{moles x 1000}}{25}$ **ALLOW ECF** from concentration of H_2SO_4 **ALLOW ECF** from moles of H_2SO_4 **ALLOW ECF** from mass of H_2SO_4 Answer is 4.7138 (g/dm^3) if answer for **(b)(i)** is 24.05 cm^3 or 4.6942 (g/dm^3) if answer for **(b)(i)** is 23.95 cm^3 **Examiner's Comments** Around a quarter of candidates were given all 5 marks. Higher attaining candidates were able to calculate the concentration of sulfuric acid in g/dm^3. Error carried forward was given from an incorrect titre in part (b) (i).

			=4.70 (g/dm^3) **or** Concentration of H_2SO_4 in g/dm^3 = 0.1177 ÷ 0.025 = 4.71 (g/dm^3)		**Assessment for learning** Examiners use **bold type** to draw the candidates' attention to key aspects of a question. Despite the emboldening of '**in g/dm^3**' in this question, many candidates calculated the concentration in mol/dm^3. Exemplar 3  This response gained full marks for this titration calculation. The candidate has clearly set out their working out, making it easy for the examiner to follow. The candidate has calculated the moles of potassium hydroxide. They have appreciated the mole ratio and correctly calculated the moles of sulfuric acid, going on to use this to calculate the concentration of the acid. The candidate has then calculated the relative molecular mass of sulfuric acid and used this to convert the concentration in mol/dm^3 to g/dm^3.
			Total	**7**	
6			**First check the answer on answer line** **If answer = 46.8 (tonnes) award 3 marks** % yield = (actual yield ÷ predicted yield) × 100 **OR** 78 = (actual yield ÷ 60) × 100 ✓	3 (AO 1.1) (2 × AO 2.2)	**ALLOW** 47 **Examiner's Comments** A very healthy proportion of candidates were given all 3 marks for correctly calculating the mass of methanol as 46.8 tonnes.

			actual yield $= \frac{78 \times 60}{100}$ ✓ $= 46.8$ (tonnes) ✓		
			Total	**3**	
7			**First check the answer on answer line** **If answer = 96 (cm^3) award 4 marks** M_r of H_2 = 2.0 ✓ Moles of $H_2 = \frac{0.008}{2}$ / 0.004 ✓ Volume of H_2 = 0.004 × 24 / 0.096 dm^3 ✓ Volume of H_2 in cm^3 = 96 (cm^3) ✓	4 (3 × AO 2.2) (AO 1.2)	**ALLOW ECF** from incorrect M_r **ALLOW ECF** from incorrect moles calculation **ALLOW ECF** from volume in dm^3 **Examiner's Comments** This question proved to be a real discriminator, as did all the calculations on this paper. Only the highest attaining candidates worked this through to the correct answer. If candidates did not obtain an answer of 96 cm^3 examiners looked to award marks for working out and/or error carried forward. It is worth centres stressing to candidates that this is only possible when a response is clearly set out. **Misconception** Common errors/misconceptions in the calculation included: • taking the M_r of H_2 to be 1 • not converting dm^3 to cm^3 • not recalling the formula 'volume = mol x 24', with many candidates giving a mass of H_2 rather than the required volume. **Assessment for learning**

					Many candidates still forget to convert cm^3 to dm^3 before calculating moles or concentrations.
			Total	**4**	