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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

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.

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Generic Mark Scheme for Papers 31 and 32

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

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

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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

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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

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

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Question	Sections	Statement	Indicative material	Ma	
1 (a)	PDO Display	Di1	Shows working in both halves of the calculation.	1	
	ACE Interpretation	I4	Correctly calculates to 3 or 4 significant figures. 31.45 cm^3 of acid for Na_2CO_3, and 19.84 or 19.85 cm^3 of acid for $NaHCO_3$	1	[2]
(b)	MMO Collection	C4	All temperatures recorded are to nearest 0.5 ^oC.	1	
	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. *For units accept only one of the following:* */ ^oC, (^oC) or* *temperature in degrees Celsius/Centigrade.*	1	[4]
(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.** *Do not award this mark if <u>completely different</u> masses are used in* **(d)**.	1	[1]
(d)	MMO Collection	C2	Records three balance readings and two masses of solid for at least one tube. *Allow masses of solid alone if use of tare facility has been stated.*	1	
	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)* *Unit must be given but do not penalise an error in the form of unit displayed if already penalised in* **(b)**.	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	[4]

*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**.

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(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. $\frac{\textbf{5.00}}{\textbf{mass in tube}} \times$ **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 *Do not award this mark if the scale is not easy to read.*	1	
		L6	All points plotted to within ½ small square in either direction and in the correct square. *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.*	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	*From a minimum of three points* 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).** *The candidate must have plotted all five points for this mark to be awarded.*	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)**). *Decimal points need not be shown for 19.00cm^3 or for 20.00 cm^3.*	1	[1]

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(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. $$\Delta H = \frac{\textbf{answer to (i) above}}{\textbf{(5/84)}}$$	1	
	PDO Display	Di1	Shows working in both sections of the calculation.	1	
		Di2	Candidate answer evaluated correct to 3 significant figures. *For the award of this mark the answer to **(i)** above and a mole quantity must have been used in the calculation.*	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 *Ignore any reference to parallax or to residual solid.* *Apply (+/-) rule to multiple answers.*	1	[1]
(j)	ACE Improvements	Imp1	Suggests an appropriate method of reducing the error identified in **(i)**. *Ignore parallax.* 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. *e.g. graph is a straight line; points lie close to line (of best fit); results are consistent.*	1	[1]
					[Total: 25]

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	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}) CaC				
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. *The C3 mark requires correct observations for two reagents unless $BaCl_2$ used as a single reagent.*	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**, no ppt with **FB 9**. *Ignore haziness with **FB 9** and sodium hydroxide.*	1	
		C3	Records precipitate turning (light) brown with **FB 7**.	1	[2]

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(d)	MMO Collection	C3	Records white or off-white ppt insoluble in excess for **FB 7** and **FB 8**, no ppt with **FB 9**. *Do **not** ignore haziness with* **FB 9** *and ammonia.* *Do **not*** accept a dash against **FB 9**. *The mark for ppt turning (light) brown may be given here if not already given in* **(c)**.	1	
	MMO Quality	Q1	In **(c)** and **(d)** records off-white ppt for **FB 7**, and white ppt with **FB 8**.	1	[2]
(e)	ACE Conclusion	Con2	Identifies solution **FB 9** (no other solution may be selected) and **two** ions from: Ba^{2+}, Ca^{2+} and NH_4^+ (or a Group I cation). *If a white precipitate is recorded, the only correct selection is Ca^{2+} and Ba^{2+}.*	1	
	MMO Decisions	De1	**Ca^{2+}/NH_4^+** Candidate heats solution with NaOH and tests for ammonia gas. **Ca^{2+}/Ba^{2+}** Candidate adds dichromate(VI) and looks for precipitate. **Ba^{2+}/NH_4^+** Candidate performs either of the tests above. *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.*	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	[3]

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^- / $Cr_2O_7^{2-}$ / 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+} of Al^{3+} may NOT be carried forward to the conclusions in (f).

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(f)	ACE Conclusions Mark the **FB 9** conclusion, consequentially from the selection of ions in **(e)** and the tests carried out on those ions. Ba^{2+} and NH_4^+ could fit observations given.		*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. *Minimum observation for Mn^{2+} is:* ***(i)*** *off-white ppt with NaOH and with ammonia* ***(ii)*** *off-white ppt, insoluble in excess, with NaOH or with ammonia* ***(iii)*** *off-white ppt, turning brown with NaOH or with ammonia*	1	
		Con2	Identifies Mg^{2+} as the cation in **FB 8** and explains the observations leading to that conclusion. *Minimum observation for Mg^{2+} is a white ppt (insoluble in excess) with NaOH and with ammonia.*	1	
		Con2	Identifies Ca^{2+} in **FB 9** and explains the **two** observations leading to that conclusion. *The minimum observations for Ca^{2+} are* ***(i)*** *no ppt with NaOH* ***or*** ***(ii)*** *no ammonia gas on heating with NaOH* ***or*** ***(iii)*** *no precipitate with dichromate.*	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]