Mark scheme – Monitoring Chemical Reactions (H)

Question			Answer/Indicative content	Marks	Guidance
1			**B ✓**	1 (AO2.2)	
			Total	**1**	
2			**D ✓**	1 (AO1.1)	
			Total	**1**	
3			**C ✓**	1 (AO1.1)	
			Total	**1**	
4			**D ✓**	1 (AO2.2)	
			Total	**1**	
5			**A ✓**	1(AO 1.2)	
			Total	**1**	
6			**A ✓**	1(AO 1.1)	
			Total	**1**	
7	a		**Any one from:** Use a single indicator / named single indicator eg methyl orange / phenolphthalein (instead of universal indicator)✓ Idea that universal indicator does not give a sudden colour change / universal indicator gives a continuous colour change / ORA ✓ **OR** Fill the burette exactly to the 0.00 cm^3 line ✓ Idea that this will give accurate volume of acid ✓ **OR** Idea of adding acid to the alkali <u>slowly</u> **or** <u>dropwise</u> (near the end point) ✓ Idea that indicator should change colour on addition of one drop (of acid) ✓ **OR** Idea of swirling the alkali while adding the acid ✓ To ensure mixing of acid and alkali / AW ✓	2 (AO3.3b)	**Explanation must be linked to improvement** **ALLOW** idea of using a pH probe or pH meter to give a more accurate indication of when neutralisation occurs **ALLOW** idea of missing the end point **ALLOW** two improvements, with no explanation, for 1 mark if no explanations given

			OR Use a white tile under the conical flask ✓ To see the colour change easily / clearly ✓ **OR** Repeat the experiment <u>until concordant or consistent results are obtained</u> ✓ To obtain a more accurate titre / AW ✓ **OR** Idea of doing a rough titration ✓ As this will give you an idea of the endpoint ✓		
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 23.65 (cm^3) award 2 marks** Use of volume of acid from titrations 2, 3 & 4 / Use of 23.60, 23.70 & 23.65 ✓ Accurate volume of acid = 23.65 (cm^3) ✓	2 (AO2.2)	**DO NOT ALLOW** 23.7 (cm^3) **ALLOW** 1 mark for average calculated using all results, ie 24.18 / 24.175 (cm^3) but **DO NOT ALLOW** 24.2 (cm^3)
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.106 (mol / dm^3) award 4 marks** moles of alkali = $\frac{0.200\times25.0}{1000}$ / 0.200 x 0.0250 / moles of acid = $\frac{0.005}{2}$ = 0.0025 / 2.5×10^{-3} ✓ = $\frac{0.0025}{0.02365}$ / $\frac{0.0025 \times 1000}{23.65}$ / $\frac{2.5\times10^{-3}}{0.02365}$ / $\frac{2.5\times10^{-3} \times 1000}{23.65}$ / 0.1057 (mol/dm^3) ✓ concentration = 0.106 (mol / dm^3) (3 sig. figs) ✓	4 (AO3 × 2.2) (AO1.2)	**ALLOW** ECF from moles of alkali **ALLOW** ECF from average titre in **(i)** **ALLOW** ECF from moles of acid i.e. conc = $\frac{\text{moles}}{0.02365}$ or $\frac{\text{moles} \times 1000}{23.65}$
			Total	**8**	
8	a	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.00125 / 1.25×10^{-3} award 2 marks** Moles = $\frac{\text{volume}}{24}$ / $\frac{0.030}{24}$ / $\frac{30}{24{,}000}$ ✓ = 0.00125 / 1.25×10^{-3} ✓	2 (AO2.2)	**ALLOW** 1 mark only for 30 ÷ 24 or 0.030 ÷ 24,000, correctly calculated

		ii	0.0025 / 2.5×10^{-3} (g) ✓	1 (AO2.2)	**unit not needed** **ALLOW** ECF from **(i)** ie 2 x answer from **(i)**
	b		Moles of chromium = $\frac{10.40}{52.0} = 0.2$ ✓ Moles of nickel = $\frac{17.61}{58.7} = 0.3$ ✓ Idea that ratio is 2:3 / ratio isn't 1:1 so equation 2 ✓	3 (AO2.2)	**ALLOW** other methods of calculation eg 10.40g of chromium forms $\frac{10.40}{52.0} \times 58.7$ = 11.74g nickel $\frac{11.74}{3} \times 2 = 17.61$g of nickel So, equation 2 **ALLOW** answers that show equation 1 is not correct **Third marking point is dependent on correct mathematical reasoning**
			Total	**6**	
9		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 120 (tonnes) award 3 marks** M_r of NH_3 = 17 **AND** M_r of NH_4NO_3 = 80 ✓ Mass of ammonium nitrate = $\frac{80}{17} \times 25.5$ / 1.5 × 80 ✓ = 120 (tonnes) ✓	3 (AO2.1)	**ALLOW** ECF from incorrect RMMs
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 10(g) award 2 marks** Actual mass $= \frac{80 \times 12.5}{100}$ ✓ = 10 (g) ✓	2 (AO1.2) (AO2.2)	**ALLOW** % yield = (am ÷ pm) × 100 **OR** 80 = (am ÷ 12.5) × 100 for 1 mark if no other mark awarded
			Total	**5**	
10	a		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.24 / 2.243 / 2.2 (dm^3) award 2 marks** Moles of ammonium chloride = 5.00 ÷ 53.5 or 0.0935 ✓ Volume of ammonia = moles × 24 = 0.0935 × 24 = 2.24 / 2.243 / 2.2 (dm^3) ✓	2(AO 2.2)	**ALLOW** 0.09 / 0.094 **ALLOW ECF** from moles of ammonium chloride **if first mark not awarded**

			OR 2 × 53.5 = 107g ammonium chloride produces 2 × 24 = 48 dm^3 ammonia ✓ So 5.00g of ammonium chloride produces $\frac{5 \times 2 \times 24}{2 \times 53.5}$ = 2.24 / 2.243 / 2.2 (dm^3) ammonia ✓		**ALLOW** 2.16 (ECF from 0.09) **Examiner's Comments** Higher ability candidates correctly calculated the volume of ammonia gas as 2.24dm^3. Examiners gave error carried forward for correctly converting an incorrectly calculated number of moles to a volume. Common errors in this calculation included • using 107 (2 × 53.5) as the formula mass before calculating the number of moles of NH_4Cl to give an answer of 1.12 • just multiplying 5(g) × 24 • dividing the number of moles by 24 • converting 24dm^3 to cm^3 before multiplying by the number of moles
	b	i	Moles of acid/HC*l* = 35.0 ÷ 1000 × 000.075 = 0.002625 / 0.0026 / 2.625 × 10^{-3} / 2.6 × 10^{-3} ✓ Moles of alkali / NaOH = 25.0 ÷ 1000 × 0.100 = 0.0025 / 2.5 × 10^{-3} ✓ The acid is in excess ✓	3(AO 2.2)	**ALLOW** 1 mark for moles of acid = 2.625 **and** moles of alkali = 2.5 (ie use of cm^3 instead of dm^3) **Third mark dependent on clear attempt at a calculation of moles of acid and alkali** **ALLOW ECF** from calculated moles of acid and alkali **Examiner's Comments** Many candidates correctly calculated the moles of HC*l* and NaOH and deduced that the HC*l* is in excess. **AfL**

					Many candidates still forget to convert cm^3 to dm^3 before calculating moles or concentrations – see also Question 22(c).
		ii	Correct choice of concordant results – 36.3 and 36.2 ✓ Mean = (36.30 + 36.20) ÷ 2 = 36.25 (cm^3) ✓	2(AO 2.2)	**ALLOW** 1 mark for **ECF** from any incorrect choice of concordant values eg 35.875 / 35.88 / 35.9 (cm^3) if all values are used **Examiner's Comments** Many candidates correctly selected the concordant results from titrations 1 & 4 to calculate the mean volume as 36.25 cm^3. Lower ability candidates tended to calculate the mean from all four titres; 1 mark was given.
			Total	**7**	
11	a		Mean titre = 17.1 (1) Because titration 1 is a rough estimate / titration 1 is an outlier / titrations 2 and 3 are identical (1)	2	**IGNORE** anything in the titration table
	b		Moles of acid = 0.00171 (1) Concentration of KOH = 0.0684 (1)	2	**ALLOW ECF** from incorrect titre / 0.100 × titre $\times 10^{-3}$ **ALLOW ECF** from incorrect moles providing answer is to 3 sig figs / moles÷volume
	c		M_r of KOH = 56.1 (1) Concentration of KOH = 3.84 (1)	2	**ALLOW** correct answer without working **ALLOW** 3.837 **ALLOW ECF** from incorrect M_r and / or incorrect concentration from (b) / M_r × conc
			Total	**6**	
12			A	1	
			Total	**1**	
13			D	1	
			Total	**1**	
14			C	1	

			Total	**1**	
15			D	1	
			Total	**1**	
16		i	Titrate ammonia against sulfuric acid to obtain volumes needed for complete neutralisation (1) Add these volumes without the use of indicator (1) Slow evaporation of reaction mixture / heat reaction mixture over a steam bath (1) Burette and other chemical apparatus not suitable for using large quantities / very difficult to use a steam bath in the large scale (1)	4	**ALLOW** heat neutral mixture with carbon or charcoal and then filter off carbon **ALLOW** Slow evaporation of filtrate / heat filtrate over a steam bath if method involving carbon is used
		ii	34 (g or tonnes) of ammonia makes 132.1 (g or tonnes) of ammonium sulfate / 17 (g or tonnes) of ammonia makes 66 (g or tonnes) of ammonium sulfate (1) So 51 tonnes makes 198.1 tonnes of ammonium sulfate (1)	2	**ALLOW** one mark for correct calculation of M_r for ammonia **AND** ammonium sulfate **IGNORE** units for the first marking point **ALLOW** one mark for 2 moles of ammonia makes 1 mole of ammonium sulfate
			Total	**6**	
17			Percentage yield = (actual yield ÷ predicted yield) × 100 / (2.2 ÷ 4.0) × 100 (1) 55 (1)	2	**ALLOW** full marks for answer with no working out
			Total	**2**	