

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2008 question paper

9701 CHEMISTRY

9701/31

Paper 31 (Practical 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.

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.

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

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

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| 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 |
|-----------|--|

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

| | | | |
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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 38.50 cm^3 of **FA 1**.

Do not round calculated averages to nearest 0.05 cm^3 .

This is given by the expression $\frac{\text{vol of FA 1 diluted}}{38.5} \times \text{titre}$

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 rough is crossed out or ticked/used by candidate**) and calculate the scaled titre for 38.50 cm^3 of **FA 1**.

If no volume of **FA 1** diluted has been given, assume candidate has used 38.50 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. <i>(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 is given as a repeated final titre in the 2nd table.)</i> | 1 | |
| | PDO Recording | R5 | (ii) All accurate burette readings in the titration table recorded to nearest 0.05 cm^3 . | 1 | |
| | MMO Collection | C2 | (iii) Follows instructions – dilutes 38.00 cm^3 to 39.00 cm^3 (uncorrected) of FA 1 . | 1 | |
| | MMO Decisions | De5 | (iv) Has at least two uncorrected titres within 0.1 cm^3 . <i>Titres labelled “rough” may be included.</i> | 1 | |
| | MMO Quality | Q1 Q1 | Accuracy Award (v) and (vi) if difference from Supervisor is 0.3 cm^3 or less. Award (v) only if difference from Supervisor is $0.3+ \text{ cm}^3$ to 0.6 cm^3 . | 2 | [6] |
| (b) | ACE Interpretation | I4 | Candidate selects/calculates correct “average” from titre values within 0.2 cm^3 . <i>Average must be calculated correct to 2 dp or nearest 0.05 cm^3 if burette read to 2 dp/0.05 cm^3. For burette readings, consistent to 1 dp the average may be correct to 1 or 2 dp).</i> | 1 | [1] |

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| (c) | ACE Interpretation | I4 | Award (i) for $\frac{25}{1000} \times \frac{3.40}{40}$ in 1 st step. | 1 | [5] |
| | PDO Display | I4 | Award (ii) for correct 2 nd step $\times \frac{1}{1} \times \frac{250}{\text{titre}}$ and correct 3 rd step $\times \frac{1000}{\text{vol diluted}}$. | 1 | |
| | | Di1 | (iii) Working shown in the first three steps. | 1 | |
| | | Di2 | (iv) 3 or 4 significant figures given in each answer attempted for sections 1–3. A minimum of two sections attempted is required before this mark can be awarded. | 1 | |
| | Di2 | (v) Award one mark for $M_r = \frac{38.68}{\text{answer to previous section correctly evaluated to 3 sig fig.}}$ (Examiner to check) <i>Allow ± 1 in 3rd sig fig.</i> <i>It may be necessary to check any calculation in which numbers have been “carried” in a calculator.</i> | 1 | | |
| | | | | | [Total: 12] |

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|--|--------------------|----------|--|---|-----|
| 2 (a) | PDO Layout | L1 | (i) Three (or four) weighings, <div style="display: flex; justify-content: space-around;"> <div> <i>mass of empty tube</i> <i>mass of tube + FA 4</i> <i>mass of tube after heating</i> </div> <div> <i>mass tube + FA 4</i> <i>mass of tube + residual FA 4</i> <i>mass of empty tube</i> <i>mass of tube after heating</i> </div> </div> mass of residue, and mass of water clearly shown. | 1 | |
| | MMO Collection | C2 | (ii) Give one mark for evidence from results of reheating and reweighing. | 1 | |
| | MMO Decisions | De1 | (iii) Give one mark for repeating heating and reweighing until final masses are within 0.1 g. | 1 | |
| | PDO Recording | R5 | (iv) Correct headings and units for each weighing/mass recorded. (Watch out for reversed residue and water.) <i>Accept only:</i> <i>/ g; (g); or mass of in grams.</i> <i>If not included in heading every entry must be followed by g.</i> | 1 | |
| | | R5 | (v) All of the balance readings recorded are consistent to 1 dp, 2 dp, etc. <i>showing the precision of the balance used.</i> | 1 | |
| <p>On each candidate's script check all subtractions in (a). Use the masses, corrected where necessary, to calculate $\frac{\text{mass of water}}{\text{mass of anhydrous solid}}$. Work to 2 dp.</p> <p>Record this value on page 4 and calculate the difference to the theoretical value of 1.05 for $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$.</p> | | | | | |
| | MMO Quality | Q1 Q1 | Accuracy Award (vi) and (vii) for a difference up to 0.15. Award (vi) only for a difference of 0.15+ to 0.25. <i>Award no Q marks if either the mass of water or the mass of residue is negative</i> or <i>mass of water driven off > mass of crystals taken.</i> | 2 | [7] |
| (b) | ACE Interpretation | I4 | Give one mark for calculating $\frac{\text{candidate's mass of water}}{\text{candidate's mass of crystals}} \times 100$ <i>This mark is for the method of calculation not for evaluation of the expression.</i> | 1 | [1] |

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| (c) | ACE Interpretation | I4 | Give one mark for correctly calculating, to within 1 dp, the two missing % of water of crystallisation. <i>Answers given to 2 dp are acceptable.</i> $x = 3 \quad \% = 31.0$ $x = 9 \quad \% = 57.4$ | 1 | [2] |
| | ACE Conclusions | Con2 | Give one mark if candidate selects a value of x consistent with the % of water calculated from experiment. <i>Accept:</i> <i>the closest integer from the table;</i> <i>a calculated (or estimated) non-integral value between appropriate integers.</i> | 1 | |
| (d) | ACE Improvements | Imp1 | Give one mark if the candidate explains how repetition of the whole experiment can: (i) show consistent results, or (ii) display reproducibility, or (iii) eliminate anomalous results <i>Accept reference to <u>accuracy</u> only if there is reference to consistent results.</i> <i>Accept reference to <u>average</u> only if there is reference to “leaving out” erroneous or inconsistent results.</i> | 1 | [1] |
| (e) | ACE Interpretation | I9 | Give one mark for calculating 250 g as being the mass giving 0.04% error when weighed on a 1 dp balance. | 1 | [1] |
| | | | | [Total: 12] | |

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| FA 5 is solid manganese(IV) oxide, FA 6 is aqueous iron(II) sulphate, FA 7 is aqueous hydrogen peroxide | | | | | |
|---|-----------------|------|---|---|-----|
| 3 (a) | MMO Decisions | De2 | (i) Give one mark if candidate explains that H ₂ should be tested first as less dense/lighter than air or the least dense/lightest gas. | 1 | [4] |
| | PDO Recording | R1 | (ii) Give one mark for a single table showing tests and observations up to a positive test for one of the three gases and starting with the gas selected in (i) above. | 1 | |
| | MMO Collection | C3 | (iii) Give one mark if correct observations are made for correct tests. Only oxygen giving positive result. | 1 | |
| | ACE Conclusion | Con2 | (iv) Give one mark for conclusion (from evidence) that oxygen is the gas given off. No e.c.f. from (iii). | 1 | |
| (b) | PDO Layout | L1 | Give one mark for clear presentation of both tests and of at least one observation. | 1 | [2] |
| | MMP Collection | C3 | Give one mark for observing: yellow / yellow-green / green solution when FA 5 is added to KI or a blue / black / blue-black / purple colour <u>in the solution</u> when starch is added. | 1 | |
| (c) | ACE Conclusions | Con2 | FA 5 Give one mark for catalyst in test (a). | 1 | [2] |
| | | Con2 | If the first mark in this section has been given or FA 5 acts as an oxidant / oxidising agent in (b): Give one mark for suggesting element is in transition block or d-block. <i>Accept also:</i> <i>Groups (3-12), B-subgroups.</i> | 1 | |

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| (d) | MMO Collection | C3 | (i) Give one mark for an initial precipitate formed in each box on addition of NaOH or NH ₃ (aq). | 1 | [5] |
| | PDO Recording | R5 | (ii) Give one mark for reporting the solubility/insolubility of any initial precipitate on adding excess reagent. | 1 | |
| | MMO Collection | C3 | (iii) Give one mark for green, (dark, dirty or muddy green acceptable but not grey-green) ppt. with FA 6 . | 1 | |
| | | C3 | (iv) Give one mark for brown, orange-brown, red-brown or rust coloured ppt. with mixture FA 6/FA 7 . | 1 | |
| | ACE Conclusions | Con2 | (v) Identifies Fe ²⁺ as cation in FA 6 , Fe ³⁺ as the cation in the mixture of FA 6 with FA 7 and that FA 7 has acted as an oxidant / oxidising agent / oxidiser. (No e.c.f.) <i>Conclusions must be supported by a minimum of a correct observation with one reagent for each ion and no contra observations.</i> | 1 | |
| (e) | PDO Layout | L1 | Give one mark for clear presentation of observations and conclusion. | 1 | |

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. Ba²⁺(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

| | | | | | |
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| | MMO Decisions | De6 | Give one mark for choosing barium chloride or nitrate and HCl or HNO ₃ as reagents or lead nitrate / lead ethanoate and HNO ₃ as reagents or barium chloride and (acidified) dichromate(VI) in separate tests. (Acid could be added and dichromate used to test for SO ₂ .) | 1 | |
|--|---------------|-----|--|---|--|

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| | MMO Collection | C3 | Give one mark for recording a white ppt. with Ba^{2+} or Pb^{2+} insoluble in presence/excess of the appropriate acid or white ppt. with Ba^{2+} and no change in orange colour of dichromate(VI) (<i>in solution or gas from acid</i>). | 1 | [3] |
| | | | | | [Total: 16] |