Publication version - 05/06/04

A2 Practical Exam: OCR 2816/03
May 2004: Mark Scheme

Skill P 16 marks (*out of 19 marks possible*)

E 8 marks Measurement of the first temperature change

E1 A known volume of known concentration aq $CuCl_2$/HCl used in a plastic cup [1]
Method of measurement of solution need not be specified

E2 Explains choice of metal used (***one** reason is required*)
- it must be more reactive than copper
- sodium ***or*** calcium (etc) are unsuitable since they react with water [1]

E3 Excess of a suitable metal (eg Mg) chosen for the first experiment [1]
Accept Mg, Zn or Fe as suitable metals.

E4 Correct calculation of mass of metal needed to react with aq HCl/$CuCl_2$ [1]

E5 Measure initial and maximum temperature of the solution [1]
Reference to the "final" temperature does not get mark E5
E5 can be scored from a cooling curve

E6 Repeat same experiment until readings are consistent/ take mean [1]

E7/8 Accuracy precautions [2]
(*Two bullet points met = 1 mark: four = 2 marks*)
- Metal is powdered to increase surface area/speed up reaction
- Stir during reaction
- Use a lid on the calorimeter *(can be scored from a diagram)*
- Use a pipette/burette to measure the aqueous HCl or $CuCl_2$
- Use a finely graduated thermometer (to 0.1 or 0.2^{o}C)
- Brief description of plotting a cooling curve
- A cooling curve sketched, with sensible extrapolation shown

R 7 marks The second reaction and calculations

- *"E" Marks can be credited in this section if not previously awarded.*
- *If the candidate used neither HCl nor $CuCl_2$, only R4 and R5 can be awarded*
- *If a different metal is used for the two reactions, only R4 and R5 can be awarded.*

R1 Uses the same metal (as in E) reacting with aqueous HCl (***or*** $CuCl_2$) [1]
*Mark R1 is for suitable reagents **and** the outline procedure*

R2 Balanced equations for both reactions studied are given [1]
State symbols are not required – but correct use of ICT is needed

R3 Calculation to work out the mass of metal needed [1]
Mass must be linked to the number of moles of solution.

R4 Method of calculation of the enthalpy change, ΔH, for either reaction [1]
*R4 is awarded for quoting (**or** using) **both** formulae below*
- *Heat produced (J) = mass of water x shc x temp rise*
- *Enthalpy change = $^{heat\ produced}/_{no\ of\ moles}$*

R5 Correct specimen calculation of enthalpy change per mole for either reaction. [1]

*ΔH must have a negative sign in final answer (**or** a comment to that effect)*

- *If solution is used in excess, ΔH must be calculated per mole of metal*

R6 Correct Hess' law diagram as applied to reactions measured [1]

The number of moles (two) is not required for R6 but it is needed for R7

R7 Enthalpy change for Cu + HCl calculated from the two measured ΔH values. [1]

ΔH (for Cu + acid) = 2 ΔH (for M + acid) – ΔH (for M + $CuCl_2$)

S 4 marks for safety, sources and qwc

S1 Hazards correctly stated for **two** different chemicals used in the procedure [1]

- *Dilute HCl is irritant (**not** corrosive) up to about 6.0 mol dm^{-3}*
- *$CuCl_2$ is harmful/irritant below [about] 1.5 mol dm^{-3} but toxic above that*
- *Mg is [highly] flammable **or** is irritant to eyes/lungs if used as a powder*
- *Zn is flammable, especially as dust/powder. It is irritant to eyes as powder.*

A blatant overstatement of a hazard, such as for HCl above, is not credited

S2 **Two sources** quoted in the text ***or*** at end of plan. [1]

*Book references **must** have chapter or page numbers*
Internet reference must go beyond the first slash of web address
One reference to "Hazcards" (or equivalent) is accepted

S3 **QWC**: text is legible ***and*** spelling, punctuation and grammar are accurate [1]

Treat ICT skills in text (eg "cm3") as an error.

S4 **QWC**: information is organised clearly and coherently [1]

- *Is a word count given and within the limits 400 – 800 words?*
  Photocopied/downloaded material must count within this total
- *Is scientific language mostly used correctly?*
  No S4 if there is a serious error - eg "strong" for "concentrated".
  No S4 for an incorrect chemical formula in the text.
- *Are the descriptions of both methods presented logically?*

A2 Practical Test (Part B)

Part 1 **[8 marks]**

- ***Readings and Observations – 5 marks***

Initial ***and*** final/maximum temperature recorded ***with*** units [1]

Accuracy of candidate's temperature rise [2]
- If within 1.0°C ***or*** 10.0% (whichever is less) of supervisor's mean rise → 2 marks
- If within 1.5°C ***or*** 15.0% (whichever is less) of supervisor's mean rise → 1 mark

Brown/gold/rust coloured solid/precipitate formed [1]
Colour (one of those listed above) ***and*** *state word are* ***both*** *needed*
Accept sensible "double" colours such as "red-brown" or "orange-brown"
Accept "[iron] powder turns brown"

Solution loses blue colour/ $CuSO_4$ goes [pale] green [1]
Reference to "solution" (or to $CuSO_4$) is required: no mark for colour only

- ***Calculation of ΔH – 3 marks***

Formula: heat produced = mass x shc x temp rise *(with figures correctly used)*
or number of moles of $CuSO_4$ used = 0.0125/0.013 mol [1]

Enthalpy change, correctly calculated **numerically** [1]
$\Delta H = {}^{heat\ produced}/_{no\ of\ moles}\ J$

Enthalpy change correct with unit given, suitable sig. fig. and negative sign [1]
This mark is only awarded if the calculated answer for ΔH is correct numerically

NB – Part 1 has 8 marks available, but only 7 on the question paper

Part 2 **[8 marks]**

Initial ***and*** final temperature quoted to one (or two) d.p,, with units [1]

Accuracy of candidate's temperature rise [2]
- If rise is within 2.0°C (or 5.0%, whichever is less) of supervisor's mean rise → **2** marks
- If it is within 4.0°C (or 10.0%, whichever is less) of supervisor's mean rise → **1** mark

Observation: fizzing ***or*** bubbling [1]

Grey/black/dark coloured precipitate/solid/mixture formed
or colourless solution formed/ blue colour of solution lost [1]
No mark for "dark solution" formed

Enthalpy change, correctly calculated [1]
$\Delta H = {}^{25 \times 4.2 \times \Delta T}/_{1000 \times 0.0125}$

- ***Safety – 2 marks****:*

Use a solution of a lower/less concentration [1]

Start with solution cooled below room temperature
or Use magnesium turnings/lumps [to reduce the surface area] [1]
No mark for reducing the mass of Mg (because it has to be in excess)

Part 3 [2 marks]

Hess' cycle labelled with ΔH required and the enthalpies of displacement [1]
The enthalpy cycle should be labelled "$CuSO_4$" at the bottom if it shows upward arrows
The enthalpy cycle should be labelled "Cu" at the bottom if it shows downward arrows

Enthalpy change correctly calculated, from candidate's stated ΔH results. [1]
ΔH (reaction) = ΔH (Part 2) – ΔH (Part 1)
or ΔH (reaction) = ΔH (Mg expt) – ΔH (Fe expt)
There is no "error carried forward" mark from a wrong Hess' cycle diagram
This mark is awarded "ecf" from candidate's answers to part 1 and/or 2
Negative sign for ΔH must be shown (if appropriate) ***and*** *the unit given (kJ or kJ mol^{-1})*

NB – Part 3 has only 2 marks available, but 3 shown on the question paper

Part 4 [4 marks]

$KMnO_4$ is decolourised
or purple colour of solution disappears/ solution goes pale yellow [1]

One correct relevant statement about the redox process [1]
- **Either**: [potassium] manganate(VII) is reduced **or** is the oxidising agent
- **Or**: iron(II) [ion/sulphate] is oxidised **or** is the reducing agent

Colourless solution is due to formation of $Mn^{2+}(aq)$
or pale yellow solution is due to iron(III)/Fe^{3+} ions formed [1]
The mark is for relating to the observed colour to the relevant ion formed

$Fe^{2+} - e^- \rightarrow Fe^{3+}$ ***or*** $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ [1]

Part 5 [9 marks, max]

(a) 4 marks available

[Pale] blue precipitate/solid/suspension [1]
Colour (blue) ***and*** *state are both required for the mark*

Copper(II) hydroxide *(named)* [1]
The Stock (oxidation) number is not required, but must be correct if used.

$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$ [2]
Any incorrect equation showing $Cu(OH)_2$ as a product scores ***1 mark***
State symbols are not required: ignore any attempt.

(b) 6 marks available

[Pale] blue precipitate/solid formed [at first] [1]

Name ***or*** formula of $Cu(OH)_2$ (referring to the precipitate)
or reference to NH_3 acting as an alkali/base [1]

Deep/dark/royal blue colour formed [with excess ammonia] [1]

A blue solution is formed [with excess ammonia] [1]
Accept any reference to the precipitate dissolving ***or*** *mixture "going clear"*

Ligand substitution/ replacement takes place
or ammonia becomes the ligand [in the deep blue complex] [1]

Correct formula ***or*** name of the tetrammine complex [1]
*Accept $[Cu(NH_3)_4(H_2O)_2]^{2+}$ **or** $[Cu(NH_3)_4]^{2+}$ **or** tetrammine copper(II) ion*

NB – Part 5 has maximum 9 marks awarded (out of 10), but only 8 on the question paper
Parts 1 – 5 inclusive are out of a total of 31, but the maximum mark is 30.

Part 6 - Evaluation [14 marks max]

(a) [4 marks available]

A1 To ensure that <u>all</u> of the copper(II) sulphate reacts [1]
No mark for "to ensure that reaction has finished"

A2 If reaction incomplete, temperature rise/enthalpy change will be too small
or excess would speed up the reaction [1]
Do not allow "temperature change would be inaccurate"

A3 No of moles of Fe = 0.0125 ***and*** Ar of iron quoted as 55.8 [1]

A4 Mass of Fe = 0.0125 x 55.8 = 0.698 g (***or*** 0.70 g) [1]
Answers = 0.7 g (one sig fig) or 0.6975 do not earn this mark

(b) [12 marks maximum]

The best <u>four</u> strands suggested by candidate are credited, plus J1

B1 **Heat losses** [1]

B2 Correct reference to <u>convection</u> ***or*** <u>conduction</u> ***or*** <u>evaporation</u> [1]

B3 Heat losses are severe in Mg experiment due to the high temp rise [1]

B4 Use a lid on the cup ***or*** use thermos/vacuum/dewar flask [1]

B5 Plot a cooling curve to compensate for heat losses [1]

C1 **Mg experiment**: fizzing was seen [1]

C2 This is evidence of an alternative/different reaction occurring [1]

C3 "Steam"/acid spray is lost during reaction [causing inaccuracy] [1]

C4 Reaction was still fizzing after maximum temperature was measured [1]

D1 **Thermometer** used was not very accurate/ only read to 1^oC [1]

D2 Significant % error in first measurement since ΔT was relatively small [1]

D3 Use thermometer reading to $0.1/0.2^oC$ ***or*** one with a more accurate <u>scale</u> [1]

E1 **Repeat readings *or*** only one reading was taken (*aw*) [1]

E2 Achieve a consistent temperature rise ***or*** take the mean
or anomalous readings can be identified/ignored [1]

E3 Consistent readings are evidence of <u>reliability</u> [1]

F1 Specific heat capacity of [$CuSO_4$] solution is not same as water
or the density of aq $CuSO_4$ is not the same as water [1]

F2 Use tables/internet/database to look up exact value of shc [1]

F3 Heat is also absorbed by the metal/apparatus [1]

G1 Use a **pipette/burette** instead of measuring cylinder [to measure $CuSO_4$] [1]

G2 Pipette/burette is accurate to 0.06/0.05 cm^3 [1]

J1 The "most significant" modification is related to <u>heat losses</u> – explained [1]