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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2009 question paper for the guidance of teachers

9701 CHEMISTRY

9701/31 Paper 31 (Advanced Practical Skills), maximum raw mark 40

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

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

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Question	Sections	Indicative material	Mark	
1 (a)	PDO layout	Two balance readings and mass of **FA 1** clearly recorded for each experiment. (Data for 2nd experiment could be on page 4) *Examiner to check subtraction for each experiment – no penalty in this section but see section* **(e)**	1	[1]
(b)	PDO Recording	***If the candidate has only performed one experiment the following points <u>only</u> can be awarded: (ii), (iii), (vi), (vii) and (x).*** **(i)** Single table recording observations for both experiments. Times at ½ minute intervals.	1	
		(ii) Appropriate headings and units *Allow times in minutes (min) or seconds*	1	
		(iii) All temps recorded to nearest 0.5 °C (Must be more than one at .5 as well as .0)	1	
	MMO Collection	**(iv)** Some temps recorded before mixing and some after mixing for **<u>each</u>** expt. **or** Candidate records initial temperature and at least three temperatures after mixing for each experiment	1	
		(v) First temperature after mixing is clearly taken 1 minute after adding the zinc powder *(Examiner judgement re temperatures recorded before mixing / temperatures only recorded after mixing)* **and** cooling for at least 5 minutes after recorded maximum temperature.	1	
	For Supervisor -	calculate mean maximum ΔT to nearest 0.5 °C; calculate mean of time taken (to nearest ½ min) to reach max temperature after mixing.		
	MMO Quality	**(vi) & (vii)** 1st expt. Compare ΔT with Supervisor. award **(vi)** and **(vii)** if within 2 °C award **(vii) only** if >2 °C and ≤5°C	2	
		(viii) & (ix) 2nd expt. Compare ΔT with Supervisor. award **(viii)** and **(ix)** if within 2 °C award **(ix) only** if >2 °C and ≤5°C	2	
		(x) (1st expt**) & (xi)** (2nd expt). Compare time after mixing at which max temp is obtained with same time for Supervisor, for each expt. If Supervisor ≤3 min; 1 mark for Δ time ≤1 min. If Supervisor >3 min; 1 mark for Δ time ≤1½ min.	1 1	[11]

If the candidate performs one experiment only, the following marks may **not** be awarded:
(i)
(iv)
(viii) & (ix)
(xi)

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Question	Sections	Indicative material	Mark	
(c)	PDO Layout	Plots temperature on *y*-axis and time on *x*-axis and has at least one temperature and one time label (*ignore absent or incorrect units*) Scales used are linear and easy for the examiner to use, *(3 or 4 min. per large square are acceptable)* Scales should enable the temperature when zinc is added and <u>all</u> points after the addition of zinc to be plotted. *Points should be within a minimum of 5 large squares on temperature axis* If the candidate has recorded temperatures and times before zinc is added: Correctly plots on <u>each</u> graph: the last temperature/time, from results **<u>before</u>** zinc is added **<u>or</u>** the temperature **and** maximum temperature *(associated time not required* If the candidate has only recorded the initial temperature of the solution: Correctly plots on <u>each</u> graph: the temperature when zinc is added **and** maximum temperature *(associated time not required* Draws a cooling curve or straight line and projects the curve / line back to the time of mixing	1 1 1 1	[4]
(d)	ACE Interpretation	**For experiment 1:** Correctly reads the temperature rise from the graph to within 1 ^{o}C of the value obtained from the graph by the examiner. If the value is incorrect for experiment 1, check value for experiment 2. Award mark if either value is correct.	1	[1]
(e)–(h)	PDO Display	Shows working in all sections attempted – *minimum of three sections required*. Significant figures in <u>final answers</u>. 2 or 3 sf in 1(e), 2 to 4 sf in 1(g), 3 sf **only** in 1(h) *minimum of three sections required*.	1 1	[2]
(e)	ACE Interpretation	Correctly calculates 2.0 x 10^{-2} mol of $CuSO_4$, and ($^{\text{mass zinc}}/_{65.4}$) for each experiment. *Answers correctly rounded for the number of significant figures displayed.* ***Do not award this mark if there is an error in subtraction or there are missing balance readings in section* (a).**	1	[1]

A completely horizontal line, drawn at the initial temperature can be accepted as equivalent to plotting of initial temperature.

If only one graph has been drawn, the 1st and 2nd marks may be awarded and one further mark if the initial and maximum temperatures are correctly plotted **and** there is an appropriate extrapolation.

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Question	Sections	Indicative material	Mark	
(f)	ACE Conclusions	To gain this mark the candidate must refer to: **(i)** the 1:1 mole ratio from the equation **and** **(ii)** the relative moles of Cu^{2+} and Zn(s) used, as calculated in **(e)** *If candidate states that "more moles of zinc were present" and this fits the calculated values in* **(e)** *– accept as the relative statement.*	1	[1]
(g)	ACE Interpretation	Shows (25 × 4.3 × candidate mean ΔT) with appropriate unit, J or kJ, on final answer. (Allow use of 4.2 or 4.18 without penalty) *Award this mark for the correct expression and unit* ***OR*** *where the expression is not shown, a correct evaluation of that expression and unit*	1	[1]
(h)	ACE Interpretation	**No mark is awarded in this section if there is no division by (moles of zinc) or by (moles of Cu^{2+}).** Calculates $\frac{\textbf{answer to (g)}}{\textbf{moles of reagent not stated as being in excess in (f)}}$ *If (moles of zinc) is used in this expression, candidate may use either value from* **(e)** *or the mean of the (moles of zinc).* Examiner evaluates the candidate expression which should be: **(i)** correctly rounded for sig fig displayed, (allow variation of $\pm$1 on 3rd significant figure) **(ii)** have a -ve sign on the final answer; **(iii)** be correctly converted to kJ	1 1	[2]
(i)	ACE Interpretation	Candidate identifies one source of error in the experiment. This must be related to: Apparatus used or method described – no human error allowed. *Heat loss is most likely error to be seen* *Accept reference to the graduation (precision) of the thermometer.*	1	[1]
(j)	ACE Improvement	**Answer must follow on from (i)** Suggests a way in which method could be improved *e.g. Use of a lid or increased insulation to minimise heat loss.*	1	[1]
Qn 1	**Total**			**[26]**

Where candidate has given a maximum temperature in **(g)**, allow use here (ecf). Also allow use of ΔT calculated in this section.

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Question	Sections	Indicative material	Mark	
FA 3 is $MnSO_4(s)$; **FA 4** is $PbCO_3(s)$; **FA 5** is $CuCO_3(s)$				
2 (a)	MMO Collection	As **FA** 5 is heated, observes: green or blue **<u>solid</u>** turning black, **or** green/blue (solid) turning to a black **<u>solid or residue</u>**	1	
	MMO Decisions	Tests gas given off with: *Ignore results* limewater, *in any of* a glowing (not burning) splint, *these tests* red litmus paper	1	[2]
(b)	MMO Collection	Observes **each** of the following: colourless solution with **FA 3 or** colourless solution with **FA 4**, **and** blue or green solution with **FA 5** **and** observation of a gas evolved with **FA 4** or with **FA 5**. *[Second mark from* **(a)** *may be awarded here if not already given in* **(a)***]*	1	[1]
(c)	ACE Conclusion	Identifies carbonate in **FA 4 <u>or</u> FA 5** and refers to carbon dioxide; *providing there has been evidence in the tests:* *a positive test with limewater,* ***or*** *effervescence with dilute acid* **<u>or</u>** Identifies carbonate in **FA 4 <u>or</u> FA 5** and refers to specific test for carbon dioxide and its result in the conclusion.	1	[1]

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Question	Sections	Indicative material	Mark	
(d)	PDO Recording	**(i)** All observations in a single table. Both reagents are required *There must be no repetition of "headings".*	1	
	MMO Collection	**(ii)** Reports addition of reagents to excess whenever a precipitate is formed on first addition of the reagent. (Minimum of 2 ppt)	1	
		(iii) white / off-white / buff / (light or pale) brown precipitate with solution from **FA 3**. Precipitate insoluble in excess <u>with both reagents</u> **and** turning brown (light or pale brown precipitate darkening) recorded for at least one of the reagents	1	
		(iv) Give **one mark** for both observations. **FA 4** – white precipitate – both reagents. soluble in excess NaOH; insoluble in excess NH_3(aq). **and** **FA 5** – blue precipitate – both reagents. insoluble in excess NaOH; soluble in excess NH_3(aq) **or** colour goes to dark/deep blue. *Mark conclusions consequentially to observations.*	1	
	ACE Conclusions	**(v)** Expected cations: **FA 3** (Mn^{2+}) **and FA 5** (Cu^{2+}) *Minimum observations required:* *Mn^{2+} – off-white (buff, pale or light brown) ppt with each reagent but NOT from white ppt alone.* *Allow from white ppt turning brown.* *Cu^{2+} – blue ppt insoluble in excess NaOH* ***or*** *dark blue colour with aqueous NH_3*	1	
		(vi) Identifies Pb^{2+} and Al^{3+} as possible cations. *(a single consequential ion is acceptable)*	1	[6]

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Question	Sections	Indicative material	Mark	
(e)		**If no pair of ions is given in (d), no mark can be awarded in this section**		
	MMO Decisions	*Mark consequentially* Selects appropriate reagent to distinguish between any pair of cations identified in **(d)**. For Pb^{2+}/Al^{3+} accept HCl, H_2SO_4 KI or chromate/dichromate *The candidate should name a reagent, e.g. potassium dichromate.* *If $Cr_2O_7^{2-}$, or dichromate is given as the reagent the (aq) state symbol must also be given or reference made to an aqueous solution of the ions.*	1	
	MMO Collection	*If selected reagent is suitable; mark consequentially for chosen reagent and Pb^{2+}.* For Pb^{2+}/Al^{3+} **FA 4** gives white precipitate with HCl and with H_2SO_4 and yellow precipitate with chromate/dichromate or iodide. *Ignore any conclusion.*	1	[2]
(f)	MMO Collection	Observes as **only** reaction: **FA 3** gives white precipitate with $Ba(NO_3)_2$ which is insoluble in dilute nitric acid, **but** *Ignore any white ppt or cloudiness with* **FA 3** *and silver nitrate,* ***and*** *ignore cation precipitates on adding NH_3(aq)* *Accept a dash in the boxes for reaction of* **FA 3**, **FA 4** *and* **FA 5** *with barium nitrate and with silver chloride as evidence of "no reaction" with that reagent*	1	
	ACE Conclusions	A conclusion that fits observations for **(i)** barium chloride with all solutions **or** **(ii)** silver nitrate with all solutions	1	[2]
Qn 2	**Total**			**[14]**

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