UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2008 question paper

9701 CHEMISTRY

9701/32 Paper 32 (Practical 2), 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.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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

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UNIVERSITY of CAMBRIDGE
International Examinations

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

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Question 1

Supervisor's Report
Check all subtractions in **(a)**. Use the titres, corrected where necessary, to select the "best average" titre to be used as an accuracy standard using the following hierarchy.

- value of 2 identical titres
- average of titres within 0.05 cm^3
- average of titres within 0.10 cm^3, etc.

Calculate, **correct to 2 dp**, the titre if the Supervisor had diluted 41.50 cm^3 of **FB 2**.
Do not round calculated averages to nearest 0.05 cm^3.

This is given by the expression $\frac{\textbf{41.50}}{\textbf{vol diluted}} \times \textbf{titre}$

Record this value on the Supervisor's script and on all candidate scripts against the titration table.

Candidate scripts
Check and correct all subtractions as above.
Examiner is to select best titre as above, (**do not include values labelled rough unless crossed out or ticked/used by candidate**) and calculate the scaled titre for 41.50 cm^3 of **FB 2**.
If no volume of **FB 2** diluted has been given, assume candidate has used 41.50 cm^3.
Record the value against the titration table and calculate the difference to Supervisor.

Question	Sections	Statement	Indicative material	Mark	
1 (a)	PDO Layout	L1	**(i)** Records initial and final burette readings in each of the tables *(If 50.00 cm^3 is used as initial burette reading, treat as 0.00 cm^3. Do **not** award **(i)** in this case or if 50.00 cm^3 is given as a repeated final burette reading in the 2nd table)*	1	
	PDO Recording	R5	**(ii)** All accurate burette readings in the titration table recorded to nearest 0.05 cm^3 *Treat 1st titration as rough unless the candidate has crossed out a "rough" label or used the value in calculating the average*	1	
	MMO Collection	C2	**(iii)** Follows instructions – Dilutes 41.00 cm^3 to 42.00 cm^3 (uncorrected) of **FB 2**	1	
	MMO Decisions	De5	**(iv)** Has two or more uncorrected titres within 0.1 cm^3 *Titres labelled "rough" may be included*	1	
	MMO Quality	Q1	**Accuracy** Award **(v) and (vi)** if difference from Supervisor's value is 0.3 cm^3 or less	2	
		Q1	Award **(v) only** for a difference of 0.3+ cm^3 to 0.6 cm^3		[6]

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(b)	ACE Interpretation	I4	Candidate selects/calculates correct "average" from titre values within 0.2 cm^3. *Average must be calculated correct to 2dp or nearest 0.05 cm^3 if burette read to 2dp/0.05 cm^3. For burette readings, consistent to 1dp the average may be correct to 1 or 2 dp)*	1	[1]
(c)	ACE Interpretation	I4 I4	**Award (i)** for $\frac{\textbf{vol diluted}}{\textbf{1000}} \times \frac{\textbf{28.44}}{\textbf{158}}$ in 1st step **Award (ii)** for (**× 2.5**) in 1st equation step **and** for (**× 2**) in 2nd equation step	1 1	
	PDO Display	Di1	**(iii)** Working shown in at least **three** of the first four steps *Correct or incorrect combination of half-equations into an equation for the reaction counts as working*	1	
		Di2	**(iv)** 3 or 4 significant figures given in **each answer** attempted for sections 1–4. *A **Minimum** of two sections attempted is required before this mark can be awarded.*	1	
		Di2	**(v)** Award one mark for **Answer to step 4** $\times \frac{\textbf{1000}}{\textbf{titre}}$ **correctly evaluated to 3 sig fig**. (Examiner to check) *Allow ±1 in 3rd sig fig.* *It may be necessary to check any calculation in which numbers have been "carried" in a calculator*	1	[5]
Qn 1	**Total**			**12**	

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2 (a)	PDO Layout	L1	**(i)** 4 balance readings + mass of X_2CO_3 and mass of CO_2 clearly shown for at least one of the two experiments	1	
	PDO Recording	R1	**(ii)** single table incorporating balance readings for **FB 6** and **FB 7** **or** balance readings for the flask + mass of X_2CO_3	1	
		R4	**(iii)** table has correct headings and units *Accept only: / g; (g); or mass of…… in grams If not included in heading every entry must be followed by g*	1	
		R5	**(iv)** all of the balance readings recorded are consistent to 1 dp, 2 dp, etc. *showing the precision of the balance used*	1	[4]
	For **FB 6** *and* **FB 7** ***Examiners calculate*** *(check and correct candidate working if necessary)* • *the mass of carbonate that reacted* • *the mass of carbon dioxide given off* • *mass of carbonate (**to 2 dp**) giving 1.0 g of carbon dioxide.*				
(b)	ACE Interpretation	I4	Accurately calculates to 1 or 2 decimal places the mass of X_2CO_3 giving 1.0 g of CO_2 for **FB 6** and **FB 7** *If the balance used reads to 2 dp the candidate must give an answer to 2 dp.*	1	
	MMO Quality	Q1 Q1	**Accuracy** Award **two marks** for a difference up to 0.3 g in the mass of carbonate in **FB 6** and **FB 7** giving 1.0 g of CO_2 Award **one mark only** for a difference of 0.3+ g to 0.6 g. Award no Q marks if any mass of CO_2 is negative or any mass CO_2 > corresponding mass of X_2CO_3	2	[3]

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(c)	ACE Interpretation	I4	Give one mark for using the following expression for **either FB 6** or **FB 7** $\frac{\textbf{candidate's mass of carbonate}}{\textbf{candidate's mass of carbon dioxide}} \times \textbf{44}$ **or** (**candidate's value in (b) × 44)** *This is a mark for using the correct expression and not a mark for the actual value calculated or for sig fig.* *Beware calculations leading to A_r of X*	1	[1]
(d)	ACE Interpretation	I7	Give one mark for identifying one of the following as the significant error • loss of acid spray • solid stuck to the sides of the flask • diffusion time for the CO_2 *Do **not** allow spillage as a source of error.* *Mark multiple answers (±), ignoring any true but irrelevant suggestions*	1	[1]
(e)	ACE Improvements	Imp1	Give one mark if the candidate **states** that loss of carbon dioxide can be reduced by **one** of the following • warming the solution (to expel dissolved gas) • saturating the acid with CO_2 before starting the experiment • extended swirling or shaking • using a smaller volume of more concentrated acid • waiting a longer time before taking the final reading	1	[1]

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(f)	MMO Collection ACE Conclusions	C3 Con3	The candidate should observe: • $BaCO_3$ insoluble in water (powder remains) • X_2CO_3 soluble in water (colourless/clear solution) • effervescence/fizzing/bubbling with X_2CO_3 and acid • more rapid reaction in acid for X_2CO_3 than $BaCO_3$ *accept comparison of effervescence including no apparent bubbling with $BaCO_3$ and bubbling with X_2CO_3* **Give the mark for three out of the four correct boxes providing at least one has a reference to evolution of gas with acid.** Give one mark for formation of insoluble barium sulphate. **or** barium sulphate is a white precipitate	1 1	[2]
Qn 2	**Total**			**12**	

FB 9 is aqueous ammonium bromide (NH_4Cl/NaBr), FB 10 is aqueous aluminium sulphate, FB 11 is aqueous lead(II) nitrate.

Selection of reagents *– Accept any of the following:*
- *a named compound or a recognisable (but not necessarily correct) formula for the compound*
- *aqueous ions, e.g. $Ba^{2+}(aq)$*
- *a solution containing a named ion*

Identification of unknowns *– Accept either of the following:*
- *a named compound (or ion)*
- *a **fully correct** formula for the compound or ion*

Question	Sections	Statement	Indicative material	Mark	
3 (a)	PDO Layout	L1	**(i)** Give one mark for presenting observations for all 6 tests in a clear fashion.	1	
	PDO Recording	R1	**(ii)** Give one mark for a single table showing observation on adding of NaOH and NH_3 and when the reagent is in excess where an initial precipitate has been formed.	1	

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	MMO Collection	C3	**(iii)** Give one mark for observing initial white ppt for **FB 10** and **FB 11** and no ppt / no reaction / clear or colourless solution with **FB 9** *Observations for both reagents required* Do not give this mark if any white ppt turns brown	1	
		C3	**(iv)** Give one mark for recorded precipitates soluble in excess NaOH and insol. in excess NH_3 for **FB 10** and **FB 11**.	1	[4]
(b)	ACE Conclusions		***Mark consequentially from observations of white or off-white precipitates*** *(Ignore ions not listed in QA Notes)*		
		Con2	Give one mark for concluding that **FB 9** contains **two** of: NH_4^+ or Ba^{2+} or Ca^{2+} (in low concentration).	1	
		Con2	Give one mark for concluding that **FB 10** and **FB 11** could contain Pb^{2+} or Al^{3+}. *Allow this conclusion from:* ***(i)*** *an off-white ppt, soluble in excess NaOH and insoluble in excess NH_3* ***(ii)*** *a white ppt sparingly soluble in NH_3* *For:* *white ppt insoluble in excess NaOH and excess NH_3 accept a conclusion of Mg^{2+} and Mn^{2+}. Allow Mn^{2+} from white ppt turning brown* *Accept Zn^{2+}, from white ppt soluble in excess NaOH and excess NH_3, for **FB 10** or **FB 11**. Mn^{2+} or Mg^{2+} may also be selected as single ions from appropriate observations*	1	[2]

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(c)			**Check the ions selected.** *Where one ion only has been selected for* **FB 9**, **FB 10**, *or* **FB 11** *a further test is still required as confirmation.*		
	MMO Decisions	De6	**(i)** Give one mark for warming the solution with NaOH and **testing** for ammonia to identify NH_4^+ ion Test must be described in method or observation **or** for the use of dichromate or chromate to identify Ba^{2+} or eliminate Ca^{2+}	1	
		De6	**(ii)** Give one mark for choosing one of the following to distinguish between Pb^{2+} and Al^{3+} HC*l* – **barium chloride** is **not** suitable, KI – solution **FB 4**, H_2SO_4 – solution **FB 3**, dichromate (VI), $K_2Cr_2O_7$, $Cr_2O_7^{2-}$ (aq) chromate (VI), K_2CrO_4, CrO_4^{2-} (aq) ***Use of $K_2Cr_2O_7$/K_2CrO_4 or H_2SO_4 as a single reagent is sufficient providing Ba^{2+} is one of <u>only two</u> ions selected for* FB 9 *in* (b) and** the reagent has been added to **all three** of the solutions.	1	
	MMO Collection	C3	**(iii)** **Mark observations consequentially**. The expected observations for possible combinations of reagents are given below.	1	

Reagent	FB 9	FB 10	FB 11
warm with NaOH	NH_3 gas liberated	no change	no change
HC*l*	no change	no change	white ppt
(allow observations also from $BaCl_2$)	no change	white ppt	ignore white ppt
KI	no change	no change	yellow ppt
H_2SO_4	no change	no change	white ppt
$Cr_2O_7^{2-}$ / CrO_4^{2-}	no change	no change	yellow ppt

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	ACE Conclusions	Con2	**(iv)** Give one mark for identifying: NH_4^+ in **FB 9** – if NH_4^+ is one of possible ions; **or** Ca^{2+} if Ca^{2+} / Ba^{2+} are selected ions. Al^{3+} in **FB 10** and Pb^{2+} in **FB 11** ***(NO e.c.f. in this section)***	1	[4]
(d)	MMO Decisions	De6	**(i)** Give one mark for choosing $BaCl_2$ / $Ba(NO_3)_2$ $Pb(NO_3)_2$ as one reagent and $AgNO_3$ / $Pb(NO_3)_2$ as the other reagent. *(Pb^{2+} not acceptable as sole reagent)*	1	
	PDO Layout	L1	**(ii)** Give one mark for tabulating tests performed and the observations in those tests **or** presenting this information in other clear format.	1	
	MMO Collection	C3	**(iii)** Give one mark for appropriate observations with the first reagent *(see below)*	1	
		C3	**(iv)** Give one mark for appropriate observations with the second reagent *(see below)*	1	

Reagent	**FB 9**	**FB 10**
$BaCl_2$ / $Ba(NO_3)_2$ (addition of HCl not required)	no change	white ppt
$AgNO_3$	off-white or cream ppt	no change
followed by $NH_3(aq)$	partially soluble	
$Pb(NO_3)_2$	white ppt	white ppt

	MMO Collection	C3	**(v)** Give one mark for **partial** solubility or **insolubility** in NH_3 of the silver halide ppt formed with Ag^+ – if that reagent was used.	1	

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	ACE Conclusions	Con2	**(vi)** Give one mark for concluding, from observations, that the anion in **FB 10** is sulphate and the anion in **FB 9** is bromide. **Bromide ions cannot be identified if Ba^{2+}/Pb^{2+} have been selected as the reagents.** *Allow the bromide conclusion from:* *(i) off-white or cream precipitate with Ag^+* *(ii) white ppt with Ag^+ partially soluble or insoluble in NH_3* *Allow a conclusion of iodide from a yellow ppt with Ag^+ although this will not have scored the observation mark*	1	[6]
Qn 3	**Total**			**16**	

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