Question	Answer	Marks	Guidance
1 a i	all atoms in reactants end up in the product (1)	1	**allow** only hydrogen peroxide is made / only one product made / no waste products / no unwanted products (1) **ignore** no product is wasted **ignore** same number of atoms on each side of the equation / all reactants have been converted into products
ii	reduce the production of unwanted **products** / reduces amount of waste **products** (1) makes the process more sustainable (1)	2	reduces waste is **not** sufficient more cost effective / makes more profit is **not** sufficient **allow** makes the process greener (1) **ignore** better for the environment
b i	idea that 2 g of H_2 makes 34 g of H_2O_2 (1) idea that 100 g of H_2 is 50 x 2 g so mass of H_2O_2 is 34 x 50 (1)	2	**allow** $\frac{34}{2} \times 100$ (2) **eg** $H_2 + O_2 \rightarrow H_2O_2$ (1) 2x 50 = 100 34 x 50 = 1700 **allow** 32 x 50 = 1600g O_2 (1) **and** 100g H_2 + 1600g O_2 = 1700g H_2O_2 (1) **but** 100g + 1600g = 1700g scores 0 if no evidence of other relevant calculation

Question	Answer	Marks	Guidance
ii	**LOOK FOR ANSWER FIRST OF ALL** **IF percentage yield = 90 AWARD 2 MARKS** $\frac{1530}{1700} \times 100$ (1) 90 (1)	2	**allow** $\frac{actual}{predicted} \times 100$ **or** $\frac{am}{pm} \times 100$ (1)
c	**LOOK FOR ANSWER FIRST OF ALL** **IF atom economy = 12.7(34) OR 13 AWARD 2 MARKS** $\frac{34}{169+98} \times 100$ **or** $\frac{34}{267} \times 100$ **or** $\frac{34}{34+233} \times 100$ (1) 12.7 (1)	2	**allow** $\frac{M_r \text{ of desired product}}{\text{sum of } M_r \text{ of all products}}$ x 100 (1)
	Total	**9**	

Question	Answer	Marks	Guidance
2 a	no undesired products made / no waste products made / all the atoms that react end up in the product / only **one** product made (1)	1	**not** the same number of atoms on each side of the equation
b i	idea that 164g of sodium ethanoate makes 120g of ethanoic acid / idea that 82g of sodium ethanoate makes 60g of ethanoic acid (1) **but** mass is 6 (2)	2	units **not** needed
b ii	$\frac{(2\times 60)}{(2\times 60)+142}\times 100$ **or** $\frac{120}{262}\times 100$ **or** $\frac{(2\times 60)}{(2\times 82)+98}\times 100$ **or** $\frac{120}{164+98}\times 100$ (1) **but** 45.8% (2)	2	**allow** full marks for correct answer despite working out **allow** 46% (2)
c i	46 % (2) but 46.2 / 46.15 / 46.154 (1)	2	answer must have **two** sig figs for two marks **allow** one mark for $\frac{2.4}{5.2}\times 100$
ii	waste a lot of starting material / wastes reactants (1)	1	**ignore** waste products **ignore** just 'a lot of waste' **ignore** wastes lots of resources
	Total	**8**	

Question	Answer	Marks	Guidance
3 a	does not give a sudden **colour** change / **colour** changes slowly / continually changes **colour** / (1)	1	**allow ora** if specified **allow** universal indicator is a mixed indicator / universal indicator is made up of different components / universal indicator has a range of colours **allow** universal indicator gives the pH rather than the end-point
b i	idea that average only uses titrations 2, 3 and 4 / titration 1 is not used to calculate the average (1) titrations 2, 3 and 4 have a consistent value / titration 1 is a rough estimate / titration 1 could be an anomalous value / titration 1 is a range-finder / titration 1 is an outlier (1)	2	**allow** calculation of the mean using the values from 2, 3 and 4 **not** just use titration 3 **not** titration 3 is the mid-value
ii	0.0015 **or** 1.5×10^{-3} (1)	1	**ignore** trailing zeroes
iii	moles of HNO_3 = 0.0015 **or** 1.5×10^{-3} (1) concentration of HNO_3 = 0.0595 (1)	2	**LOOK FOR THE ANSWER FIRST IF IT IS 0.0595 AWARD 2 marks** **allow** ecf from (b)(ii) **allow** one mark for 0.06 / 0.05952 or answers with more significant figures **allow** ecf providing answer has three significant figures i.e. mole/volume
	Total	**6**	

Question			Answer	Marks	Guidance
4	(a)		titration 1 is not consistent / only consistently close readings should be included / all the other volumes are close to one another / all the other volumes are within 0.2 cm^3 (1)	1	**allow** titration 1 is a rough titration / titration 1 is inaccurate / it is a practice titration **allow** titre 1 is an outlier or anomaly **allow** it is a very different from the other values e.g. it is (at least) 0.5 cm^3 different **ignore** it does not follow the pattern
	(b)		**LOOK FOR ANSWER FIRST OF ALL** **IF concentration = 0.08 (mol/dm^3) AWARD 3 MARKS** no of moles in acid = $\frac{20\times0.100}{1000}$ / 0.02×0.100 / 0.002 (1) moles of alkali = 0.002 / moles of acid = moles of alkali (1) concentration = 0.08 (mol/dm^3) (1)	3	If answer correct **ignore** any working out **allow** ecf from moles of acid **unit** not needed **allow** ecf from moles of alkali ie conc = $\frac{moles}{0.025}$ / $\frac{moles\times1000}{25}$
	(c)		single indicator or phenolphthalein only gives a single **colour** change / gives a sudden **colour** change (1) mixed indicator or universal indicator can give several **colour** changes / mixed indicator gives a gradual **colour** change (1)	2	**The first mark awarded must refer to a colour change** **allow** phenolphthalein only has two **colours** / is either **pink** or **colourless** / phenolphthalein changes **colour** at the end-point **ignore** clear **allow** universal indicator shows many **colours** / universal indicator changes **colour** all the time
			Total	**6**	

Question			Answer	Marks	Guidance
5	(a)		**LOOK FOR ANSWER FIRST OF ALL** **IF percentage = 27.4 (%) OR 27(%) AWARD 2 MARKS** $\frac{19.2}{70} \times 100$ (1)	2	
	(b)	**(i)**	0.46 (g) (1)	1	**not** 0.5
		(ii)	idea that some of the sodium may have come from sources other than salt (1)	1	**allow** not all sodium is from sodium chloride / may be other sodium compounds present
			Total	**4**	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6 a</td><td>239 (1)</td><td>1</td><td></td></tr>
<tr><td>b</td><td>FIRST LOOK AT THE ANSWER
IF ANSWER = 33% AWARD 2 MARKS

0.33 g (1)

33 (%) (1)</td><td>2</td><td>

allow ecf from wrong mass</td></tr>
<tr><td>c</td><td>C_2H_5 (1)</td><td>1</td><td>allow any order of symbols

not C^2H^5 / C2H5 / or use of lower case H</td></tr>
<tr><td>d</td><td>FIRST LOOK AT THE ANSWER
IF ANSWER = Fe_2O_3 AWARD 3 MARKS

<table><tr><td>symbols</td><td>Fe</td><td>O</td></tr><tr><td>mole ratio</td><td>$\frac{70}{56}$ or 1.25</td><td>$\frac{30}{16}$ or 1.875</td></tr><tr><td>simplest mole ratio</td><td>$\frac{1.25}{1.25}$ or 1</td><td>$\frac{1.875}{1.25}$ or 1.5</td></tr></table>mole ratio (1)

simplest mole ratio (1)

empirical formula is Fe_2O_3 (1)</td><td>3</td><td>

If fraction is the wrong way around = 0 marks for the question

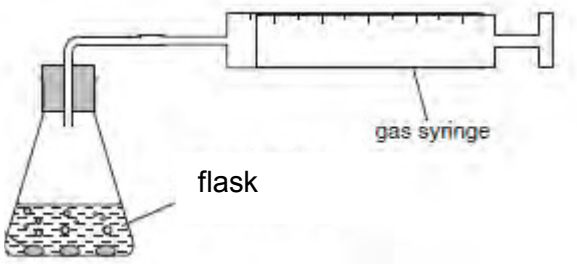
If divide by atomic number = 0 marks for the question

If just use ratio of masses = 0 for the question

allow ecf from mole ratio

allow ecf from simplest ratio

allow $FeO_{1.5}$ = 2 marks for the question</td></tr>
<tr><td></td><td>Total</td><td>7</td><td></td></tr>
</table>

Question	Answer	Marks	Guidance
7 a	**any two from:** correct piece of apparatus to collect and measure gas e.g. (gas) syringe, upturned measuring cylinder with water or upturned burette with water (1) workable and gas tight (1)	2	 The measuring apparatus must be graduated and does not need to be assembled. The apparatus does not need to be named if there is no ambiguity from the diagram **allow** even if the syringe / measuring cylinder is not graduated **allow** the tube can be a single line **ignore** if tube does not appear to go through the stopper **not** the delivery tube must not go in the reaction mixture

Question	Answer	Marks	Guidance
7 b	**Level 3** **Describes the difference between strong and weak acids** **AND** **explains the different shapes of the graphs in terms of collision frequency and hydrogen ions** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **Level 2** **EITHER** **Describes the difference between strong and weak acids <u>and</u> explains the different shapes of the graphs in terms of rate of reaction and strength of acid** **OR** **explains the different shapes of the graphs in terms of collision frequency or hydrogen ions** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **Level 1** **EITHER** **Describes the difference between strong and weak acids** **OR** **explains the different shapes of the graphs in terms of rate of reaction and strength of acid** Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. (0marks)	6	**This question is targeted at grades up to A.** **Indicative scientific points at level 3 must include:** **Shapes of graph** • reference to hydrogen ions e.g. nitric acid has more hydrogen ions / greater concentration of hydrogen ions • reference to collision frequency e.g. nitric acid has more collisions per second / collisions more often / greater collision frequency **allow** references to increased chance of collision, collisions more often, collisions more likely, as alternatives to increased collision frequency **allow** ora for propanoic acid **Indicative scientific points at all levels may include:** **Strength of acid** • strong acid completely dissociates / ionises completely • weak acid partially dissociates / does not completely ionise **Shapes of graph** • nitric acid faster than propanoic acid • nitric acid has more reacting particles / greater concentration of reacting particles • nitric acid has more collisions • nitric acid has particles closer together **allow** ora for propanoic acid **ignore** comments about similarities of the graph **Use the L1, L2, L3 annotations in Scoris; do not use ticks.**
7 c i	Moles = $0.0025 / 2.5 \times 10^{-3}$ (1)	1	

Question	Answer	Marks	Guidance
ii	Mass = 0.25 (g) / 2.5×10^{-1} (1)	1	**allow** ecf from number of moles, i.e. moles × 100
	Total	**10**	

Question	Answer	Marks	Guidance
8 a	The rate of the forward reaction is faster than the rate of the backward reaction [ ] The position of equil brium will not change if more product is added [ ] The concentration of the reactants does not change [✓] The rate of the forward reaction is the same as the rate of the backward reaction [✓] The concentration of the reactants is the same as the concentration of the products [ ] The position of equil brium moves to the left when product is removed from the equil brium [ ] **one** correct answer (1) **but** **two** correct answers (2)	2	
b	(yes) it is exothermic because the percentage yield goes down as **temperature** increases (1) (no) there are less moles on right hand side because the percentage yield goes up as **pressure** increases (1)	2	**Answers must refer to yield, or amount of product** **reference to only position of equilibrium is not sufficient** **ignore** references to bond making and bond breaking **allow** ora if specified
	Total	**4**	

Question	Answer	Marks	Guidance
9 a	NO_x (1) greatest (negative) gradient (1)	2	The second marking point is **dependent** on the correct pollutant **allow** greatest (negative) slope / steepest graph **allow** correct comparison of mass change shown by quoting values e.g. 190, 80 and 20 (within ±1 square) has greatest change in mass is not sufficient unless supported by data – one piece of data is sufficient
b i	$\frac{52}{3600} \times 100$ (1) 1.44 (%) (1)	2	**FIRST LOOK AT ANSWER** **IF ANSWER = 1.44 or 1.4 AWARD 2 MARKS** **do not allow** 1 / 1.45
ii	Other countries make more than their share (of ammonia) / Sweden makes less (ammonia) than expected / Sweden makes less (ammonia) per million of population (1)	1	**allow** Sweden has better anti-pollution laws **ignore** values are roughly the same **allow** Sweden makes less than average **allow** ecf from percentage above 1.9% in (b)(i)
iii	**FIRST LOOK AT ANSWER** **IF ANSWER = 25 AWARD 2 MARKS** $\frac{974}{39}$ (1) 25 (1)	2	**allow** 24.974 correctly rounded up for the first mark

Question	Answer	Marks	Guidance
iv	Poland makes more (sulfur dioxide) than expected / Poland makes more (sulfur dioxide) than the average / Poland makes more (sulfur dioxide) per million of population (1)	1	**allow** Poland uses a fuel that makes lots of sulfur dioxide **allow** fewer pollution control laws in Poland / Poland cannot afford (modern) pollution controls **allow** some countries produce less than the average **allow** pollution instead of sulfur dioxide **allow** ecf from (b)(iii) if below 9.1
v	Quotes some evidence that indicates a higher population gives more pollutants / ora e.g. Germany has a higher population than Estonia **and** makes more pollutants (1) Quotes some evidence that indicates a higher population gives less pollutants / ora e.g. UK has a higher population than Poland **and** makes less pollutants (1)	2	**The data quoted must be able to be checked to see if it is correct and not ambiguous** **allow** the higher populated countries like Germany Poland and the UK produces a lot more pollution
	Total	**10**	