Cambridge Assessment International Education

Interactive

Interactive Example Candidate Responses
Paper 52 (May/June 2016), Question 1

Cambridge International AS & A Level
Chemistry 9701

Version 1.0

Cambridge Pathway

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HIGH | MIDDLE | LOW

1 A more reactive metal will displace a less reactive metal from a solution of its salt. This reaction is exothermic. If the same reaction is set up in an electrochemical cell then, instead of an enthalpy change, electrical energy is produced and a cell voltage can be measured.

You are to plan an investigation of the reaction of three different metals (magnesium, iron and zinc) with aqueous copper(II) sulfate. You will plan to investigate whether there is a relationship between their cell potential values, E°_{cell}, and their enthalpy changes of reaction, ΔH_r.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$
$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$
$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Copper(II) sulfate solution is classified as a **moderate hazard**.

Zinc sulfate solution is classified as **corrosive**.

Iron(II) sulfate solution is classified as a **health hazard**.

(a) Predict how ΔH_r may change as E°_{cell} increases. Give a reason for your prediction.

When E°cell increases, the more (-)ve the ~~ΔH°~~ enthalpy changes. Reaction is more likely to take place therefore E°cell higher ~~for ΔH_r + (-)ve val~~ (more spontaneous) When metal is more reactive [1]

(b) The first part of the investigation is to determine the enthalpy change, ΔH_r, for the reaction of the same number of moles of three powdered metals with 0.500 mol dm^{-3} copper(II) sulfate.

When determining the ΔH_r for the reaction of the metals listed above with aqueous copper(II) sulfate,

the independent variable is ~~volume of solution~~. ~~number of moles of powder~~ (~~the~~ metal powder used.

the dependent variable is Temperature change of solution.

[2]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

1(d)

1(e)

1(f)

1(g)

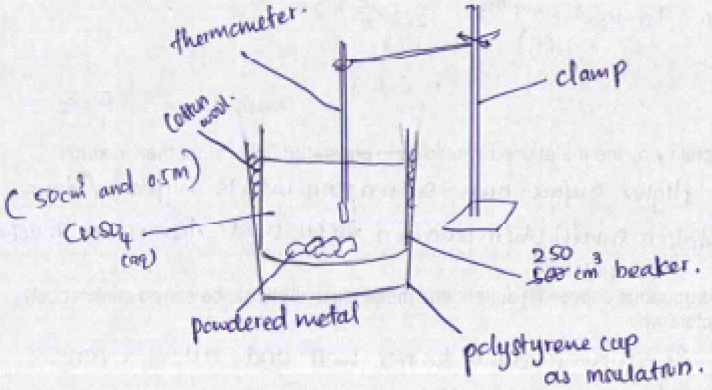
Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
(b)	Independent variable: The (type of) metal Dependent variable: temperature change or rise or increase OR enthalpy change **[1]**
(c)(i)	Diagram should indicate a labelled insulated container AND a labelled thermometer in the liquid. **[1]**
(c)(ii)	Mass of metal before and after Initial temperature (before metal added) AND Highest temperature (after metal added) **[1]**
(c)(iii)	Wear gloves **[1]**
(c)(iv)	Moles CuSO4 = 0.025 mol, therefore moles of magnesium = 0.025 mol (minimum) mass Mg > (0.025 × 24.3 =) 0.6075 g AND mass required value is greater than 0.6075 g **[1]**
(c)(v)	Larger surface area AND causes increased rate of reaction **[1]**
(c)(vi)	Ensure uniformity of heating (of solution) **[1]**
(d)	50.0 × 4.18 × 58.5 = 12 226.5 (J) ΔHr = 12 226.5 / 0.025 = 489 000 = – 489 1000 **[1]**
(e)	Complete circuit involving labelled voltmeter; labelled salt bridge; two separate solutions; (Solutions are) magnesium sulfate or MgSO4 with magnesium or Mg rod and copper(II) sulfate CuSO4 with copper or Cu rod Concentration of solution(s) is 1 mol dm–3 or 1 M **[1]**
(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

MARK SCHEME

You are provided with a sample of powdered metal and 50.0 cm³ of 0.500 mol dm⁻³ aqueous copper(II) sulfate.

(c) (i) Draw a fully labelled diagram to show how the apparatus should be set up to allow you to determine the increase in temperature of aqueous copper(II) sulfate.
You should use apparatus normally found in a school or college laboratory.



[1]

(ii) State the measurements you would make in your experiment.

final temperature and initial temperature of solution in beaker.

mass / volume of solution ~~after addition of sample.~~

number of moles of metal added (mass of metal added). [2]

(iii) Other than eye protection, state **one** precaution you would take to make sure that the experiment proceeds safely.

Reactions are exothermic wear gloves when handling

apparatus [1]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(iv) For the reaction with magnesium, calculate the mass of magnesium, in g, you would use so that it is in a small excess.

# of moles of $CuSO_4$ present = $\frac{50}{1000} \times 0.5$
= 0.025 mol.

mass To react exactly (g) = 0.025×24
= 0.6 g

mass of Mg = ...0.8........ g [2]

(v) Explain why the metal used should be in powdered form rather than in strips.

Higher surface area so reaction rate is higher (time taken small) when powdered metal used. Also ensure reaction completion. [1]

(vi) The aqueous copper(II) sulfate and metal mixture should be stirred continuously. Explain why.

To allow reactants to mix well and allow even heat distribution in the solution [1]

(d) In one experiment, the increase in temperature when excess magnesium powder is added to $50.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ aqueous copper(II) sulfate is 58.5 °C.

Calculate the enthalpy change for this reaction, ΔH_r, in $kJ\,mol^{-1}$.
Assume the specific heat capacity, c, of the reaction mixture is $4.18\,J\,g^{-1}\,K^{-1}$.
Assume $1.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ aqueous copper(II) sulfate has a mass of 1.0 g.
Include a sign in your answer.

$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$

$\Delta\theta = 58.5$

$1cm^3 \rightarrow 1g$
$m = 50\,g$
$\Delta\theta = 58.5$

Mg:
0.025 mol → 12.2
1 mol → x

$Q = mc\Delta\theta$
$= 50 \times 4.18 \times 58.5$
$= 12,230\,J$

x = 488

ΔH_r = ~~-12.2~~ -488 $kJ\,mol^{-1}$ [2]

Your Mark

1(a)
1(b)
1(c)(i)
1(c)(ii)
1(c)(iii)
1(c)(iv)
1(c)(v)
1(c)(vi)
1(d)
1(e)
1(f)
1(g)

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	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
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(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

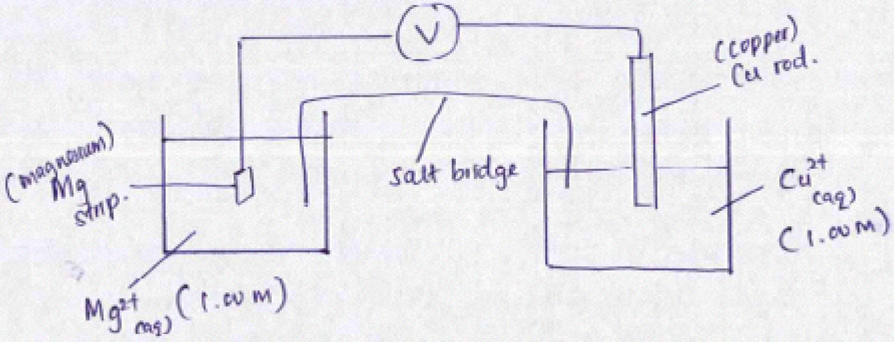
EXAMINER COMMENTS

MARK SCHEME

(e) The second part of the investigation involves determining the cell potential, E°_{cell}, for the three electrochemical cells.

cell reaction
$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Draw a diagram of the apparatus you would use to measure the E°_{cell} for the magnesium/copper cell. Your labels should include the **names** of the metals and the **names** and **concentrations** of the solutions you would use.



[3]

(f) Explain why the enthalpy change determination and cell potential determination should be carried out at the same temperature as each other.

Temperature needs to be standardised, so that temperature doesnt become the factor that affects $E^{\ominus}$cell. All condition except the once that are measured should be kept Constant. [1]

Select page

HIGH MIDDLE LOW

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

1(d)

1(e)

1(f)

1(g)

Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
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(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

MARK SCHEME

(g) Accepted E°_{cell} values are shown for the cell reactions.

	cell reaction	E°_{cell}/V	ΔH_r	
1	$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$	+2.72	~~−12.2~~	−488
2	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$	+1.10	~~−8.3~~	−250
3	$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	+0.78	~~−4.4~~	−130

Use your prediction in **(a)**, your answer to **(d)** and data from the table to predict ΔH_r values for reactions 2 and 3.
Complete the table with these values. [1]

[Total: 18]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

1(d)

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Select page

HIGH MIDDLE LOW

1 A more reactive metal will displace a less reactive metal from a solution of its salt. This reaction is exothermic. If the same reaction is set up in an electrochemical cell then, instead of an enthalpy change, electrical energy is produced and a cell voltage can be measured.

You are to plan an investigation of the reaction of three different metals (magnesium, iron and zinc) with aqueous copper(II) sulfate. You will plan to investigate whether there is a relationship between their cell potential values, E°_{cell}, and their enthalpy changes of reaction, ΔH_r.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$
$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$
$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

> **Copper(II) sulfate solution** is classified as a **moderate hazard**.
>
> **Zinc sulfate solution** is classified as **corrosive**.
>
> **Iron(II) sulfate solution** is classified as a **health hazard**.

(a) Predict how ΔH_r may change as E°_{cell} increases. Give a reason for your prediction.

ΔH_r increases as E°_{cell} increase because more reactive metals have a higher E°_{cell} and ~~are~~ also ~~also~~ release more heat in their displacement reactions [1]

(b) The first part of the investigation is to determine the enthalpy change, ΔH_r, for the reaction of the same number of moles of three powdered metals with 0.500 mol dm^{-3} copper(II) sulfate.

When determining the ΔH_r for the reaction of the metals listed above with aqueous copper(II) sulfate,

the independent variable is The metal chosen for the reaction hence E°_{cell}

the dependent variable is ~~[illegible]~~ change in temperature

[2]

Your Mark

1(a) 1(b) 1(c)(i) 1(c)(ii) 1(c)(iii) 1(c)(iv) 1(c)(v) 1(c)(vi) 1(d) 1(e) 1(f) 1(g)

Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
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(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

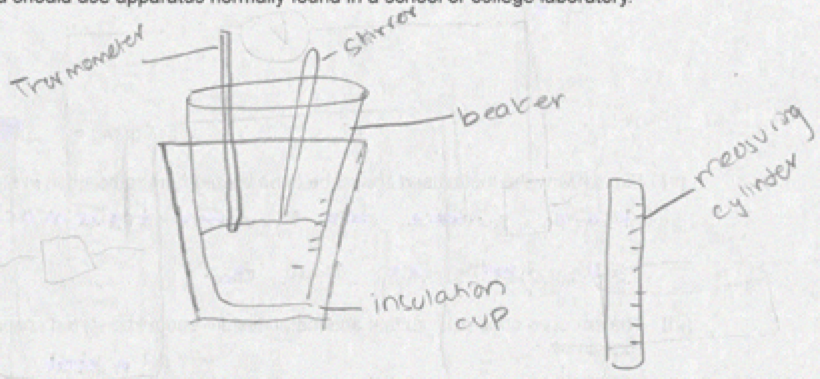
MARK SCHEME

Select page

HIGH | MIDDLE | LOW

You are provided with a sample of powdered metal and 50.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

(c) (i) Draw a fully labelled diagram to show how the apparatus should be set up to allow you to determine the increase in temperature of aqueous copper(II) sulfate.
You should use apparatus normally found in a school or college laboratory.



[1]

(ii) State the measurements you would make in your experiment.

The initial temperature of $CuSO_4$ and the final temperature after adding the powered metal

[2]

(iii) Other than eye protection, state **one** precaution you would take to make sure that the experiment proceeds safely.

Use a large beaker so the content dont spill out if the reaction is too vigourous.

[1]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

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Select page

HIGH | MIDDLE | LOW

(iv) For the reaction with magnesium, calculate the mass of magnesium, in g, you would use so that it is in a small excess.

~~89%~~ x ~~0.5~~ 50 cm³ x 1g = 50

Higher surface area therefore faster reaction and subsequently less heat loss. [1]

(vi) The aqueous copper(II) sulfate and metal mixture should be stirred continuously. Explain why.

~~To~~ To ~~be~~ properly mix the ~~metea~~ metal and the solution and to ensure that all ~~ene~~ of the metal reach. [1]

(d) In one experiment, the increase in temperature when excess magnesium powder is added to 50.0 cm³ of 0.500 mol dm⁻³ aqueous copper(II) sulfate is 58.5 °C.

Calculate the enthalpy change for this reaction, ΔH_r, in kJ mol⁻¹.
Assume the specific heat capacity, c, of the reaction mixture is 4.18 J g⁻¹ K⁻¹.
Assume 1.0 cm³ of 0.500 mol dm⁻³ aqueous copper(II) sulfate has a mass of 1.0 g.
Include a sign in your answer.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$

Q = mcΔθ

Q = 50 x 4.18 x 58.5

Q = 12226.5

12226.5 / 50 x 0.5 = 489.0

ΔH_r = – 0.489 kJ mol⁻¹ [2]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

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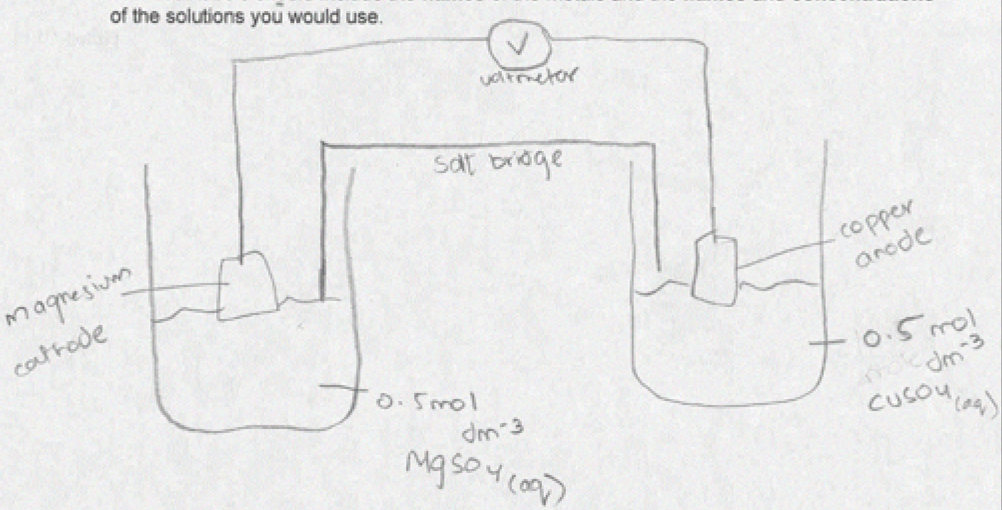
EXAMINER COMMENTS

MARK SCHEME

(e) The second part of the investigation involves determining the cell potential, $E^{\ominus}_{cell}$, for the three electrochemical cells.

cell reaction
$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Draw a diagram of the apparatus you would use to measure the $E^{\ominus}_{cell}$ for the magnesium/copper cell. Your labels should include the **names** of the metals and the **names** and **concentrations** of the solutions you would use.



[3]

(f) Explain why the enthalpy change determination and cell potential determination should be carried out at the same temperature as each other.

Because at different temperatures CuSO4 has different ~~sou~~ ~~solut~~ solubility ~~constant~~ constant with water. [1]

Select page

HIGH MIDDLE LOW

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

1(d)

1(e)

1(f)

1(g)

Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
(b)	Independent variable: The (type of) metal Dependent variable: temperature change or rise or increase OR enthalpy change **[1]**
(c)(i)	Diagram should indicate a labelled insulated container AND a labelled thermometer in the liquid. **[1]**
(c)(ii)	Mass of metal before and after Initial temperature (before metal added) AND Highest temperature (after metal added) **[1]**
(c)(iii)	Wear gloves **[1]**
(c)(iv)	Moles CuSO4 = 0.025 mol, therefore moles of magnesium = 0.025 mol (minimum) mass Mg > (0.025 × 24.3 =) 0.6075 g AND mass required value is greater than 0.6075 g **[1]**
(c)(v)	Larger surface area AND causes increased rate of reaction **[1]**
(c)(vi)	Ensure uniformity of heating (of solution) **[1]**
(d)	50.0 × 4.18 × 58.5 = 12 226.5 (J) ΔHr = 12 226.5 / 0.025 = 489 000 = – 489 1000 **[1]**
(e)	Complete circuit involving labelled voltmeter; labelled salt bridge; two separate solutions; (Solutions are) magnesium sulfate or MgSO4 with magnesium or Mg rod and copper(II) sulfate CuSO4 with copper or Cu rod Concentration of solution(s) is 1 mol dm–3 or 1 M **[1]**
(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

MARK SCHEME

(g) Accepted E°_{cell} values are shown for the cell reactions.

	cell reaction	E°_{cell}/V	ΔH_r
1	$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$	+2.72	−0.489
2	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$	+1.10	−0.300
3	$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	+0.78	−0.200

Use your prediction in **(a)**, your answer to **(d)** and data from the table to predict ΔH_r values for reactions 2 and 3.
Complete the table with these values. [1]

[Total: 18]

Select page

HIGH MIDDLE LOW

Your Mark

1(a)
1(b)
1(c)(i)
1(c)(ii)
1(c)(iii)
1(c)(iv)
1(c)(v)
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EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH MIDDLE LOW

1 A more reactive metal will displace a less reactive metal from a solution of its salt. This reaction is exothermic. If the same reaction is set up in an electrochemical cell then, instead of an enthalpy change, electrical energy is produced and a cell voltage can be measured.

You are to plan an investigation of the reaction of three different metals (magnesium, iron and zinc) with aqueous copper(II) sulfate. You will plan to investigate whether there is a relationship between their cell potential values, E°_{cell} and their enthalpy changes of reaction, ΔH_r.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$
$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$
$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Copper(II) sulfate solution is classified as a **moderate hazard**.
Zinc sulfate solution is classified as **corrosive**.
Iron(II) sulfate solution is classified as a **health hazard**.

(a) Predict how ΔH_r may change as E°_{cell} increases. Give a reason for your prediction.

ΔHr will increase when E°cell increases.

[1]

(b) The first part of the investigation is to determine the enthalpy change, ΔH_r, for the reaction of the same number of moles of three powdered metals with 0.500 mol dm^{-3} copper(II) sulfate.

When determining the ΔH_r for the reaction of the metals listed above with aqueous copper(II) sulfate,

the independent variable is, Cell potential values i.e E°cell

the dependent variable is. Enthalpy change of reaction

[2]

Your Mark

1(a) 1(b) 1(c)(i) 1(c)(ii) 1(c)(iii) 1(c)(iv) 1(c)(v) 1(c)(vi) 1(d) 1(e) 1(f) 1(g)

Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
(b)	Independent variable: The (type of) metal Dependent variable: temperature change or rise or increase OR enthalpy change **[1]**
(c)(i)	Diagram should indicate a labelled insulated container AND a labelled thermometer in the liquid. **[1]**
(c)(ii)	Mass of metal before and after Initial temperature (before metal added) AND Highest temperature (after metal added) **[1]**
(c)(iii)	Wear gloves **[1]**
(c)(iv)	Moles CuSO4 = 0.025 mol, therefore moles of magnesium = 0.025 mol (minimum) mass Mg > (0.025 × 24.3 =) 0.6075 g AND mass required value is greater than 0.6075 g **[1]**
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(d)	50.0 × 4.18 × 58.5 = 12 226.5 (J) ΔHr = 12 226.5 / 0.025 = 489 000 = – 489 1000 **[1]**
(e)	Complete circuit involving labelled voltmeter; labelled salt bridge; two separate solutions; (Solutions are) magnesium sulfate or MgSO4 with magnesium or Mg rod and copper(II) sulfate CuSO4 with copper or Cu rod Concentration of solution(s) is 1 mol dm–3 or 1 M **[1]**
(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

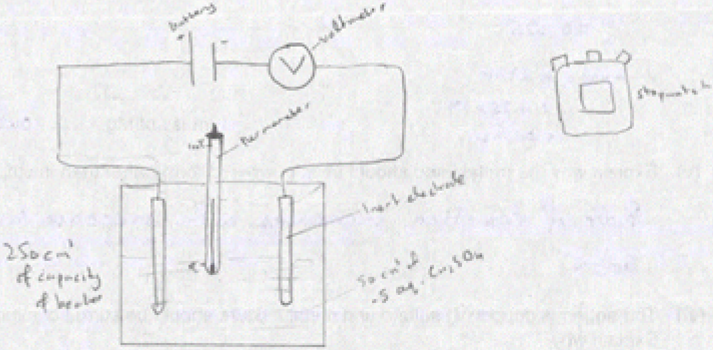
MARK SCHEME

Select page

HIGH MIDDLE LOW

You are provided with a sample of powdered metal and 50.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

(c) (i) Draw a fully labelled diagram to show how the apparatus should be set up to allow you to determine the increase in temperature of aqueous copper(II) sulfate.
You should use apparatus normally found in a school or college laboratory.



[1]

(ii) State the measurements you would make in your experiment.

Initial and final temperature

The cell voltage

The time taken [2]

(iii) Other than eye protection, state **one** precaution you would take to make sure that the experiment proceeds safely.

~~Make sure there is constant power supply without any intruption.~~ Wear protective gloves as ZnSO4 is corrosive [1]

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

1(c)(iv)

1(c)(v)

1(c)(vi)

1(d)

1(e)

1(f)

1(g)

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(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

EXAMINER COMMENTS

MARK SCHEME

Select page

HIGH | MIDDLE | LOW

(iv) For the reaction with magnesium, calculate the mass of magnesium, in g, you would use so that it is in a small excess.

n = cxv
= ·5x50 / 1000
= 0.025

mass = n x Mr
= 0.025x24
= 0.6g

mass of Mg = ...0.6........ g [2]

(v) Explain why the metal used should be in powdered form rather than in strips.

Rate of reaction increases with increase in surface area [1]

(vi) The aqueous copper(II) sulfate and metal mixture should be stirred continuously. Explain why.

So that constant heat is provided to all the reactants [1]

(d) In one experiment, the increase in temperature when excess magnesium powder is added to $50.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ aqueous copper(II) sulfate is 58.5 °C.

Calculate the enthalpy change for this reaction, ΔH_r, in $kJ\,mol^{-1}$.
Assume the specific heat capacity, c, of the reaction mixture is $4.18\,J\,g^{-1}\,K^{-1}$.
Assume $1.0\,cm^3$ of $0.500\,mol\,dm^{-3}$ aqueous copper(II) sulfate has a mass of 1.0 g.
Include a sign in your answer.

$$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$$

1cm³ = 1g
50cm³ = 50g

ΔH = mcΔθ
= -50/1000 x 4.18 x 58.5
= -12.2 kJ

ΔH_r = ...-12.2.......... $kJ\,mol^{-1}$ [2]

Your Mark

1(a)
1(b)
1(c)(i)
1(c)(ii)
1(c)(iii)
1(c)(iv)
1(c)(v)
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1(d)
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Q1	Mark scheme
	Expected answer
(a)	(As the E° cell value increases) ΔH_r decreases or ΔH_r becomes more negative or ΔHr becomes more exothermic. AND The more reactive the metal then the greater the energy release will be. OR Energy output of both reactions is dependent upon the difference in reactivity (of metals). **[1]**
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(f)	So that values can be compared **[1]**
(g)	Both ΔHr (Zn) and ΔHr (Fe) values which are consistent with the prediction in (a). **[1]**

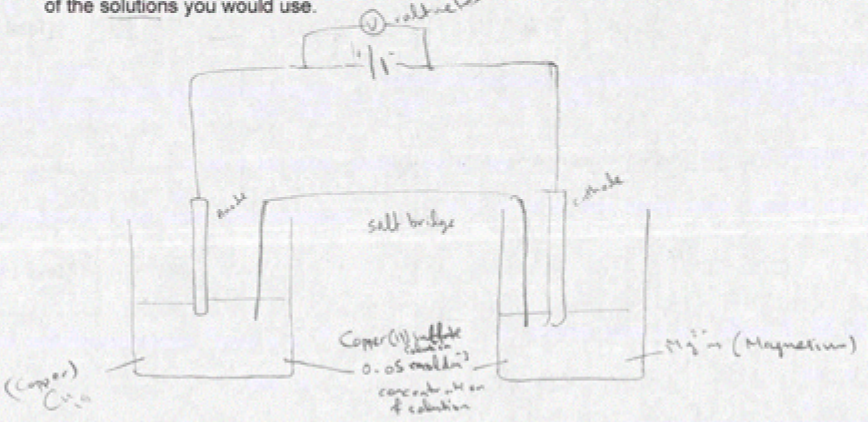
EXAMINER COMMENTS

MARK SCHEME

(e) The second part of the investigation involves determining the cell potential, E°_{cell}, for the three electrochemical cells.

cell reaction
$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Draw a diagram of the apparatus you would use to measure the E°_{cell} for the magnesium/copper cell. Your labels should include the **names** of the metals and the **names** and **concentrations** of the solutions you would use.



[3]

(f) Explain why the enthalpy change determination and cell potential determination should be carried out at the same temperature as each other.

A relationship between E°cell and ΔH° could be established

[1]

Your Mark

1(a)
1(b)
1(c)(i)
1(c)(ii)
1(c)(iii)
1(c)(iv)
1(c)(v)
1(c)(vi)
1(d)
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(g) Accepted E°_{cell} values are shown for the cell reactions.

	cell reaction	E°_{cell}/V	ΔH_r
1	$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$	+2.72	
2	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$	+1.10	6.05
3	$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	+0.78	3.2

Use your prediction in **(a)**, your answer to **(d)** and data from the table to predict ΔH_r values for reactions 2 and 3.
Complete the table with these values. [1]

[Total: 18]

Select page

HIGH MIDDLE LOW

Your Mark

1(a)

1(b)

1(c)(i)

1(c)(ii)

1(c)(iii)

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EXAMINER COMMENTS

MARK SCHEME

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