Chemical Equations: Titrations

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 1
Sub Topic	Chemical Equations: Titrations
Booklet	Mark Scheme

Time Allowed: **90 minutes**

Score: **/76**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	(Freshly prepared) starch (solution/indicator) ALLOW Startch **(1)** Blue-black / blue / dark blue/ black to colourless IGNORE …to clear **(1)** Mark independently	Purple to…	2

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Pale yellow/straw coloured	Brown/yellow/brown-yellow/tawny	1

In 1(b) to (d)(ii)

Penalise rounding errors **only once**

Penalise 1 SF **only once**

(Both may be penalised)

Question Number	Acceptable Answers	Reject	Mark
1(b)	**Fully scroll down answer** Number of moles of electrons $= \frac{0.2 \times 15 \times 60}{96\,500}$ $= 1.865 \times 10^{-3}$ / 0.001865 (mol) Correct answer with no working scores 1 IGNORE SF except 1SF IGNORE electrons for units		1

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	19.45 18.6(0) 19.05 18.7(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	**Method 1** Titres/results/runs 1 **and** 3 should be discarded **(1)** as they are not concordant/within (±) 0.2 cm^3 IGNORE The(ir) first reading is zero OR Reading(s) too far from the others **(1)** **Method 2** Run 1 as rangefinder/rough **(1)** Run 2 as not concordant / within (±) 0.2 cm^3 **(1)** **Use method giving higher mark**		2

Question Number	Acceptable Answers	Reject	Mark
1(c)(iii)	18.65/18.7 (cm^3) ALLOW TE from (i) and (ii) Runs 2, 3, 4 give 18.783/18.78/18.8 Runs 1, 3, 4 give 19.067/19.07/19.1 Runs 3, 4 give 18.875/ 18.88/ 18.9	18.6 19.06 18.87	1

Question Number	Acceptable Answers	Reject	Mark
1(c)(iv)	$\frac{18.65 \times 0.0100}{1000}$ = 1.865×10^{-4} / 0.0001865 (mol) TE from (iii)		1

Question Number	Acceptable Answers	Reject	Mark
1(c)(v)	$1.865 \times 10^{-4} \times 100/10$ $= 1.865 \times 10^{-3}$ / 0.001865(mol) TE from (iv)		1

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e(-)$ **(1)** $2I^-(aq) \rightarrow I_2(aq) + 2e(-)$ **(1)** **OR** $2S_2O_3^{2-}(aq) - 2e(-) \rightarrow S_4O_6^{2-}(aq)$ **(1)** $2I^-(aq) - 2e(-) \rightarrow I_2(aq)$ **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	1.865×10^{-3} / 0.001865 (mol) of electrons… lost/gained/equals/reacts with/taken from/ given to/equivalent to 1.865×10^{-3}/0.001865 (mol) $S_2O_3^{2-}$ **NOTE** Numbers do not have to be the same eg 0.001865 electrons with 0.001906 $S_2O_3^{2-}$ **OR** 1 mol of electrons equivalent to 1 mol $S_2O_3^{2-}$ **ALLOW** Any indication of 1:1 ratio for electrons:$S_2O_3^{2-}$ IGNORE Answers referring to equations only.		1

Question Number	Acceptable Answers	Reject	Mark
1(e)(i)	Uncertainty in titre value: (±)0.51/0.514% **OR** **$\frac{2 \times 0.05}{19.45} \times 100 =$** = 0.5 **(1)** Uncertainty in the pipette measurement: $\frac{(0.04 \times 100)}{(10.0)}$ = (±)0.4% **(1)**		

Question Number	Acceptable Answers	Reject	Mark
1(e)(ii)	The uncertainty is not significant because the data are rounded to 1 SF / produce a ratio to the nearest whole number ALLOW Uncertainties are very small/ < 5% / < 1% Other reasonable points: eg insignificant as only equation is required	…is significant Uncertainties do not matter as titres have been averaged	1

(Total for Question 1 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	To avoid (loss of solid due to) 'spitting' ALLOW To prevent loss of solid/reactant IGNORE reference to water vapour	Spillage Removal of impurities	1

Question Number	Acceptable Answers	Reject	Mark
2(b)	Heat to constant mass/weight IGNORE Keep heating until .... no more steam/misty fumes are given off OR there is no further reaction OR the crystals turn to powder		1

Question Number	Acceptable Answers	Reject	Mark
2(c)	Anhydrous (sodium carbonate)	Dry/Dehydrated	1

Question Number	Acceptable Answers	Reject	Mark
2(d)(i)	**Additional Comments** **Throughout 3d,** **correct answers score full marks** **and** **ignore SF (including 1SF)** **and** **penalise incorrect units once only** (M_r Na_2CO_3=) 2x23 + 12 + 3x16 / 106 ($g\ mol^{-1}$) **(1)** (1.06 ÷ 106 =) 0.01/ 1.0 x 10^{-2} (mol) **(1)** TE for incorrect M_r		2

Question Number	Acceptable Answers	Reject	Mark
2(d)(ii)	(m= 2.50 – 1.06 = 1.44(g) n = 1.44 ÷18=) 0.08 (mol)		1

Question Number	Acceptable Answers	Reject	Mark
2(d)(iii)	(0.08 ÷ 0.01 =) 8 TE from (d)(i) and (d)(ii)		1

Question Number	Acceptable Answers	Reject	Mark
2(e)	Washings/Rinsing (from the beaker) should have been transferred to the volumetric flask		1

Question Number	Acceptable Answers	Reject	Mark
2(f)	Titration 1 is not concordant/a range finder/ an overshot/ an outlier/a trial /only a 'rough'/ more than 0.2 cm^3 from the other 2 titres IGNORE Inaccurate OR (Titrations 2 and 3) are within 0.1/0.2 cm^3/concordant IGNORE More accurate		1

Question Number	Acceptable Answers	Reject	Mark
2(g)(i)	**Throughout 3g ignore SF except 1SF** (Mean titre = 16.5 cm^3/ 0.0165 dm^3) n=(0.10 x 0.0165=) 1.65 x 10^{-3}/0.00165 (mol) Correct answer with no working scores (1) No TE on incorrect mean		1

Question Number	Acceptable Answers	Reject	Mark
2(g)(ii)	n=(1.65 x 10^{-3} ÷ 2=) 8.25 x 10^{-4}/0.000825 (mol) TE Ans to (g) ÷ 2		1

Question Number	Acceptable Answers	Reject	Mark
2(g)(iii)	n(8.25 x 10^{-4} x 10=) 8.25 x 10^{-3}/0.00825 (mol) TE Ans to (g)(ii) x 10		1

Question Number	Acceptable Answers	Reject	Mark
2(g)(iv)	M_r=(2.50 ÷ 8.25 x 10^{-3} =) 303.03 **(1)** (303.03 -106 = 197.03 then 197.03 ÷ 18=) (x =) 10.946/10.95/10.9/11 **(1)** Alternative Methods M_r = 106 + 18x Mass = (8.25 x 10^{-3}) x M_r = 0.8745 + 0.1485x **(1)** 2.50 = 0.8745 + 0.1485x X=(2.50-0.8745) ÷ 0.1485 = 10.946 **(1)** OR Mass Na_2CO_3 = 8.25x10^{-3} x106 = 0.8745(g) Mass H_2O = 2.5 – 0.8745 = 1.6255 **(1)** Mol H_2O = 1,6255÷18 = 0.0903 X = 0.0903÷ 8.25x10^{-3} = 10.946 **(1)** TE from previous answers Correct final answer with/without working scores (2)		2

Question Number	Acceptable Answers	Reject	Mark
2(h)	**Marking point 1** The number of moles of sodium carbonate would be too large **OR** the molar mass of hydrated salt would be too small **(1)** **Marking point 2** Hence the value of x would be too small/low **(1)** MP2 is **not** standalone and may be awarded only if one or other of the statements for the first mark is given No TE on incorrect MP1		2

(TOTAL FOR QUESTION 2 = 16 MARKS)

Question Number	Acceptable Answers	Reject	Mark
3(a)	(250 cm^3) Volumetric flask / graduated flask	Flat bottom flask Titration flask Measuring flask Measuring cylinder Conical flask Pipette Burette Beaker	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	(From) colourless **(1)** (to) pink **(1)** ALLOW (to) red (to) Combination of pink and red/ permanent pink From pink to colourless scores **(1)**	 to purple Blue to red **loses both marks**	2

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	As an indication of when to add drop by drop OR Add slowly when approaching rough value OR Add a significant volume /a stated volume in region 18-23.0 cm^3 of alkali/a volume approaching range finder volume (quickly) **and** then slow down ALLOW It is an indication of when to slow down IGNORE To prevent overshooting Don't use in calculating mean titre The answer should show how the rough titration value is used when carrying out the accurate titration	Just "to get an estimate" It gives an idea of where the end-point is Use as a control Add slowly when reaches rough value	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	$\frac{(2 \times 0.050 \times 100)}{23.30}$ = (±)0.42918/ 0.4292/0.429 / 0.43/ 0.4 (%)		1

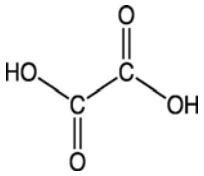
Question Number	Acceptable Answers	Reject	Mark
3(b)(iv)	23.3(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
3(b)(v)	Mol NaOH = $(23.3 \times 0.1 \times 10^{-3})$ $= 2.33 \times 10^{-3}$ **(1)** Mol H_2A = $\frac{(23.3 \times 0.1 \times 10^{-3})}{2}$ $=1.165 \times 10^{-3} / 1.17 \times 10^{-3}$ **(1)** Ignore sf except 1 sf TE on 3b(iv) Correct answer with no working scores 2		2

Question Number	Acceptable Answers	Reject	Mark
3(b)(vi)	mol acid in 250 cm^3 = 1.165×10^{-2} /0.01165 **(1)** $M_r = 1.05/1.165 \times 10^{-2}$ = 90.129/ 90.1 / 90 Ignore sf **(1)** Give both marks for final answer if some working is shown, even if first marking point is not shown separately. TE from 3b(v) Final answer of **901** because mol acid in 25 cm^3 is used **scores (1)** Using 1.17×10^{-3} gives M_r = 89.7 Using 1.2×10^{-2} gives M_r = 87.5 Using 1.15×10^{-2} gives M_r = 91.3	90 with no working (just deduced from (c)(i))	2

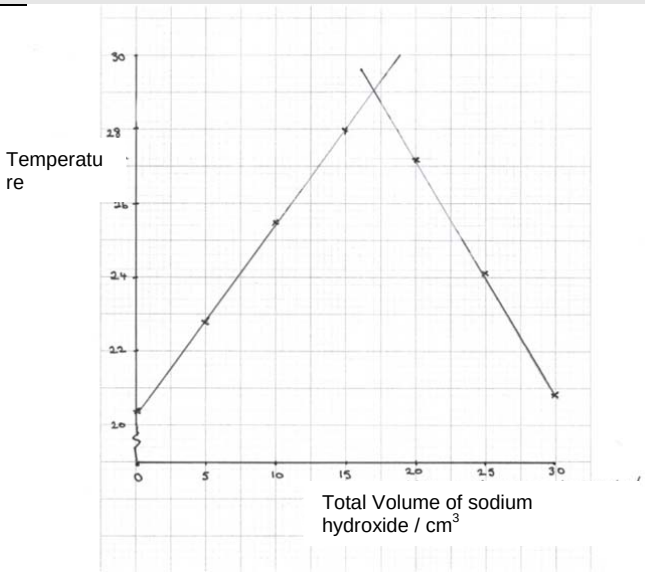
Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Potassium/ sodium dichromate((VI))/ $K_2Cr_2O_7$ / $Na_2Cr_2O_7$ **and** sulfuric acid/ H_2SO_4 **(1)** IGNORE concentration of acid alcoholic potassium/ sodium dichromate((VI)) (Heat under) reflux **(1)** Mark independently.	Potassium manganate(VII)/ potassium permanganate hydrochloric acid nitric acid Just "heat"	2

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	Orange to (dark)green / blue / brown TE if one of the reagents in c(i) is potassium dichromate and the other is not coloured. TE on use of potassium manganate(VII) and sulfuric acid: Purple to colourless No TE on other incorrect reagents		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	 Allow undisplayed O-H as above or O-H bonds shown. Ignore orientation/ bond angles		1

Total for Question 3 = 14 marks

Question Number	Acceptable Answers	Reject	Mark
4(a)	In acid: colourless **(1)** In alkali: (pale) pink ALLOW Purple / red / magenta in alkali or combinations of colours eg purple-red **(1)** Correct colours wrong way round scores **(1)**	Clear or white for colourless Violet	**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)	 Points correctly plotted **(1)** 2 best-fit straight lines through the points intersecting **(1)** Maximum temperature 29.1 ± 0.2 °C TE on linear extrapolation **(1)** Volume of NaOH 17.25 ± 0.5 cm^3 ALLOW 17 cm^3 TE on volume corresponding to maximum temperature after linear extrapolation **(1)** IGNORE sf except for one sf		**4**

Question Number	Acceptable Answer	Reject	Mark
4(c)(i)	35.5 x 4.18 x 10.2 = (1513.578) = 1514 (J) ALLOW 1.514 kJ IGNORE sf except 2 sf or less	1500 J 1513 J 1.5 kJ / 1.513 kJ	**1**

Question Number	Acceptable Answers	Reject	Mark

4(c)(ii)	(1513.578/3.00 x 10^{-2} = 50452.6 J)
	
	ΔH = -50.5 (kJ mol^{-1})
	Value
	
	ALLOW
	If (c)(i) is 1510, ΔH = -50.3 (kJ mol^{-1})
	
	TE from (c)(i)
	e.g.
	If (c)(i) is 1500, ΔH = -50.0 (kJ mol^{-1})
	If (c)(i) is 1513, ΔH = -50.4 (kJ mol^{-1})
	
	If (c)(i) = 20 x 4.18 x 10.2 = 852.72J
	Then ΔH = -28.4 (kJ mol^{-1}) **(1)**
	
	Sign **and** 3 sf if a value has been calculated **(1)**
			2

Question Number	Acceptable Answers	Reject	Mark
4(c)(iii)	Temperature is taken before heat loss occurs / before mixture cools ALLOW Because heat will be lost To reduce errors due to heat loss Temperature falls / drops quickly	 To prevent heat loss Temperature rises / changes quickly	**1**

Question Number	Acceptable Answer	Reject	Mark
4(c)(iv)	**One** mark each for any TWO of the following Temperatures are monitored continuously Equivalent to having more / many readings More points give a more accurate line / plot Magnetic stirrer more efficient than manual stirring / stirring is more uniform / makes temperature more uniform / makes concentration more uniform Heat loss is reduced because reaction is completed more quickly / because there is no time delay in readings IGNORE Comments on insulation of beaker, rate of reaction as opposed to time for experiment to be completed, parallax error Prevents human error	 Monitored frequently Prevents errors when drawing graphs Just "Heat loss is reduced"	**2**

Question Number	Acceptable Answers	Reject	Mark
4(d)(i)	Correct answer without working scores **(2)** (Moles of HCl) = 20.0 x 1.50/1000 = 3.00 x 10^{-2} = (Moles of NaOH) ALLOW Moles of HCl / NaOH = 3.00 x 10^{-2} **(1)** Concentration =($\frac{3.00 \times 10^{-2}}{15.50}$ x 10^{3} =) 1.93548 / 1.94 /1.9 (mol dm^{-3}) **(1)** IGNORE sf except 1 sf TE from first to second mark	 Just '3.00 x 10^{-2} / 0.03' 1.93 and other incorrect roundings	**2**

Question Number	Acceptable Answers	Reject	Mark
4(d)(ii)	$\frac{2 \times 0.05}{5.00}$ x 100% = (±)2%	Two answers eg 0.02 and 2	**1**

Question Number	Acceptable Answers	Reject	Mark
4(e)(i)	To make temperature (change) bigger / (more) obvious / (more) significant OR To make more exothermic / to produce more heat energy / so more heat is given out OR To reduce percentage error in **temperature** (change) IGNORE Additional comments on rate increasing if rest of answer is correct Reference to volumes Easier to measure temperature change	To allow reaction to go to completion To increase enthalpy change Just 'to increase the heat'	**1**

Question Number	Acceptable Answer	Reject	Mark
4(e)(ii)	It is corrosive / burns skin / damages eyes / caustic ALLOW Damages skin IGNORE More irritant or harmful or dangerous NaOH is an alkali	Toxic Just "damaging" Flammable	**1**

Total for Question 4 = 17 marks

Question Number	Acceptable answers	Reject	Mark
5(a)(i)	No sharp colour change / colour change gradual / difficult to see end-point/ end-point not clear / end-point not obvious / no specific colour change at end-point / colour change hard to distinguish many different colours during the vertical section of a pH curve	Colour changes slowly Does not give accurate results No significant colour change end-point not visible Colour does not change in vertical section of pH curve Forms various colours with acid and alkali Comments about suitability for weak/ strong acids	**1**

Question Number	Acceptable answers	Reject	Mark
5(a)(ii)	Suitable acid-base indicator (**1**) correct colours (**1**) Likely answers: methyl orange (**1**) red in acid, yellow in alkali (**1**) Phenolphthalein (**1**) colourless in acid, pink / purple / red in alkali (**1**) ALLOW Bromothymol blue (**1**) Yellow in acid, blue in alkali (**1**) No TE on colours for litmus Second mark depends on first	Litmus Orange for red Spelling is not a reasonable match for pronunciation	**2**

Question Number	Acceptable answers	Reject	Mark
5(b)(i)	$\frac{(22.80 \times 0.250)}{1000}$ = 5.70×10^{-3}/ 5.7×10^{-3} / 0.0057	6×10^{-3}	**1**

Question Number	Acceptable answers	Reject	Mark
5(b)(ii)	5.70×10^{-3} / 5.7×10^{-3} / 0.0057 TE: Same as 3b(i)		**1**

Question Number	Acceptable answers	Reject	Mark
5(b)(iii)	$(2.00 \times 10^{-2} - 5.70 \times 10^{-3})$ $=1.43 \times 10^{-2}$ / 14.30×10^{-3} / 0.0143 TE 2.00×10^{-2} – answer from 3b(ii) IGNORE SF except 1	Numbers obtained without having done a subtraction	**1**

Question Number	Acceptable answers	Reject	Mark
5(b)(iv)	Mol $Mg(OH)_2$ = answer to 3b(iii) /2 (**1**) $=7.15 \times 10^{-3}$ /0.00715 mass = 58.3 x number of mol =0.416845 =0.417 (g) (**1**) TE for second mark based on number of moles calculated for first mark. ALLOW use of 58 instead of 58.3 (giving 0.415(g)) Correct answer with no working scores 2	Answers with more or less than 3 significant figures	**2**

Question Number	Acceptable answers	Reject	Mark
5(c)(i)	Split sample into two / several portions (so that titration can be repeated) OR make solution to a standard volume (e.g. 100cm^3) and take measured aliquots	Just "repeat the titration" Just " use more concentrated acid " or "Use more acid". Use more accurate burettes / pipettes / balance	**1**

Question Number	Acceptable answers	Reject	Mark
5(c)(ii)	$\frac{100 \times (2 \times 0.05)}{40.00}$ = (±) 0.250/ 0.25% Doubling error in each reading (**1**) Final answer (**1**) 0.125%/ 0.13% scores 1 mark	0.3/ 0.30% 0.12, 0.1	**2**

Question Number	Acceptable answers	Reject	Mark
5(d)	Any two from Use (finely) powdered magnesium hydroxide Use moderately concentrated acid / acid which is not very dilute/ acid of higher concentration / keep excess acid to minimum possible volume. Ensure good mixing / stir mixture ALLOW Measure temperature before adding magnesium hydroxide and for some time after; plot temperatures against time and extrapolate (cooling) line (to where reagents are mixed, to allow for cooling) IGNORE Put a lid on the container/ other comments on insulation	Break magnesium hydroxide into smaller pieces Use a more accurate thermometer Just "plot temperatures against time and extrapolating"	**2**

Total for Question 5 = 13 marks