

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2008 question paper

9701 CHEMISTRY

9701/31

Paper 31 (Advanced Practical Skills 1), maximum raw mark 40

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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

CIE is publishing the mark schemes for the May/June 2008 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



UNIVERSITY of CAMBRIDGE
International Examinations

Page 2	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

Generic Mark Scheme for Papers 31 and 32

Skill		Breakdown of marks	
Manipulation, measurement and observation	16 marks	Successful <u>collection</u> of data and observations	8 marks
		<u>Quality</u> of measurements and observations	4 marks
		<u>Decisions</u> relating to measurements or observations	4 marks
Presentation of data and observations	12 marks	<u>Recording</u> data and observations	5 marks
		<u>Display</u> of calculation and reasoning	3 marks
		Data <u>layout</u>	4 marks
Analysis, conclusions and evaluation	12 marks	<u>Interpretation</u> of data or observations and identifying sources of error	6 marks
		Drawing <u>conclusions</u>	5 marks
		Suggesting <u>improvements</u>	1 mark

Statement Bank

MANIPULATION, MEASUREMENT AND OBSERVATION (MMO)

Successful collection of data and observations (Collection)

C1	Set up apparatus correctly
C2	Follow instructions given in the form of written instructions or diagrams
C3	Use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials
C4	Make measurements using pipettes, burettes, measuring cylinders, thermometers, and other common laboratory apparatus

Quality of measurements or observations (Quality)

Q1	Make accurate and consistent measurements and observations
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Decisions relating to measurements or observations (Decisions)

De1	Decide how many tests or observations to perform
De2	Make measurements that span a range and have a distribution appropriate to the experiment
De3	Decide how long to leave experiments running before making readings
De4	Identify where repeated readings or observations are appropriate
De5	Replicate readings or observations as necessary
De6	Identify where confirmatory tests are appropriate and the nature of such tests

Page 3	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

PRESENTATION OF DATA AND OBSERVATIONS (PDO)

Recording of data and observations (Recording)

R1	Present numerical data, values or observations in a single table of results
R2	Draw up the table in advance of taking readings/making observations so that they do not have to copy up their results
R3	Include in the table of results, if necessary, columns for raw data, for calculated values and for analyses or conclusions
R4	Use column headings that include both the quantity and the unit and that conform to accepted scientific conventions
R5	Record raw readings of a quantity to the same degree of precision and observations to the same level of data

Display of calculation and reasoning (Display)

Di1	Show their working in calculations, and the key steps in their reasoning
Di2	Use the correct number of significant figures for calculated quantities

Data layout (Layout)

L1	Choose a suitable and clear method of presenting the data, e.g. tabulations, graph or mixture of methods of presentation
L2	Use the appropriate presentation medium to produce a clear presentation of the data
L3	Select which variables to plot against which and decide whether the graph should be drawn as a straight line or a curve
L4	Plot appropriate variables on clearly labelled x- and y-axes
L5	Choose suitable scales for graph axes
L6	Plot all points or bars to an appropriate accuracy
L7	Follow the ASE recommendations for putting lines on graphs

Page 4	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

ANALYSIS, CONCLUSIONS AND EVALUATION (ACE)

Interpretation of data or observations and identify sources of error (Interpretation)

I1	Describe the patterns and trends shown by tables and graphs
I2	Describe and summarise the key points of a set of observations
I3	Find an unknown value by using co-ordinates or intercepts on a graph
I4	Calculate other quantities from data, or calculate the mean from replicate values, or make other appropriate calculations
I5	Determine the gradient of a straight line
I6	Evaluate the effectiveness of control variables
I7	Identify the most significant sources of error in an experiment
I8	Estimate, quantitatively, the uncertainty in quantitative measurements
I9	Express such uncertainty in a measurement as an actual or percentage error
I10	Show an understanding of the distinction between systematic errors and random errors

Drawing conclusions (Conclusions)

Con1	Draw conclusions from an experiment, giving an outline description of the main features of the data, considering whether experimental data supports a given hypothesis, and making further predictions
Con2	Draw conclusions from interpretations of observations, data and calculated values
Con3	Make scientific explanations of the data, observations and conclusions that they have described

Suggesting Improvements (Improvements)

Imp1	Suggest modifications to an experimental arrangement that will improve the accuracy of the experiment or the accuracy of the observations that can be made
Imp2	Suggest ways in which to extend the investigation to answer a new question
Imp3	Describe such modifications clearly in words or diagrams

Page 5	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

<i>Skill</i>	<i>Total marks</i>	<i>Breakdown of marks</i>			<i>Question 1</i>	<i>Question 2</i>
		<i>Statement</i>	<i>Marks</i>			
Manipulation, measurement and observation (MMO)	16 marks	Successful <u>collection</u> of data and observations	C	8	2	6
		<u>Quality</u> of measurements and observations	Q	4	4	0
		<u>Decisions</u> relating to measurements of observations	De	4	2	2
Presentation of data and observations (PDO)	12 marks	<u>Recording</u> data or observations	R	5	3	2
		<u>Display</u> of calculation and reasoning	Di	3	3	0
		Data <u>layout</u>	L	4	4	0
Analysis, conclusions and evaluation (ACE)	12 marks	<u>Interpretation</u> of data or observations and identifying sources of error	I	6	6	0
		<u>Drawing conclusions</u>	Con	5	0	5
		<u>Suggesting improvements</u>	Imp	1	0	1
Total					24	16

The Examiner is to check all subtractions on Supervisor and candidate scripts.

Record Supervisor values for titres in **(a)** and **(b)** on the front cover of the Supervisor's script.

Where a Supervisor has not provided titre information or where the Supervisor value is suspect (more than half the candidates in the Centre scoring zero marks in **(a)** or **(b)**) list the candidate values and attempt to obtain a suitable "average/mean" from these values.

Correct units

One of three forms acceptable.

Use of solidus, e.g. / cm³

Unit in brackets, e.g. (cm³)

In words, e.g. volume in cubic centimetres

Page 6	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

Question	Sections	Statement	Indicative material	Mark	
1 (a)	MMO Quality	Q	Cross out any titration labelled as rough unless only titration recorded. Give two marks if the titre in (a) within 0.2 cm³ of the Supervisor. Give one of these marks for a titre of 0.20+ to 0.50 cm³. <i>If titres are repeated – assess the value closer to that obtained by the Supervisor.</i>	2	[2]
(b)	MMO Quality	Q	Titre in (b) within 0.2 cm³ of Supervisor. <i>Treat repeated titres as in (a)</i>	1	[1]
(c)	ACE Interpretation	I4	Correctly calculates (to 3 or 4 significant figures) the predicted end-point from titres (a) and (b) $\frac{\text{titre (a)}}{\text{titre (a) - titre (b)}} \times 12$	1	[1]
(d)	PDO Recording	R1	Results incorporated into a single table (volume of FA 3, burette readings, and titre) (a) and (b) need not be included if titration data fully included in those sections.	1	
		R2	Table drawn up in advance of taking readings. Selected volumes of FA 3 must be sequential. <i>Must include (a) and (b) which can be at beginning, at end or entered sequentially.</i>	1	
	MMO Collection	R4	Correct column or row headings <u>and units</u> (see page 1 for acceptable form of units). <i>Minimum – volume of FA 3 and titre.</i>	1	
		C2	Selects four additional volumes of FA 3 to add.	1	
	MMO Decisions	C4	Makes all volume measurements of FA 2 and FA 3 with a burette. <i>(all burette readings and/or volumes/titres recorded to 2 dp or to nearest 0.05 cm³).</i>	1	
		De2	Candidate selects four points around the predicted “end-point” (or 20 cm³), either (i) one value to left and three to right, or (ii) two values to each side. <i>If there are only three additional points give this mark if one value to left and two values to right.</i> <i>The C2 and De2 marks can be awarded if volumes of FA 3 have been selected but the titration not performed.</i>	1	
					[6]

Page 7	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

(e)	PDO Layout	L4	Clearly and correctly labelled axes. <i>Accept volume of FA 2 or FA 2 / cm³ or FA 2 / ml, etc. as a label. Units not required.</i>	1	
		L5	Suitable scales selected. More than ½ of each axis used. <i>Allow “difficult” scale on x-axis but only if it easily fits the selected values of FA 3.</i>	1	
		L6	All points (including values from (a) and (b)) plotted to within ½ small square in either direction and in the correct square.	1	
		L7	2 continuous straight lines drawn, each passing close to the majority of points. (Minimum of 2 points on either side of the end-point) – meeting on x-axis.	1	
	ACE Interpretation	I3	Reads, to nearest small square, the x-axis value of the intersection of the two lines. <i>Intersection need not be on the x-axis.</i> <i>Where the left-hand line only has been drawn (or there is a right hand line with no plotted points) allow the intersection of the left-hand line with the x-axis providing there are at least 3 points close to the line drawn.</i>	1	
	MMO Quality	Q	Not more than one anomalous point (off Examiner selected “best-fit” left-hand line) on plotted graph. <i>Minimum – three well-spaced points on or close to line.</i> <i>Do not award this mark if the points are “bunched” in a small area of the paper.</i>	1	[6]
(f)	MMO	De5	Identifies valid titre to be repeated or states correctly that no titre needs repeating. <i>Only award this mark if two lines (allow curves) have been drawn using plotted data for each line.</i> <i>If lenient in awarding L7 mark in (e) be tighter in this section.</i>	1	[1]
Calcs	PDO Display	Di1	Shows working in all sections attempted.	1	
		Di2	3 or 4 significant figures in final section answers to (g) / (h) – if attempted.	1	[2]

Page 8	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

(g)	ACE Interpretation	I4	Calculates $M_r = 392$ (stated or used). <i>Check any expression, adding A_r values to confirm that the values add up to 392 if no total given.</i>	1	[2]
		I4	Expression or calculated value: $\frac{15.68}{\text{cand } M_r} \times \frac{25.0}{1000} \quad \text{or}$ $0.04 \times \frac{25}{1000} \quad \text{or}$ $1(.00) \times 10^{-3}$ <i>Do not penalise incorrect evaluation of a correct expression.</i>	1	
(h)	ACE Interpretation	I4	Calculates: $\frac{\text{intercept from graph}}{1000} \times 0.025$	1	[1]
(i)	ACE Interpretation	I4	Expression or calculation: $\frac{\text{ans(g)}}{\text{ans(h)}}$	1	[2]
	PDO Display	Di2	candidate values evaluated correctly to 3 significant figures. <i>Candidate must <u>use</u> an answer to (g) and (h) for the award of this mark (expression may be inverted).</i>	1	
				[Total: 24]	

Page 9	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

FA 4 (0.1 mol dm ⁻³) NH ₄ I (actually NaI), FA 5 (0.1 mol dm ⁻³) Al ₂ (SO ₄) ₃ , FA 6 (0.1 mol dm ⁻³) Zn(NO ₃) ₂					
2 (a)	PDO Recording	R1	Data in single table. <i>No repeat of reagents or reactants.</i> <i>Allow for single reagent and three solutions.</i>	1	
	MMO Decisions	De1	Selects silver nitrate, Ag ⁺ (aq) or solution containing Ag ⁺ as one reagent.	1	
		De1	Select (aqueous) ammonia as 2 nd reagent to use with AgNO ₃ or selects soluble lead salt or Pb ²⁺ (aq) or solution containing Pb ²⁺ as separate reagent. <i>If ion is given with no state symbol or reference to the ion being in solution - penalise once only.</i> <i>Ignore incorrect formulae for reagents if intention is clear.</i>	1	
	MMO Collection	C3	Records correct observations for both reagents selected (FA 4 contains the iodide). <i>Ignore observations for FA 5/FA 6 – unless observations for iodide in these solutions.</i> <i>Where all three reagents have been selected allow two out of three correct observations.</i>	1	
	ACE Conclusions	Con2	Correct conclusion (from one piece of evidence) that FA 4 contains iodide ion. <i>Allow this conclusion if AgNO₃ or Pb(NO₃)₂ used as a single reagent.</i>	1	[5]
(b)	PDO Recording	R5	Observations to show degree of precision – addition of NaOH to excess where a precipitate has been observed on addition of NaOH. <i>A precipitate must be recorded with FA 5 <u>and/or</u> FA 6.</i>	1	
	MMO Collection	C3	Records white ppt soluble in excess with FA 5 white ppt soluble in excess with FA 6 <i>Ignore FA 4 column.</i>	1	[2]
(c)	MMO Collection	C3	Records white ppt insoluble in excess with FA 5 white ppt soluble in excess with FA 6 <i>Ignore FA 4 column.</i>	1	[1]

Page 10	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

(d)	MMO Collection	C3	Records white ppt with FA 5 insoluble in acid no ppt with FA 6	1	[2]
	MMO Collection	C3	Records no ppt or no reaction for FA 4 with reagent in each of tests (b) , (c) and (d)(i) – addition of BaCl_2 . <i>Accept blank boxes as no reaction</i>	1	
(e)	MMO Collection	C3	Records yellow ppt with FA 4 , soluble/partially soluble on heating or yellow ppt with FA 4 and forming crystals or (more) precipitate on cooling. <i>Accept precipitate forms as an acceptable observation when cooling the solution.</i> <i>Accept shiny precipitate/sparkly solid/spangles as equivalent to observing crystal formation.</i> and no ppt with FA 6 <i>Ignore FA 5, unless yellow ppt formed.</i>	1	[1]
(f)	ACE Conclusions		Marks in this section must be based on evidence from the tests performed. All formulae used in this section must be correct (identified ions or reagents). <i>It is acceptable to refer back to (e.g. test (a)) providing the observation mark was awarded for that test.</i> <i>Allow named compounds or chemically correct formulae as well as ions .</i>	1	[4]
		Con3	Identifies I^- as the anion in FA 4 and explains two observations leading to that conclusion. <i>Minimum observation for I^- is yellow precipitate with silver ions, soluble in ammonia.</i> or <i>yellow precipitate with silver ions and with lead ions.</i>	1	
		Con3	Identifies Al^{3+} and SO_4^{2-} as the ions in FA 5 and explains the observations leading to that conclusion. <i>Minimum observation for Al^{3+} is white precipitate insoluble in excess ammonia.</i> <i>Minimum observation for SO_4^{2-} is white precipitate with barium chloride.</i>	1	
		Con3	Identifies Zn^{2+} as the cation in FA 6 and explains the observations leading to that conclusion. <i>Minimum observation for Zn^{2+} is white precipitate soluble in excess ammonia.</i>	1	
		Con3	States that NH_4^+ and NO_3^- have not been identified. <i>This may be recorded at any point in (f).</i>		

Page 11	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	31

(g)	ACE Improve	Imp2	NaOH, Al and heat used to test for NO_3^- would also liberate ammonia from NH_4^+ so would not be specific to NO_3^- . <i>Candidates must show clear understanding of why the solution must be tested for ammonium ion before being tested for nitrate.</i>	1	[1]
					[Total: 16]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2008 question paper

9701 CHEMISTRY

9701/32

Paper 32 (Advanced Practical Skills 2), maximum raw mark 40

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International Examinations

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	GCE A/AS LEVEL – May/June 2008	9701	32

Generic Mark Scheme for Papers 31 and 32

Skill		Breakdown of marks	
Manipulation, measurement and observation	16 marks	Successful <u>collection</u> of data and observations	8 marks
		<u>Quality</u> of measurements and observations	4 marks
		<u>Decisions</u> relating to measurements or observations	4 marks
Presentation of data and observations	12 marks	<u>Recording</u> data and observations	5 marks
		<u>Display</u> of calculation and reasoning	3 marks
		Data <u>layout</u>	4 marks
Analysis, conclusions and evaluation	12 marks	<u>Interpretation</u> of data or observations and identifying sources of error	6 marks
		Drawing <u>conclusions</u>	5 marks
		Suggesting <u>improvements</u>	1 mark

Statement Bank

MANIPULATION, MEASUREMENT AND OBSERVATION (MMO)

Successful collection of data and observations (Collection)

C1	Set up apparatus correctly
C2	Follow instructions given in the form of written instructions or diagrams
C3	Use apparatus to collect an appropriate quantity of data or observations, including subtle differences in colour, solubility or quantity of materials
C4	Make measurements using pipettes, burettes, measuring cylinders, thermometers, and other common laboratory apparatus

Quality of measurements or observations (Quality)

Q1	Make accurate and consistent measurements and observations
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Decisions relating to measurements or observations (Decisions)

De1	Decide how many tests or observations to perform
De2	Make measurements that span a range and have a distribution appropriate to the experiment
De3	Decide how long to leave experiments running before making readings
De4	Identify where repeated readings or observations are appropriate
De5	Replicate readings or observations as necessary
De6	Identify where confirmatory tests are appropriate and the nature of such tests

Page 3	Mark Scheme	Syllabus	Paper
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PRESENTATION OF DATA AND OBSERVATIONS (PDO)

Recording of data and observations (Recording)

R1	Present numerical data, values or observations in a single table of results
R2	Draw up the table in advance of taking readings/making observations so that they do not have to copy up their results
R3	Include in the table of results, if necessary, columns for raw data, for calculated values and for analyses or conclusions
R4	Use column headings that include both the quantity and the unit and that conform to accepted scientific conventions
R5	Record raw readings of a quantity to the same degree of precision and observations to the same level of data

Display of calculation and reasoning (Display)

Di1	Show their working in calculations, and the key steps in their reasoning
Di2	Use the correct number of significant figures for calculated quantities

Data layout (Layout)

L1	Choose a suitable and clear method of presenting the data, e.g. tabulations, graph or mixture of methods of presentation
L2	Use the appropriate presentation medium to produce a clear presentation of the data
L3	Select which variables to plot against which and decide whether the graph should be drawn as a straight line or a curve
L4	Plot appropriate variables on clearly labelled x- and y-axes
L5	Choose suitable scales for graph axes
L6	Plot all points or bars to an appropriate accuracy
L7	Follow the ASE recommendations for putting lines on graphs

Page 4	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

ANALYSIS, CONCLUSIONS AND EVALUATION (ACE)

Interpretation of data or observations and identify sources of error (Interpretation)

I1	Describe the patterns and trends shown by tables and graphs
I2	Describe and summarise the key points of a set of observations
I3	Find an unknown value by using co-ordinates or intercepts on a graph
I4	Calculate other quantities from data, or calculate the mean from replicate values, or make other appropriate calculations
I5	Determine the gradient of a straight line
I6	Evaluate the effectiveness of control variables
I7	Identify the most significant sources of error in an experiment
I8	Estimate, quantitatively, the uncertainty in quantitative measurements
I9	Express such uncertainty in a measurement as an actual or percentage error
I10	Show an understanding of the distinction between systematic errors and random errors

Drawing conclusions (Conclusions)

Con1	Draw conclusions from an experiment, giving an outline description of the main features of the data, considering whether experimental data supports a given hypothesis, and making further predictions
Con2	Draw conclusions from interpretations of observations, data and calculated values
Con3	Make scientific explanations of the data, observations and conclusions that they have described

Suggesting Improvements (Improvements)

Imp1	Suggest modifications to an experimental arrangement that will improve the accuracy of the experiment or the accuracy of the observations that can be made
Imp2	Suggest ways in which to extend the investigation to answer a new question
Imp3	Describe such modifications clearly in words or diagrams

Page 5	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

<i>Skill</i>	<i>Total marks</i>	<i>Breakdown of marks</i>			<i>Question 1</i>	<i>Question 2</i>
		<i>Statement</i>	<i>Marks</i>			
Manipulation, measurement and observation (MMO)	16 marks	Successful <u>collection</u> of data and observations	C	8	2	6
		<u>Quality</u> of measurements and observations	Q	4	3	1
		<u>Decisions</u> relating to measurements of observations	De	4	1	3
Presentation of data and observations (PDO)	12 marks	<u>Recording</u> data or observations	R	5	5	0
		<u>Display</u> of calculation and reasoning	Di	3	3	0
		Data <u>layout</u>	L	4	4	0
Analysis, conclusions and evaluation (ACE)	12 marks	<u>Interpretation</u> of data or observations and identifying sources of error	I	6	5	1
		Drawing <u>conclusions</u>	Con	5	1	4
		Suggesting <u>improvements</u>	Imp	1	1	0
Total					25	15

Page 6	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

Question	Sections	Statement	Indicative material	Mark	
1 (a)	PDO Display	Di1	Shows working in both halves of the calculation.	1	[2]
	ACE Interpretation	I4	Correctly calculates to 3 or 4 significant figures. 31.45 cm ³ of acid for Na ₂ CO ₃ , and 19.84 or 19.85 cm ³ of acid for NaHCO ₃	1	
(b)	MMO Collection	C4	All temperatures recorded are to nearest 0.5 °C.	1	[4]
	PDO Layout	L1	Records temperature readings and ΔT for each of the 3 mixtures clearly but not necessarily systematically.	1	
	PDO Recording	R1	All data presented in a single table.	1	
		R4	Each column/row has appropriate heading and unit. <i>For units accept only one of the following: /°C, (°C) or temperature in degrees Celsius/Centigrade.</i>	1	
(c)	MMO Decisions	De2	Chooses one mixture containing between (1.01 g and 2.49 g) of sodium carbonate and another mixture containing between (2.51 g and 3.99 g) of sodium carbonate. The total volume in each tube must be between 4.90 g and 5.10 g. <i>Do not award this mark if <u>completely different</u> masses are used in (d).</i>	1	[1]
(d)	MMO Collection	C2	Records three balance readings and two masses of solid for at least one tube. <i>Allow masses of solid alone if use of tare facility has been stated.</i>	1	[4]
	PDO Recording	R2	Award this mark if it appears that a table has been prepared before any data is entered. Do not award the mark if the experiment has clearly been performed, rough values jotted down and then entered into the table.	1	
		R4	Correct column headings/units given (/g, (g) or mass in grams) <i>Unit must be given but do not penalise an error in the form of unit displayed if already penalised in (b).</i>	1	
		R5	All masses (and weighings) recorded to at least 1 decimal place and <u>all</u> showing the same precision of measurement. (all to 1 dp or all to 2 dp, etc).	1	

The Supervisor should have provided data for all **five** experiments. Plot the Supervisor's results on the graph page of the Supervisor's script. Draw the "best-fit" straight line and use this to compare with temp change for candidates' mixtures in section (e).

Where no Supervisor data exists for **FB 5** and **FB 6** plot the three values for **FB 2**, **FB 3** and **FB 4**.

Page 7	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

(e)	MMO Quality		Check subtractions, etc. and compare the ΔT values for tubes FB 5 and FB 6 with the values from the Supervisor's graph. Where the contents of the tube(s) do not total 5.00 g – scale (to the nearest 0.5 °C) the temperature change(s) for 5.00 g. $\frac{5.00}{\text{mass in tube}} \times \text{temperature change}$ Q1 Q1 Give two marks if the closer of these two values is within 1.0 °C of the value from the Supervisor's graph. Give one of these two marks for a value with a difference of (1.0+ - 2.0) °C.	2	[2]
(f)	PDO Layout	L5	Graph plotted has suitable scales: -10 °C to (+10 °C) on the y-axis, 0 – (100%) on the x-axis <i>Do not award this mark if the scale is not easy to read.</i>	1	
		L6	All points plotted to within ½ small square in either direction and in the correct square. <i>Plotted points must be for the actual increase or decrease in temperature recorded. Be aware of some candidates changing the sign for the temperature change.</i>	1	
	MMO Quality	L7	An appropriate straight line is drawn passing close to most of the points and extrapolated to cut the y-axis.	1	
		Q1	<i>From a minimum of three points</i> Give one mark if none of the candidate's points is further than 0.5 °C from the "best-fit" line that <u>would be drawn</u> by the Examiner. (Do NOT draw line). <i>The candidate must have plotted all five points for this mark to be awarded.</i>	1	[4]
(g)	ACE Interpretation	I3	Correctly reads the value of the intercept within ½ small square. (See guidelines on acceptable plotting/reading points from a graph in (f)). <i>Decimal points need not be shown for 19.00cm³ or for 20.00 cm³.</i>	1	[1]

Page 8	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

(h)	ACE Interpretation	I4	(i) Shows expression or calculates. (35 x 4.3 x ΔT) Ignore any sign, but note if value given is in J or kJ.	1	
		I4	(ii) Shows correct expression for or correctly calculates ΔH (in kJ mol ⁻¹), with correct sign. ΔH = $\frac{\text{answer to (i) above}}{(5/84)}$	1	
	PDO Display	Di1	Shows working in both sections of the calculation.	1	
		Di2	Candidate answer evaluated correct to 3 significant figures. <i>For the award of this mark the answer to (i) above and a mole quantity must have been used in the calculation.</i>	1	[4]
(i)	ACE Interpretation	I7	Identifies the most significant source of error in the experiment. acid spray/"frothing"/loss of solution heat loss/gain (explained) thermometers only able to read to 1 °C <i>Ignore any reference to parallax or to residual solid.</i> <i>Apply (+/-) rule to multiple answers.</i>	1	[1]
(j)	ACE Improvements	Imp1	Suggests an appropriate method of reducing the error identified in (i). <i>Ignore parallax.</i> use of a larger/deeper container use of a lid to stop convection, a "thermos" flask to reduce all forms of heat loss, additional insulation to reduce conduction thermometers graduated at less than 1 °C – not just "more accurate", accept digital thermometers	1	[1]
(k)	ACE Conclusions	Con 1	Provides supporting evidence, from experimental data, for or against the method used to calculate ΔH. <i>e.g. graph is a straight line;</i> <i>points lie close to line (of best fit);</i> <i>results are consistent.</i>	1	[1]
				[Total: 25]	

Page 9	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

FB 7 (0.1 mol dm ⁻³) MnSO ₄ , FB 8 (0.10 mol dm ⁻³) MgSO ₄ , FB 9 (0.005 mol dm ⁻³) CaCl ₂					
2 (a)	MMO Decisions	De1	Selects, as the two reagents: barium chloride, Ba ²⁺ (aq) or solution containing Ba ²⁺ followed by hydrochloric acid or barium chloride, Ba ²⁺ (aq) or solution containing Ba ²⁺ and lead nitrate, Pb ²⁺ (aq) or solution containing Pb ²⁺ .	1	
	MMO Collection	C3	Records for FB 7 and for FB 8 : white precipitate with BaCl ₂ insoluble in HCl or white ppt with barium chloride and with lead nitrate. <i>The C3 mark requires correct observations for two reagents unless BaCl₂ used as a single reagent.</i>	1	[2]
(b)	MMO Decisions	De1	Selects, as the two reagents: silver nitrate, Ag ⁺ (aq) or solution containing Ag ⁺ followed by (aqueous) ammonia or silver nitrate, Ag ⁺ (aq) or solution containing Ag ⁺ and lead nitrate, Pb ²⁺ (aq) or solution containing Pb ²⁺ .	1	
	MMO Collection	C3	Records for FB 9 white precipitate with AgNO ₃ soluble in ammonia or white ppt with silver nitrate and with lead nitrate.	1	[2]
In parts (a) and (b) (i) Where all three reagents have been selected allow two out of three correct observations. (ii) If ion is given with no state symbol or reference to the ion being in solution - penalise once only. (iii) Ignore incorrect formulae for reagents if intention is clear.					
(c)	MMO Collection	C3	Records white or off-white ppt insoluble in excess for FB 7 and FB 8 , <u>no ppt</u> with FB 9 . <i>Ignore haziness with FB 9 and sodium hydroxide.</i>	1	
		C3	Records precipitate turning (light) brown with FB 7 .	1	[2]

Page 10	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

(d)	MMO Collection	C3	Records white or off-white ppt insoluble in excess for FB 7 and FB 8 , <u>no ppt</u> with FB 9 . <i>Do not ignore haziness with FB 9 and ammonia.</i> <i>Do not accept a dash against FB 9.</i> <i>The mark for ppt turning (light) brown may be given here if not already given in (c).</i>	1	[2]
	MMO Quality	Q1	In (c) and (d) records off-white ppt for FB 7 , and white ppt with FB 8 .	1	
(e)	ACE Conclusion	Con2	Identifies <u>solution FB 9</u> (no other solution may be selected) and two ions from: Ba^{2+} , Ca^{2+} and NH_4^+ (or a Group I cation). <i>If a white precipitate is recorded, the only correct selection is Ca^{2+} and Ba^{2+}.</i>	1	[3]
	MMO Decisions	De1	$\text{Ca}^{2+}/\text{NH}_4^+$ Candidate heats solution with NaOH and <u>tests for ammonia gas</u> . $\text{Ca}^{2+}/\text{Ba}^{2+}$ Candidate adds dichromate(VI) and <u>looks for precipitate</u> . $\text{Ba}^{2+}/\text{NH}_4^+$ Candidate performs either of the tests above. <i>In any of the distinguishing tests above, the intention to test for a gas or look for a precipitate may be found anywhere in (e), e.g. in the observations.</i>	1	
	ACE Interpretation	I2	Explains how lack of ammonia gas confirms Ca^{2+} and eliminates NH_4^+ or no ppt with dichromate confirms Ca^{2+} and eliminates Ba^{2+} .	1	

De1 mark above:

*If there is a white ppt, soluble in excess NaOH in **either** **FB 8** or **FB 9**, allow this solution to be selected and allow Pb^{2+} or Al^{3+} as ions present in the solution.*

Award a suitable test for Pb^{2+} - with I^- / $\text{Cr}_2\text{O}_7^{2-}$ / HCl or NaCl .

*(Do **NOT** allow BaCl_2 as the source of the chloride ion because of possible sulphate precipitate.)*

The choice of Pb^{2+} or Al^{3+} may NOT be carried forward to the conclusions in (f).

Page 11	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	32

(f)	ACE Conclusions		Allow named compounds or chemically correct formulae as well as ions.		
		Con2	Identifies Mn^{2+} as the cation in FB 7 and explains the observations leading to that conclusion. <i>Minimum observation for Mn^{2+} is:</i> <i>(i) off-white ppt with NaOH and with ammonia</i> <i>(ii) off-white ppt, insoluble in excess, with NaOH or with ammonia</i> <i>(iii) off-white ppt, turning brown with NaOH or with ammonia</i>	1	
		Con2	Identifies Mg^{2+} as the cation in FB 8 and explains the observations leading to that conclusion. <i>Minimum observation for Mg^{2+} is a white ppt (insoluble in excess) with NaOH and with ammonia.</i>	1	
		Con2	Identifies Ca^{2+} in FB 9 and explains the two observations leading to that conclusion. <i>The minimum observations for Ca^{2+} are</i> <i>(i) no ppt with NaOH or</i> <i>(ii) no ammonia gas on heating with NaOH or</i> <i>(iii) no precipitate with dichromate.</i>	1	[3]
(g)	MMO Collection	C3	Records: off-white ppt turning brown/black in first test and brown/black ppt in second test (no initial off-white ppt).	1	[1]
				[Total: 15]	