

**MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers**

9701 CHEMISTRY

9701/31

Paper 31 (Advanced Practical Skills 1),
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.

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Question	Sections	Indicative material	Mark	
1 (a)	PDO Layout	I Volume given for rough titre and accurate titre details tabulated. <i>Minimum of 2 × 2 boxes.</i>	1	
	MMO Collection	II Initial and final burette readings recorded for rough titre and initial and final burette readings and volume of FA 2 added recorded for each accurate titre. <i>Headings should match readings.</i> <i>Do not award this mark if:</i> <i>50.(00) is used as an initial burette reading;</i> <i>more than one final burette reading is 50.(00); any burette reading is greater than 50.(00)</i>	1	
	PDO Recording	III All accurate burette readings (initial and final) recorded to nearest 0.05 (cm ³) <i>Assessed on burette readings only.</i>	1	
		IV Has two uncorrected, accurate titres within 0.1 cm ³ <i>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 fourth titration, within 0.1 cm³ of any of the previous titres has also been carried out.</i>	1	
Round any burette readings to the nearest 0.05 cm ³ . Check and correct subtractions in the titre table. Examiner then selects the “best” titre using the hierarchy: two identical; titres within 0.05 cm ³ ; titres within 0.1 cm ³ ; etc				
	MMO Quality	V, VI and VII Award V, VI and VII for a difference from Supervisor within 0.20 cm ³ Award V and VI for a difference of > 0.20 – ≤ 0.40 cm ³ Award V for a difference of > 0.40 – ≤ 0.60 cm ³ <i>If the “best” titres are ≥ 0.60 cm³ apart cancel one of the Q marks.</i>	3	
				[7]

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(b)	ACE Interpretation	Calculates the mean, correct to 2 decimal places from any accurate titres within 0.20 cm^3. <i>The third decimal place may be rounded to the nearest 0.05 cm^3.</i> <i>A mean of exactly .x25 or .x75 is allowed but the candidate may round up or down to the nearest 0.05 cm^3.</i> <i>If ALL burette readings are given to 1 decimal place then the mean can be given to 1 decimal place if numerically correct without rounding.</i> Mean of 24.3 and 24.4 = 24.35 (✓) Mean of 24.3 and 24.4 = 24.4 (✗) Titres to be used in calculating the mean must be clearly shown – in an expression or ticked in the titration table.	1	[1]
(c)	ACE Interpretation	I Expression needed in step (i) (= mean titre $\times 0.15/1000$ mol) and step (ii) (= answer to step (i) / 2) <i>No irrelevant or incorrect working should be included.</i>	1	
		II Correctly evaluates step (iii) (= answer to step (ii) $\times 10$) and step (iv) (= answer to step (iii) $\times 40$)	1	
	PDO Display	III Some relevant working shown in a minimum of three parts in the calculation. (In (ii) could be $\times 2$ or $\div 2$, in (iii) could $\times 10$ or $\div 10$).	1	
		IV All answers given are quoted to 3 or 4 sig figs (must be a minimum of three steps)	1	[4]
				[Total: 12]

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2 (a)	MMO Collection	I Two pairs of temperature values recorded as instructed in (a), with units for all readings in (a) and (b) – minimum of 3 readings. <i>Acceptable units are /°C, (°C), temperature in degrees Celsius, temperature in °C.</i>	1	
	PDO Recording	II All thermometer readings recorded to 0.0 °C or 0.5 °C. (check readings in sections 2(a) and 2(b) – minimum of 4 readings).	1	
	ACE Interpretation	III Correct subtractions to give temperature rises and the correct mean value in 2(a). <i>Mean value may be rounded to 0.5 °C or to one d.p or to 0.05 °C and from 0.025 and 0.075 or these may be rounded up or down to nearest 0.1.</i>	1	
Supervisor script: check subtractions and calculate mean ΔT Marks are awarded for comparing the “true” means: check working of candidate and Supervisor. Show Supervisor’s mean (corrected if necessary) on the script in a ring.				
	MMO Quality	Award IV and V if candidate’s mean temp rise is within 2.0 °C of Supervisor’s (incl) Award IV if the difference is between 2.0 °C and 3.0 °C.	1 1	[5]
	PDO Display	Heat produced (J) = $25 \times 4.3 \times \text{temp rise}$ (method mark). Unit is needed in the quoted answer (kJ if divided by 1000). Correctly evaluates enthalpy change = $\frac{\text{heat produced}}{0.016}$. Division by 1000 is not required if candidate did this in the previous step. Answer must be negative and to 3 sig figs.	1 1	

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Examiner to calculate 20% and 40% of supervisor's ΔT and convert to nearest 0.5°C.

(b)	ACE Interpretation MMO Quality	I Both temperature measurements clearly shown. Award II and III if candidate's temp rise is within 20% of Supervisor's. Award II if candidate's temp rise is within 40% of Supervisor's.	1 1 1	[3]
	ACE Interpretation PDO Display	IV Calculates 0.032 for moles in (ii) or 0.016 for moles in (a)(ii) . V Enthalpy change correctly calculated (= $-\frac{\text{heat change}}{0.032}$). <i>Answer must show negative sign (unless already penalised) and be given to 3 sig figs. (unless already penalised).</i>	1 1	
	ACE Conclusions	VI Correct calculation of enthalpy change $\Delta H_1 = \Delta H_2 - \Delta H_3 - 286$	1	[3]
(c)	ACE Improvements	Extra/thicker lagging or use a lid or use a vacuum flask	1	[1]
[Total: 14]				

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FA 7 is $\text{Zn}(\text{NO}_3)_2(\text{s})$; FA 8 is $\text{CuSO}_4(\text{s})$					
3	(a) (i)	MMO Collection	No change (or no precipitate or no reaction) both with barium chloride and silver nitrate.	1	
		MMO Collection	Gentle heat: solid melts or dissolves or gives a colourless liquid	1	
	(ii)		Brown fumes/gas produced (allow 'qualified' brown e.g. red/brown, do not allow orange).	1	
			(Gas produced) that relights a glowing splint or yellow solid, goes white on cooling. (Allow precipitate).	1	
	(iii)	ACE Conclusions	FA 7 is a nitrate/nitrite (from some evidence)	1	
	(iv)	MMO Decisions	(Heat) FA 7 with Al foil and NaOH/ecf from anion given.	1	
		MMO Collection	Gas/vapour/ NH_3 produced and it turns red litmus to blue and confirms that FA 7 contains nitrate/nitrite ions.	1	
	(v)	MMO Decisions	Adds ammonia. (<i>This mark is not awarded if a second test is also used</i>)	1	
		ACE Conclusions	Zinc ions are present. (No ecf) (Deduction must be consistent with observations recorded – white ppt soluble in excess).	1	
(b)	(i)	MMO Collection	With KI, goes yellow/orange/brown and gives a blue (blue-black or purple or black) colour with starch. <i>No reference to the state is required, just the colours.</i>	1	
			Brown/yellow/white/off- white precipitate forms.	1	
	(ii)	ACE Conclusions	KI is the reducing agent (or it is oxidised) as iodine is formed or $2\text{I}^- - 2\text{e}^- \rightarrow \text{I}_2$ or $2\text{Cu}^{2+} + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Cu}^+$ <i>Ignore state symbols.</i>	1	
	(iii)	MMO Collection	Blue (do not allow dark blue) precipitate obtained, which does not dissolve in excess NaOH	1	
		ACE Conclusions	$\text{Cu}^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{OH})_2$	1	
					[5]
					[Total: 14]

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Question	Sections	Indicative material	Mark	
1 (a)	PDO Layout	I Volume given for Rough titre and accurate titre details tabulated. <i>Minimum of 2 × 2 boxes.</i>	1	
	MMO Collection	II Initial and final (burette) (readings) and volume of FB 2 added/reading at start and finish recorded for each accurate titre (not 'difference'). and mass tube + FB 1 , mass tube + residue/empty, mass FB 1 . Ignore units. <i>Headings should match readings.</i> <i>Do not award this mark if:</i> <i>50(.00) is used as an initial burette reading;</i> <i>More than one final burette reading is 50(.00);</i> <i>Any burette reading is greater than 50(.00).</i>	1	
	PDO Recording	III All accurate burette readings (initial and final) recorded to nearest 0.05 cm ³ . <i>Assessed on burette readings only (minimum of 2 readings).</i>	1	
	MMO Decisions	IV Has two uncorrected accurate titres within 0.1 cm ³ . <i>Do not award this mark if, having performed two titres within 0.1 cm³, a further titration is performed that is more than 0.10 cm³ from the closer of the initial two titres, unless a fourth titre, within 0.1 cm³ of any of the previous titres, has also been carried out.</i>	1	
Round any burette readings to the nearest 0.05 cm³. Check and correct, if necessary, subtractions in the titre table and in the calculation of mass. Examiner then selects the 'best' titre using the hierarchy: two identical; titres within 0.05 cm³, titres within 0.1 cm³ etc. Calculate: candidate's titre × $\frac{\text{Supervisor mass}}{\text{candidate mass}}$ to 2 decimal places Calculate difference in Supervisor and candidate scaled values and award quality marks as below.				
	MMO Quality	V, VI and VII Award V, VI and VII if $\delta \leq 0.25 \text{ cm}^3$ Award V and VI if $0.25 < \delta \leq 0.50 \text{ cm}^3$ Award V if $0.50 < \delta \leq 0.80 \text{ cm}^3$ <i>If the 'best' titres are $\geq 0.60 \text{ cm}^3$ apart cancel one of the Q marks.</i>	3	[7]

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2	(a)	PDO Layout	I Two balance readings, one mass, two thermometer readings and one change in temperature shown in suitable layout.	1	
		PDO Recording	II Masses and temperatures recorded with correct headings and units for all data shown. <i>Acceptable units for temperature are / °C, (°C), temperature in degrees Celsius, temperature in °C., units for mass are /g, (g), mass in grams.</i>	1	
		PDO Recording	III All thermometer readings recorded to 0.0 °C or 0.5 °C and all balance readings recorded to same degree of accuracy.	1	
		Round all thermometer readings to nearest 0.5 °C. Check and correct, if necessary, subtractions in the temperature change and the mass used. Calculate to 1 decimal place: candidate temperature change $\times \frac{\text{Supervisor mass}}{\text{candidate mass used}}$ Calculate difference in candidate and Supervisor scaled values and award quality marks as below.			
		MMO Quality	IV and V Award IV and V for changes within 0.8 °C of Supervisor Award V for changes > 0.8 but within 1.6 °C of Supervisor	2	[5]
(b)	(i)	ACE Interpretation	I Expression for heat change in (i) = $25 \times 4.3 \times \text{temperature change from (a)}$ (answer given must correspond to units quoted).	1	
	(ii)		II Expression for moles of washing soda from mass used and M_r from (a) or $M_r = 259$ or $M_r = 286$ in (ii)	1	
	(iii)		III Correctly evaluates enthalpy change = heat change / (1000 $\times$ moles of washing soda) in (iii) (if 1000 not used, must say J).	1	
		ACE Conclusions	IV Enthalpy change shown as positive and to 3 sig figs. (Answer need not be arithmetically correct). Ignore sig figs (except if approximated to 1 sig fig in rest of question.)	1	[4]
(c)		ACE Improvements	Use a more precise thermometer/a thermometer with more accurate calibrations/a thermometer that reads to 0.1 °C or 0.2 °C (a more accurate thermometer/a digital thermometer/thermocouple is insufficient) or use a more precise method to measure the volume of acid or use a deeper plastic cup or scaling up apparatus and quantities of chemicals used (Do not accept 'add a lid')	1	[1]
					[Total: 10]

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FB 5 is $\text{MgSO}_4(\text{aq})$; FB 6 is $\text{Pb}(\text{NO}_3)_2(\text{aq})$ FB 7 is $\text{Al}_2(\text{SO}_4)_3(\text{aq})$; FB 8 is $(\text{NH}_4)_2\text{FeSO}_4(\text{aq})$					
3	(a) (i)	MMO Decisions	I Reagents chosen $\text{KI}(\text{aq})$ or $\text{HCl}(\text{aq})$ or K_2CrO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$ or H_2SO_4 and $\text{NaOH}(\text{aq})$ (penalise additional reagents)	1	[4]
		MMO Collection	II NaOH white precipitates for all	1	
			III Excess NaOH no effect FB 5 , precipitate dissolves FB 6 and FB 7	1	
			IV $\text{KI} / \text{HCl} / \text{K}_2\text{CrO}_4 / \text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4$ nothing/no visible reaction for (FB 5 and FB 7), yellow precipitate/white precipitate for FB 6 .	1	
	(ii)	ACE Conclusions	Ignore observations for additional reagents.		
			I FB 5 contains Mg^{2+} , FB 6 contains Pb^{2+} and FB 7 contains Al^{3+} (no ecf and must follow observations in (i))	1	
			II FB 5 (white) precipitate with NaOH , insoluble in excess	1	
			III FB 6 (yellow) precipitate with $\text{KI} /$ (yellow) precipitate with K_2CrO_4 or $\text{K}_2\text{Cr}_2\text{O}_7 /$ (white) precipitate with HCl or H_2SO_4 .	1	
			FB 7 No precipitate with $\text{KI} / \text{HCl} / \text{H}_2\text{SO}_4$ and (white) precipitate with NaOH , soluble in excess. (Both observations needed unless FB 6 already identified as Pb^{2+}).	1	
			Allow ecf, based on candidate's observations, for II, III and IV.		

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(b)	(i)	MMO Collection	Effervescence/bubbles/hydrogen produced (ignore any test for ammonia but tests for other gases negate). (Do not accept gas produced) or Black/grey solid/coating on magnesium	1	[5]
	(ii)		Ammonia/gas turns litmus paper blue	1	
	(iii)		Green precipitate (any qualified green including grey/green but do not allow green/brown.)	1	
			Turns brown (any qualified brown) on addition of hydrogen peroxide. Allow rusty or orange/brown precipitate but not orange alone. Ignore effervescence.	1	
			Fe ²⁺ / iron (II).	1	
			(+)2 to 0 (ecf on chromium (+)3 to 0) or (+)3 to (+)2).	1	
	ACE Conclusions	(+)2 to (+)3.	1		
		Conclusions are free standing but must be Fe ²⁺ .			[2]
					[Total: 15]

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Question	Sections	Indicative material	Mark	
1 (a)	PDO Layout	I Volume given for rough titre and accurate titre details tabulated. <i>Minimum of 2 × 2 “boxes”.</i>	1	
	PDO Recording	II Appropriate headings and units for data given in weighing and accurate titration tables. <i>Acceptable headings:</i> <i>mass of tube + FA1;</i> <i>mass of tube + residue/mass of empty tube (mass of FA1 used);</i> <i>initial/final or 1st/2nd (burette) (reading)/(reading at start/finish;</i> <i>volume added/used/ titre; or wtte [not “difference”]</i> <i>Acceptable units are solidus: /cm³; brackets: (cm³); in words: volume in cubic centimeters, volume in cm³. Similarly for mass in g, etc</i> If units are not included in the heading every entry in the table must have the correct unit.	1	
	PDO Recording	III All accurate burette readings are given to the nearest 0.05 cm ³ . <i>Do not award this mark if:</i> <i>50(.00) is used as an initial burette reading;</i> <i>more than one final burette reading is 50.(00);</i> <i>any burette reading is greater than 50.(00)</i>	1	
	MMO Decision	IV Two uncorrected titres within 0.10 cm ³ <i>Do not allow the Rough even if ticked.</i> <i>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 fourth titration, within 0.1 cm³ of any other has also been carried out.</i>	1	
Examiner rounds any burette readings to the nearest 0.05 cm ³ , checks subtractions and then selects the “best” titre using the hierarchy: <i>two identical; titres within 0.05 cm³; titres within 0.1 cm³; etc</i> to calculate mean (ignore any labelled rough). Examiner compares [corrected mean titre/corrected mass of FA 1] with Supervisor result. Calculate the ratios to 2 dp.				
	MMO Quality	Award V , VI and VII if $\delta \leq 0.05$ (cm ³ g ⁻¹) Award V and VI if $0.05 < \delta \leq 0.10$ Award V only if $0.10 < \delta \leq 0.20$ <i>If the “best” titres are ≥ 0.60 cm³ apart cancel one of the Q marks.</i>	1 1 1	[7]

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(b)	MMO Decision	Selects correctly subtracted accurate titre values within 0.20 cm ³ . Must use more than one value. If no calculation shown then titres must be indicated (e.g. with a tick) in the table	1	
	PDO Display	Correct mean from any values selected (may include rough) by candidate given to same decimal places as most precise burette reading recorded in the table. <i>The third decimal place may be rounded to the nearest 0.05 cm³.</i> <i>A mean of exactly .x25 or .x75 is allowed but the candidate may round up or down to the nearest 0.05 cm³.</i> <i>If ALL burette readings are given to 1 decimal place then the mean may be given to 1 decimal place if numerically correct without rounding.</i> <i>Mean of 24.3 and 24.4 = 24.35 (✓)</i> <i>Mean of 24.3 and 24.4 = 24.4 (✗)</i> If no working shown allow mean if value identical to that used by Examiner.	1	
(c)	ACE Interpretation	I In part (i) {titre from (b)/1000} × 0.01(0) <i>If no working shown then answer must be correct.</i>	1	
		II ans to (i) × 5 and ans to (ii) × 10 <i>with no additional steps</i>	1	
		III ans to (iii) × 55.8 <i>If (iii) incorrect allow correct (ii) × 10 × 55.8</i>	1	
		IV correct (ans to (iii) × 55.8/mass of FA 1) × 100 to sf shown (ecf allowed from (iii)) (sf shown may come from (i) with no previous rounding) <i>If (iii) incorrect allow correct (ii) × 10 × 55.8 × 100/mass FA 1</i> <i>(If choice of answer take the one in the answer space.)</i>	1	
	PDO Display	V 3 or 4 significant figures in final answers to all parts attempted (minimum three parts)	1	
(d)	ACE Interpretation	(i) Uncertainty either 1 or .5 in final place. If balance displays to 1 decimal place: error in balance reading is ±0.05 g or ±0.1(0) g If balance displays to 2 decimal places: error in balance reading is ±0.005 g or ±0.01 g If balance displays to 3 decimal places: error in balance reading is ±0.0005 g or ±0.001g	1	
		(ii) {2 × (i)/mass used} × 100 answer to 2, 3 or 4 sf	1	
[Total: 16]				

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2 (a)	PDO Display	I Tabulates mass of (empty) crucible, mass of crucible + FA 4 , mass of crucible + residue/ FA 4 after heating, mass of FA 4 /hydrated magnesium sulfate, mass of water lost. <i>Do not award if mass of FA 4 or mass of water incorrect</i>	1	
	PDO Recording	II Records all weighings consistently to at least 1 decimal place [minimum three weighings].	1	
	MMO Decision	III Final weighings after reheating are within 0.05 g or identical if masses recorded to 1 dp	1	
Examiner to calculate [lowest mass of residue/mass of FA 4] of Supervisor and candidate to 2 dp. If two experiments carried out then use sum of masses of residues and sum of masses of FA 4 to calculate the ratio. <i>If the Supervisor's value is doubtful (higher than the majority of candidates) then check whether candidates are close to the expected value of 0.55 or use candidate average if majority in close agreement. (Contact team leader)</i>				
	MMO Quality	Award IV and V if $\delta \leq 0.05$ Award IV only if $0.05 < \delta \leq 0.10$	1 1	[5]
(b)	ACE Interpretation	Part (i) [mass of water lost/(7 × 18)] or [mass of water lost × 246.4/18] (allow $m(\text{H}_2\text{O}) \times 246.4/7$) <i>$M_r \text{ H}_2\text{O}$ must be 18</i> <i>Allow ecf for mass of water lost</i> <i>If two experiments carried out then mass of water may be taken from either or the mean.</i> <i>Allow mark if answer calculated correctly but working not shown.</i>	1	[2]
		Part (i) [mass of water lost × 246.4/7 × 18] correctly evaluated to 3 sf [= mass of water lost × 1.956] (Ignore part (ii)) There are other chemically correct methods – mark accordingly.	1	
(c)	ACE Improvements	Use a lid (for the early gentle heating) or larger mass (for smaller percentage error) or use (cool in) desiccator	1	[1]
[Total: 8]				

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FA 5 is NaHCO ₃ (s); FA 6 is NH ₄ Br(s); FA 7 is H ₂ SO ₄ (aq)					
3	(a)	MMO Collection	On heating, steam or condensation or water vapour, misty vapour is noted or solid becomes powdery	1	[2]
		MMO Decisions	Tests for gas using limewater or in 3(d)	1	
(b)	PDO Layout		Presents results of tests in an unambiguous way <i>Minimum 4 × 2 boxes</i>	1	[6]
	MMO Collection		(No reaction with cold NaOH and) gas/ammonia/fumes produced (on heating) that turn(s) red litmus blue <i>Do not award if ppt reported with NaOH (CON)</i>	1	
			No reaction with ammonia and no reaction with barium chloride/nitrate	1	
			Cream ppt with silver nitrate that partially dissolves/is insoluble in aqueous ammonia	1	
		ACE Conclusion	FA 6 cation: ammonium/NH ₄ ⁺ <i>from some evidence and no CON obs</i>	1	
	FA 6 anion: bromide/Br ⁻ <i>No ecf but can award Br⁻ from any mention of cream but ppt must be present or off-white ppt insoluble or partially soluble in NH₃.</i>		1		
(c)	MMO Collection	Ignore any observations after water added. Steamy/misty white/orange/red/red-brown (not brown) gas/vapour/ fumes/smoke produced or gas/vapour/fumes/smoke bleaches litmus (paper) or gas/vapour/fumes/smoke turns (potassium) dichromate (solution) from orange to green	1	[3]	
	ACE Conclusion	(White) solid turns red/orange (not yellow, not brown, not solution, not ppt) Ignore “hot”	1		
		FA 6 is oxidised/redox reaction/oxidation because Br ⁻ becomes Br ₂ /Br ₂ is produced or redox/reduction because H ₂ SO ₄ forms/becomes SO ₂ (with positive dichromate observation) or exothermic because tube becomes hot/heat given out.	1		
(d)	MMO Collection	Fizzing/effervescence/bubbling (occurs) (<i>not gas is produced</i>) If limewater test used here give second mark in (a). White ppt with lead nitrate and no reaction with silver nitrate	1 1	[2]	

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(e)	MMO Decision	barium chloride/nitrate followed by hydrochloric/nitric acid (not $\text{Ba}^{2+}(\text{aq})$, BaNO_3 , ...) (If H^+ already identified then “followed by hydrochloric/nitric acid” is not essential.)	1	[3]
	ACE Conclusion	FA 7 cation: protons/ H^+ if there is a positive observation with blue litmus paper/ $\text{K}_2\text{CrO}_4/\text{Mg}/\text{Na}_2\text{CO}_3$	1	
		FA 7 anion: sulfate/ SO_4^{2-} Allow from minimum evidence of white ppt with $\text{Ba}^{2+}(\text{aq})$	1	
	[Total: 16]			

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	GCE AS/A LEVEL – May/June 2011	9701	34

Question	Sections	Indicative material	Mark
1 (a)	PDO Layout	I Volume given for Rough titre and accurate titre details tabulated. <i>Minimum of 2×2 “boxes”.</i>	1
	MMO Collection	II Follows instructions – dilutes 45.50–46.50 cm ³ FB 1 and initial and final burette readings and volume of FB 2 added recorded for each accurate titre (on page 3) <i>Headings should match readings. Ignore units. Acceptable headings: initial/final or 1st/2nd (burette) (reading)/(reading at) start/finish; volume added/used/ titre; or wtte [not “difference”]</i> <i>Do not award this mark if:</i> <i>50(.00) is used as an initial burette reading;</i> <i>more than one final burette reading is 50.(00);</i> <i>any burette reading is greater than 50.(00)</i>	1
	PDO Recording	III All accurate burette readings (initial and final) recorded to nearest 0.05 cm ³ (Accurate titration & dilution tables) <i>Assess this mark on burette readings only, ignore volumes of FB 1 and FB 2 added</i>	1
	MMO Decisions	IV Has two uncorrected, accurate titres within 0.1 cm ³ <i>Do not consider the Rough even if ticked.</i> <i>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 fourth titration, within 0.1 cm³ of the third titration (or first two) has also been carried out.</i>	1

Round any burette readings to the nearest 0.05 cm³.

Check and correct, if necessary, subtractions in the titre table.

Examiner then selects the “best” titre using the hierarchy:
two identical; titres within 0.05 cm³; titres within 0.1 cm³; etc

Calculate candidate titre × $\frac{\text{candidate volume added}}{\text{Supervisor volume added}}$

Calculate difference in Supervisor and candidate scaled values and award “quality” marks as below.
[If candidate has not recorded a volume diluted, use 46.00 cm³]

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Question	Sections	Indicative material	Mark	
	MMO Quality	V, VI and VII Award V, VI and VII for a difference from Supervisor within 0.20 cm^3 Award V and VI only for $0.20 < \delta \leq 0.40 \text{ cm}^3$ Award V only for $0.4 < \delta \leq 0.6 \text{ cm}^3$ <i>Apply spread penalty as follows:</i> <i>If titres selected (by Examiner) differ 0.60 cm^3 cancel one of the Q marks</i>	1 1 1	[7]
(b)	ACE Interpretation	Calculates the mean, correct to 2 decimal places (third decimal place may be rounded up to the nearest 0.05 cm^3) from any accurate titres within 0.20 cm^3 . <i>A mean of exactly .x25 or .x75 is allowed but the candidate may round up to .x3 or .x8 or to the nearest 0.05 cm^3.</i> <i>If ALL burette readings are given to 1 decimal place then the mean can be given to 1 decimal place if numerically correct without rounding.</i> Mean of 24.3 and 24.4 = 24.35 (✓) Mean of 24.3 and 24.4 = 24.4 (✗) Titres to be used in calculating the mean must be clearly shown – in an expression or ticked in the titration table. <i>Allow ecf from subtraction error for titre</i>	1	[1]
(c)	ACE Interpretation PDO Display	I correctly evaluates 1.25×10^{-4} II, III, IV are awarded for the correct expression but with no extra steps or for the correct answer if no working shown. II answer to (i) $\times 2.5$ (3.125 or 3.13×10^{-4}) and answer to (ii) $\times 2$ (6.25×10^{-4}) III Answer to (iii) $\times 250/\text{mean titre in (b)}$ IV Answer to (iv) $\times 1000/\text{volume diluted}$ V Working shown in a minimum of 4 steps <i>working must be in the right direction:</i> (i) 0.005×25 (ii) <i>indicate use of mole ratio ($\times 5/2$ or $2/5$)</i> <i>(If iodide used then $\times 5$ or $/5$)</i> (iii) <i>use of $\times 2$ or $\times 1/2$</i> <i>(If iodide used then $\times 2/2$ not $\times 1$)</i> (iv) <i>answer to (iii) $\times 250$ or (iii)/mean titre</i> (v) <i>answer to (iv) and volume diluted used in denominator</i> (vi) All final answers to steps to 3 or 4 sf (minimum of 3 steps)	1 1 1 1 1 1	[6]
(d)	ACE Interpretation	$(0.06/25) \times 100$ (= 0.24%) and $(0.10/\text{titre in (b)}) \times 100$ <i>(only expressions needed)</i>	1	[1]
				[Total: 15]

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Question	Sections	Indicative material	Mark	
2 (a)	PDO Recording	I Records volume of FB 6 , t and $1/t$ unambiguously for the four experiments <i>Do not award if t is not to the nearest second</i>	1	
	MMO Decisions	II Correct headings and units: volume (cm^3) or $/\text{cm}^3$ or volume in cubic centimetres/ cm^3 ; time (s) or $/\text{s}$ or time in seconds/s; $1/\text{time}$ (s^{-1}) or $/\text{s}^{-1}$ or $1/\text{time}$ or rate in per second III Selects two volumes of FB 6 one between $25\text{--}30\text{ cm}^3$ and one between $35\text{--}40\text{ cm}^3$ and sufficient water to make the solutions up to 45 cm^3 before adding acid or between $30\text{--}35$ and $10\text{--}15$ with corresponding volumes of water.	1	
	Examiner corrects any fractional times to the nearest second for 45 cm^3 and 20 cm^3 of FB 6 and calculates t_{20}/t_{45} to 2 dp			
	MMO Quality	Award IV only if $1.90 \leq t_{20}/t_{45} < 2.60$ Award IV and V if $2.10 \leq t_{20}/t_{45} < 2.40$	1 1	[5]
(b)	ACE Conclusions	Volume of FB 6 is directly proportional to its concentration (if total volume is constant) or to keep the concentration of FB 5 constant or to keep the depth constant	1	[1]
(c)	ACE Conclusions	Rate of reaction is proportional to concentration of FB 6 (<i>allow directly proportional</i>) or increase in concentration increases rate or $1/t$	1	[1]
(d)	ACE Interpretation	Either shortest time as greatest percentage/fractional error or longest time as greatest uncertainty in judging when printing is obscured	1	[1]
(e)	ACE Improvements	Keep volume of thio/ FB 6 constant, change volume of acid/ FB 5 and (add water to) make total volume constant or use different concentrations of acid/ FB 5 and keep the volume of it and the thio/ FB 6 constant	1	[1]
	[Total: 9]			

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Question	Sections	Indicative material	Mark	
FB 7 is $\text{Al}_2(\text{SO}_4)_3$, FB 8 is $\text{Zn}(\text{NO}_3)_2$, FB 9 is $\text{Pb}(\text{NO}_3)_2$, FB 10 is anhydrous NaHCO_3				
3 (a)	PDO Layout	<i>Do not allow a dash for 'no reaction' except for FB 8 with 2nd reagent provided NH_3 obs correct.</i> I Unambiguous layout of all (six minimum unless as above) observations with the two reagents <i>independent of reagents chosen</i>	1	
	MMO Decisions	II Chooses NH_3 and $\text{KI/K}_2\text{CrO}_4/\text{H}_2\text{SO}_4/\text{HCl}$ (allow sodium/potassium dichromate)	1	
	MMO Collection	III three white ppts with NH_3	1	
		IV Three correct obs FB 7: ppt insol in excess NH_3 , FB 8: ppt soluble in excess NH_3 , FB 9: ppt insol in excess NH_3	1	
		V three correct obs for a suitable reagent Expected obs: FB 7 and FB 8 no reaction, no change, no ppt, and FB 9 white or yellow ppt depending on reagent Allow obs mark if BaCl_2 used as 2 nd reagent: white ppt with FB 7, no ppt with FB 8 and white ppt or no ppt with FB 9. (If three reagents used mark obs for the two specified on 'reagent' line.) If any solutions appear to have been transposed, mark strictly as mark scheme.	1	
(b)	ACE Conclusions	FB 7 contains Al^{3+} /aluminium (ions) as (white) ppt insoluble in excess NH_3 and no reaction with 2 nd reagent FB 8 contains Zn^{2+} /zinc (ions) as (white) ppt soluble in excess NH_3 FB 9 contains Pb^{2+} /lead (ions) as ppt with 2 nd reagent Only penalise missing charge once. If NaOH used as 2 nd reagent allow 1 st mark if both Al^{3+} & Pb^{2+} specified for FB 7 and FB 9 , (FB 8 mark is still available) The evidence for FB 7 and FB 9 may come from a third reagent (if used) For 'transposed' solutions, if conclusions are valid for the obs given, a maximum of 2 marks may be awarded. If BaCl_2 used and only white ppt with FB 7 then allow FB 7 as Pb^{2+} . If two (white) ppts both unknowns should be Pb^{2+} or $\text{Al}^{3+}/\text{Pb}^{2+}$.	1 1 1	
				[5]
				[3]

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Question	Sections	Indicative material	Mark	
(c)	MMO Collection	(i) Steam/water vapour/misty vapour/condensation/droplets of liquid/water or lime water turns milky/cloudy white (ii) (pale) blue/green ppt/solid (<i>ignore effervescence</i>) (iii) effervescence/fizzing/bubbling (<i>ignore any reference to ppt</i>) (iv) white ppt and either effervescence (with acid) or (colourless) solution/ppt or solid dissolves (v) solid/ppt turns black/dark green/ darkens in 2nd box <i>Allow is formed/changes to</i>	1 1 1 1	[5]
(d)	ACE Conclusions	(i) CO_3^{2-} from limewater turning milky in any part of (c) or fizzing/effervescence with acid <i>Allow SO_3^{2-} from correct obs in (c)(iv)</i> (ii) thermal decomposition or loss of water of crystallisation/dehydration (if CO_2 not tested for) (iii) effervescence suggests $\text{Al}^{3+}(\text{aq})/\text{Al}_2(\text{SO}_4)_3$ is acidic or FB 10 contains Ba^{2+} or Pb^{2+} (both needed) if white ppt recorded or CO_2 (produced) as limewater turns milky/cloudy white/forms white ppt or endothermic if cooling noted in (c)(iii)	1 1 1	[3]
				[Total: 16]

MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/35

Paper 31 (Advanced Practical Skills 1),
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 must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

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Question	Sections	Indicative material	Mark	
1 (a)	PDO layout	I Volume given for rough titre and accurate titre details tabulated <i>Minimum of 2×2 “boxes”</i>	1	
	MMO collection	II Follows instructions – dilutes 44.50–45.50 cm ³ FA 2 and records unambiguous initial and final burette readings and volume of FA 2 diluted and volume of FA 3 added for each titration. <i>Headings should match readings.</i> <i>Do not award this mark if:</i> <i>50(.00) is used as an initial burette reading;</i> <i>more than one final burette reading is 50.(00);</i> <i>any burette reading is greater than 50.(00)</i>	1	
	MMO decisions	III All accurate burette readings (initial and final) recorded to nearest 0.05 cm ³ including dilution table <i>Assess this mark on burette readings only, ignore volume of FA 3 added.</i>	1	
	PDO recording	IV has two titres within 0.10 cm ³ <i>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 fourth titration, within 0.1 cm³ of any other has also been carried out.</i>	1	
	Examiner to check and correct (if necessary) subtractions in the titre table. Examiner then selects the “best” titre using the hierarchy: two identical; titres within 0.05 cm³, titres within 0.10 cm³, etc., (ignore rough titre) For candidates and Supervisor scale titre for 45.00 cm³ FA 2 diluted. Calculate titre $\times \frac{45.00}{\text{volume of FA 2 diluted}}$ to 2 dp Calculate difference in Supervisor and candidate scaled values and award “quality” marks as below.			
	MMO quality	Award V , VI and VII for a difference from Supervisor, $\delta \leq 0.30 \text{ cm}^3$	1	
		Award V and VI for $0.30 < \delta \leq 0.60 \text{ cm}^3$	1	
		Award V only for $0.60 < \delta \leq 1.00 \text{ cm}^3$ <i>If “best” titres are 0.60 cm^3 apart cancel one of the Q marks</i>	1	[7]

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(b)	ACE interpretation	Calculates the mean, correct to 2 decimal places from any accurate titres within 0.20 cm^3. <i>The third decimal place may be rounded to the nearest 0.05 cm^3.</i> <i>A mean of exactly .x25 or .x75 is allowed but the candidate may round up or down to the nearest 0.05 cm^3.</i> <i>If ALL burette readings are given to 1 decimal place then the mean can be given to 1 decimal place if numerically correct without rounding.</i> <i>Mean of 24.3 and 24.4 = 24.35 (✓)</i> <i>Mean of 24.3 and 24.4 = 24.4 (x)</i> <i>Titres to be used in calculating the mean must be clearly shown – in an expression or ticked in the titration table.</i>	1	[1]
(c)	ACE interpretation	I Expression correct in step (i) $\text{volume diluted} /_{250} \times 1.00$	1	
		II Correctly uses $\text{titre from (b)} /_{1000} \times \text{ans to (i) in (ii)}$ and $\frac{1}{2} \times \text{ans to (ii) in (iii)}$	1	
		III $\text{ans to (iii)} \times \frac{1000}{25} \times 201.2 \text{ in (iv)}$	1	
		IV Uses $(38.10 - \text{ans to (iv)}) /_{38.10} \times 100 \text{ in (v)}$	1	
	PDO display	V Working shown in all steps attempted and a minimum of 3 steps. (use of 2 in (iii), missing $\times 40$ or M_r in (iv) gains the mark) <i>(Working should be a step in the right direction)</i>	1	
		VI 3 to 4 significant figures shown in final answer to all steps attempted – minimum of 3 steps	1	[6]
(d)	ACE interpretation	Correctly evaluates: $\frac{0.06}{25} \times 100 \text{ or } 0.24 \%$ and $\frac{0.10}{\text{titre in (b)}} \times 100$ <i>Answers must be given to at least 2 significant figures and correctly rounded for the significant figures shown.</i>	1	[1]
[Total: 15]				

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2 (a)	PDO layout	I All data presented clearly in all three sections. (6,6,7)	1	
	PDO recording	II Has correct headings and units on page 7.	1	
		III All thermometer readings recorded to nearest 0.5 °C in each of the experiments	1	
		IV Each pair of balance readings consistent and to at least 1 decimal place	1	[4]
(b)	Examiner to calculate (corrected) $\Delta T_1/m_1$ and $\Delta T_2/m_2$ for Supervisor and candidate. Compare candidate value with the same value from the Supervisor report. Award Q marks on the closer value.			
	MMO	Award I and II for $\delta \leq 0.10 \text{ } ^\circ\text{Cg}^{-1}$	1	
	quality	Award I only for $0.10 < \delta \leq 0.30 \text{ } ^\circ\text{Cg}^{-1}$	1	[2]
(c)	MMO collection	I Follows instructions – weighs between 8.5 and 9.5 g of FA 6 (mass bottle with FA 6 – mass bottle)	1	
	PDO layout	II Check Δm and ΔT are correct in (c)	1	[2]
(d)	ACE interpretation	Examiner to check there is no obvious error in the evaluation of the expression, then award one mark for a mass of sodium carbonate between 2.5 and 3.5 g.	1	[1]
(e)	ACE improvements	Give one mark for: suggesting weighing, heating and weighing again, or weighing, heating and measuring gas volume or giving an outline for a titration method using 2 indicators.	1	[1]
	[Total: 10]			

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FA 8 is NaCl(aq); FA 9 is NaNO ₂ (aq); FA 10 is NaBr(aq); FA 11 is CuSO ₄ (aq); FA 12 is MgSO ₄ (aq)				
3 (a)	MMO decisions	Selects any named acid	1	
	MMO collection	Records brown gas with FA 9 and no reaction with FA 8 and FA 10	1	[2]
(b)	MMO decisions	I Selects: (<i>correct full name or formula</i>) silver nitrate as first reagent, aqueous ammonia as second reagent, aqueous ammonia added to tube with Ag⁺, 1st box ticked (<i>do not allow if Pb²⁺ used as 2nd reagent</i>) or lead nitrate as first reagent, silver nitrate as second reagent, Ag⁺(aq) added to fresh sample, 2nd box ticked	1	
	MMO collection	II <u>If Ag⁺ used as 1st reagent</u> Give one mark for white ppt with FA 8 and cream ppt with FA 10 <u>If Pb²⁺ used as 1st reagent</u> Give one mark for white ppt with FA 8 and FA 10 <i>If FA 9 not previously identified then no change/no reaction/no ppt (ignore any yellow colouration of solution with Pb²⁺)</i>	1	
		III <u>If Ag⁺ used as 1st reagent (with NH₃ as 2nd)</u> Give one mark if white ppt with FA 8 is soluble in aqueous ammonia and cream ppt with FA 10 is insoluble or partially soluble in aqueous ammonia <u>If Ag⁺ used as 1st reagent (with Pb²⁺ as 2nd)</u> Allow observations marks <u>If Pb²⁺ used as 1st reagent (with Ag⁺ as 2nd)</u> Give one mark for white ppt with FA 8 and Ag⁺ and cream ppt with FA 10 and Ag⁺. <i>Ignore observations for FA 9.</i>	1	[3]
(c)	ACE conclusion	Mark consequentially on observations; Give one mark for appropriate anions identified for FA 8 , FA 9 and FA 10 . (Allow from off-white or cream ppt for Br ⁻ + Ag ⁺)	1	[1]

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(d)	PDO recording	I Observations in a single table. All additions of NaOH(aq) and NH ₃ (aq) shown to excess where there is an initial ppt	1	
	MMO collection	II All observations correct for FA 11 (Blue ppt in each, blue ppt insoluble in excess NaOH, soluble in excess NH ₃ or forming/turning to a deep/dark blue solution)	1	
		III All observations correct for FA 12 (White ppt insoluble in each)	1	[3]
(e)	ACE conclusion	I Mark consequentially to observations. Expected conclusion is Cu ²⁺ in FA 11 and Mg ²⁺ in FA 12 Allow Ca ²⁺ from white ppt insoluble in excess NaOH and no ppt with NH ₃ .	1	
		II Gives appropriate evidence for each ion in the conclusion. Minimum evidence required for the expected ions: Cu²⁺ Records a blue ppt with either of the reagents or deep blue solution with excess NH ₃ . Mg²⁺ White ppt insoluble in excess NH ₃ (or in each of the reagents)	1	[2]
(f)	MMO collection	I Blue, black, purple colour observed on adding starch in (ii)	1	
		II The brown (solution) or (brown) solution formed in (i) is decolourised/colour fades/paler or brown (solution) in (i) and white, off-white or light brown ppt recorded.	1	
	ACE conclusion	Award III and IV for two correct pairs	1	
		Award III only for one correct pair Expected results (i) I ⁻ is oxidised, Cu ²⁺ is reduced (ii) S ₂ O ₃ ²⁻ is oxidised, I ₂ is reduced Mark horizontally or vertically.	1	[4]
	[Total: 15]			