

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/31

Paper 3 (Advanced Practical Skills) maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

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Question	Sections	Indicative material	Mark	Total
1 (a)	PDO Layout	<p>I The following data must be given</p> <ul style="list-style-type: none"> • mass of solid used (or both weighings) • volume for rough titre (or both readings) • initial and final readings for two (or more) accurate titrations. 	1	
	PDO Recording	<p>II Appropriate headings for all data given in weighing and accurate titration tables and g and cm³ units.</p> <ul style="list-style-type: none"> • mass/weight (of) beaker (empty) • mass/weight (of) beaker + FA 1/solid • initial/start (burette) reading/volume • final/end (burette) reading/volume • titre or volume/FA 2 used/added • unit: /cm³ or (cm³) or in cm³ or cm³ for each volume <p><i>If g and/or cm³ units are not given in the heading, every entry in the table must have the correct unit.</i></p>	1	
	PDO Recording	<p>III All accurate burette readings (including 0.00) are to the nearest 0.05 cm³.</p> <p><i>The need to record to 0.05 applies only to the burette readings and not to the recorded titres. Do not award this mark if:</i></p> <ul style="list-style-type: none"> • 50.(00) is used as an initial burette reading or • more than one final burette reading is 50.(00) or • any burette reading is greater than 50.(00). 	1	
	MMO Decision	<p>IV There are two uncorrected accurate titres within 0.10 cm³.</p> <p><i>Do not include a reading if it is labelled “rough”. Do not award this mark if, having performed two titres within 0.1 cm³, a further titration is performed which is more than 0.10 cm³ from the closer of the initial two titres, unless a further titration, within 0.1 cm³ of any other, has also been carried out.</i></p> <p><i>Do not award the mark if any ‘accurate’ burette readings (apart from initial 0) are given to zero dp.</i></p>	1	

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Question	Sections	Indicative material	Mark	Total
(a) (cont)	MMO Quality	Award V , VI and VII if $\delta \leq 0.03$ (cm ³ g ⁻¹) <i>i.e. three Q marks.</i> Award V and VI if $0.03 < \delta \leq 0.06$ <i>i.e. two Q marks.</i> Award V , only, if $0.06 < \delta \leq 0.10$ <i>i.e. one Q mark.</i> Spread penalty: if the two “best” (corrected) titres used by the Examiner were ≥ 0.50 cm ³ apart, cancel one Q mark.	1 1 1	[7]
(b)	MMO Decision	Check mean titre is correctly calculated from clearly selected values (ticks or working). <ul style="list-style-type: none"> • Candidate must average two (or more) titres where the total spread is ≤ 0.20 cm³. • Working must be shown or ticks must be put next to the two (or more) accurate readings selected. • The mean should normally be quoted to 2 dp rounded to the nearest 0.01. [e.g. 26.667 must be rounded to 26.67] Two special cases where the mean may not be to 2 dp: allow mean to 3 dp only for 0.025 or 0.075 e.g. 26.325; allow mean to 1 dp if all accurate burette readings were given to 1 dp (<i>ignoring initial given as 0</i>) and the mean is exactly correct. [e.g. 26.0 and 26.2 = 26.1 is correct but 26.0 and 26.1 = 26.1 is incorrect.] Do not award this mark if: <ul style="list-style-type: none"> • the rough titre was used to calculate the mean; • candidate carried out only 1 accurate titration; • burette readings were incorrectly subtracted to obtain any of the accurate titre values; • all burette readings (resulting in titre values used in calculation of mean) are integers. 	1	[1]
(c) (i)	ACE Interpretation	I Correctly calculates No. of moles of KMnO ₄ = $0.0200 \times \frac{(b)}{1000}$	1	
(ii)	ACE Conclusion	II $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e$ / $5\text{Fe}^{2+} \rightarrow 5\text{Fe}^{3+} + 5e$	1	
(iii) + (iv)	PDO Display	III Correct working shown in (iii) and (iv). <i>The answer to (i) should be multiplied by 5 to give (iii).</i> <i>The answer to (iii) should be multiplied by 10 to give (iv).</i>	1	
(v)	ACE Interpretation	IV Correct calculation of relative formula mass. $M_r = \frac{\text{correct mass of FA 1 used}}{\text{answer to (iv)}}$	1	

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Question	Sections	Indicative material	Mark	Total
(v) (cont)	PDO Display	V All answers are quoted to 3 or 4 significant figures. A minimum of three answers is needed to qualify.	1	[5]
(d) (i)	ACE Interpretation	% error for pipette = $\frac{0.06}{25} \times 100 = 0.24\%$ (or 0.240%)	1	
(ii) + (iii)	ACE Interpretation	<i>If balance displays to 1 decimal place: error in balance reading is $\pm 0.05\text{g}$ or $\pm 0.1(0)\text{g}$. If balance displays to 2 decimal places: error in balance reading is $\pm 0.005\text{g}$ or $\pm 0.01\text{g}$. If balance displays to 3 decimal places: error in balance reading is $\pm 0.0005\text{g}$ or $\pm 0.001\text{g}$. % error = $2 \times \frac{\text{balance error (above)}}{\text{mass of FA 1 used}} \times 100$ Correct answer is not required, but if the “$\times 100$” factor was omitted, a correctly calculated % error answer scores the mark.</i>	1	[2]
				[Total: 15]
2 (a)	MMO Collection	I The masses of FA 5 used by the candidate were between 2.0–2.4 g (expt 1) and 1.5–1.9 g (expt 2).	1	
	PDO Display	II Suitable headings for a table or list, shown completely for at least one experiment carried out. If 2 experiments, all headings must be correct. <ul style="list-style-type: none"> • (mass of) empty crucible • (mass of) crucible + FA 5 • (mass of) crucible + residue / FA 5 after heating • (mass of) residue (<i>owtte</i>) • mass lost or (mass of) water lost. and unit was given “covering” every weighing; <i>Unit: /g or (g) or in grams or g following each weighing</i>	1	
	PDO Recording	III Records all weighings consistently to at least 1 dp. <i>A minimum of three weighings are needed.</i>	1	
<p>Accuracy (Q) marks for gravimetric experiment – 3 marks available Examiner checks working for mass of residue and mass of water and expresses the ratio $\frac{\text{mass of hydrated solid}}{\text{mass of water}}$ to 2 dp for each experiment. The expected ratio = $\frac{244}{36} = 6.78$.</p>				

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Question	Sections	Indicative material	Mark	Total	
(a) (cont)	MMO Quality	Award IV if the ratio in expt 1 is between 6.30 and 7.25. Award V If the ratio in expt 2 is between 6.30 and 7.25. Award VI If the ratio in both of experiments 1 and 2 is between 5.90 and 7.65, inclusive.	1 1 1	[6]	
(b) (i)	MMO Display	Correct expression for the number of moles of water lost (from mass as recorded) or correct answer.	1		
(ii)	ACE Interpretation	Correct expression for the number of moles of residue with correct masses of anhydrous salt and 208 and answer expressed to 2–4 sf or correct answer and 2–4 sf If only one expt carried out then correct calculation for number of moles of residue expressed to 2–4 sig fig.	1		
(iii)	ACE Interpretation	Correct calculation of (i) ÷ (ii) to give answer as an integer. (should be x = 2)	1	[3]	
(c) (i)	ACE Improvements	Heat to constant mass (owtte)	1		
(ii)	ACE Interpretation	An attempt to “ scale ” mass loss to the mass of FA 5 used or to calculate x separately for the two experiments.	1		
	ACE Conclusion	Uses calculated values to comment sensibly on the consistency the results.	1	[3]	
				[Total: 12]	
FA 6 is (NH ₄) ₂ Fe(SO ₄) ₂ (s); FA 7 is Na ₂ CO ₃ (aq); FA 8 is Pb(NO ₃) ₂ (aq); FA 9 is K ₂ CrO ₄ (aq)					
3	(i)	MMO Collection	Green precipitate and ppt insoluble in excess NaOH/ppt turning brown (in air / on standing).	1	
		MMO Decision	(When heated with NaOH) gas / NH ₃ turns red litmus to blue.	1	
		MMO Collection	(With BaCl ₂), white precipitate forms and insoluble in HCl.	1	
(ii)	ACE Conclusion	FA 6 contains ammonium ions and sulfate ions. (correct evidence needed for each ion in the observations table).	1		
(iii)	ACE conclusion	Fe ²⁺ + 2OH → Fe(OH) ₂	1		

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Question	Sections	Indicative material	Mark	Total
(iv)	MMO collection	Any two of <ul style="list-style-type: none"> Solid goes paler / loses green colour (at first) and then becomes brown (on strong heating) Condensation / water vapour / steam produced (Gas/NH₃) turns red litmus blue. 	1 1	[7]
(b)	MMO collection	FA 7 + FA 3 : Fizzing/effervescence and limewater goes milky.	1	
		FA 8 + FA 3 and FA 8 + FA 7 : white precipitate obtained in both cases	1	
		FA 9 + FA 3: (solution) turns orange FA 9 + FA 7: statement of no change/yellow solution FA 9 + FA 8: (bright) yellow precipitate/solid (formed). <i>All three observations in the third column must be correct.</i>	1	
	ACE Conclusion	FA 7 contains carbonate ions (evidence needed) / CO ₃ ²⁻	1	
		FA 8 contains lead ions or barium ions (or both) (evidence needed) / Pb ²⁺ / Ba ²⁺	1	
		FA 9 contains chromate(VI) ions / CrO ₄ ²⁻	1	[6]
			[Total: 13]	