Transition Metals

Mark Scheme 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 2
Sub Topic	Transition Metals
Booklet	Mark Scheme 1

Time Allowed:

69 minutes

Score: /57

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Acceptable Answer	Reject	Mark
1(a)	d block OR Transition elements / metals / block ALLOW D block Transitional for transition element / metal		1

Question Number	Acceptable Answer	Reject	Mark
1(b)	Cu^{2+} / copper(II) OR Fe^{3+} / iron(III) OR Cu^{2+} /copper(II) **and** Fe^{3+} / iron(III)	copper / Cu Fe^{2+} / iron(II) iron / Fe	1

Question Number	Acceptable Answer	Reject	Mark
1(c)	Cu^{2+} / copper(II) ALLOW $Cu(H_2O)_6{}^{2+}$ / $Cu(H_2O)_4{}^{2+}$	Cu / copper	1

Question Number	Acceptable Answer		Reject	Mark
1(d)	Chlorine / Cl_2	**(1)**	Cl / chloride	2
	Chloride / Cl^-	**(1)**	Cl / chlorine / Cl_2	

Question Number	Acceptable Answer		Reject	Mark
1(e)	copper(I) chloride / CuCl	**(1)**		2
	No TE on 1(c)			
	oxidation / redox (reaction)	**(1)**	Reduction / disproportionation	
	Standalone mark			

Question Number	Acceptable Answer		Reject	Mark
1(f)	(To a solution of **A**) add (dilute aqueous) ammonia / NH_3((aq)) (until no further change) **(1)**			2
	(pale blue precipitate dissolves) to form a dark blue solution ALLOW (pale) blue precipitate /solid /crystals **(1)**			
	OR			
	Flame test **(1)** Blue-green / blue /green colour **(1)**		Pale green	
	OR			
	Add potassium iodide / KI **(1)** Turns brown **(1)**			
	ALLOW			
	Add sodium hydroxide (solution) **(1)** (pale) blue precipitate /solid /crystals (insoluble in excess) **(1)**		Green ppt	
	OR			
	Add zinc / Zn / magnesium / Mg **(1)** Brown solid /crystals / precipitate **(1)**			
	IGNORE			
	Identity of cation at this point			
	No TE on incorrect cations			
	Reagent / flame test mark standalone			

Question Number	Acceptable Answer	Reject	Mark
1(g)	(Add dilute nitric acid to a solution of **A** then) add (aqueous) silver nitrate / $AgNO_3((aq))$ **(1)** White precipitate (soluble in dilute aqueous ammonia) **(1)** OR Add **concentrated / conc** sulfuric acid /H_2SO_4 **(1)** Steamy / misty / white fumes **(1)** IGNORE Identity of anion at this point No TE on incorrect anions	Sulfuric acid Additional reagents e.g. NaOH (loses MP1 only) smoke Just 'fumes'	2

Question Number	Acceptable Answer	Reject	Mark
1(h)	(Yellow colour due to) $[CuCl_4]^{2-}$ **(1)** (Green colour due to) $[CuCl_3]^-$ ALLOW $CuCl_2$ / $[CuCl]^+$ OR A mixture of $[Cu(H_2O)_6]^{2+}$ / $Cu^{2+}((aq))$ **and** $[CuCl_4]^{2-}$ **(1)** IGNORE water ligands on chloro copper ions and $CuCl_2$ Omission of square brackets		2

(Total for Question 1 = 13 marks)

Question Number	Acceptable Answer	Reject	Mark
2(a)(i)	Amount of iron = 5.00/55.8 (mol) **(1)** = amount H_2SO_4 (= 0.089606 / 8.9606 x 10^{-2} (mol)) Volume of 2.00 mol dm^{-3} H_2SO_4 required = 5.00/55.8 ÷ 2 = 0.044803 / 4.4803 x 10^{-2} dm^3 OR = 44.803 cm^3 **(1)** If A_r(Fe) = 56, volume = 0.044643 dm^3 (= 44.643 cm^3) TE on incorrect mol IGNORE all SF and rounding errors **except** 1 SF on final answer, and rounding errors affecting final answer	Units incorrect or omitted	2

Question Number	Acceptable Answer	Reject	Mark
2(a)(ii)	To remove **solid** impurities ALLOW Undissolved **solids** OR **Insoluble** impurities	To remove unreacted iron	1

Question Number	Acceptable Answer	Reject	Mark
2(a)(iii)	Evaporate the solution to crystallization point OR until crystals /solids begin to form ALLOW **Concentrate** the solution by evaporation OR Reduce the volume by 25 – 75 % **(1)** (Cover solution and) allow to stand / cool **and** dry crystals between filter papers ALLOW Dry in a **warm** oven / desiccator **(1)** IGNORE Filtering Points relating just to recrystallization	Just 'evaporate the solution' OR Evaporate **all** water OR Distillation Dry the solution T>80°C Hot oven	2

Question Number	Acceptable Answer	Reject	Mark

2(a)(iv)	Mr ($FeSO_4.7H_2O$) = 277.9
	 ALLOW
	          = 278 **(1)**
	
	 Maximum yield = 277.9 x 5.00÷55.8 **(1)**
	           = 277.9 x 0.08961
	           (= 24.901 g)
	
	 89.5% yield = 0.895 x 277.9 x 5.00/55.8
	         = 22.287 (g)
	
	 OR
	
	 If A_r(Fe) = 56 and A_r(S) = 32
	  89.5% yield = 22.215 (g) **(1)**
	
	 TE at each stage
	
	 IGNORE SF except 1 SF
	
	 Correct answer with no working scores 3
	
	 Additional Comment
	 The 89.5% yield can be applied to the mass of iron, the mass of $FeSO_4.7H_2O$ or the moles of $FeSO_4.7H_2O$ to gain MP3
			3

Question Number	Acceptable Answer	Reject	Mark
2(b)(i)	These marks are standalone Transfer solution to a volumetric / graduated / standard flask **(1)** add washings **(1)** Make up to mark / line / 250 cm^3 (with distilled water / dilute sulfuric acid) **and then** mix **(1)** ALLOW Different indication of mixing (e.g. swirl / invert / stir). Mixing **must** follow making up to mark IGNORE reference to weighing bottle and mixing when dissolving solid and washings from the weighing		3

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	(Pale green solution turns) yellow /orange / brown OR (Pale green solution forms) yellow /orange / brown (solution / cloudy solution / precipitate **(1)** Because (some of) the iron(II) / Fe^{2+} ions are oxidized (to iron(III) / Fe^{3+}) OR iron(III) / Fe^{3+} ions are formed (from iron(II) / Fe^{2+} ions) ALLOW $Fe(OH)_3$ formed **(1)**	red red Just 'oxidation'	2

Question Number	Acceptable Answer	Reject	Mark
2(b)(iii)	(colourless /pale yellow to first permanent pale) pink	(colourless /pale yellow to purple / mauve purple to pink pink / purple to colourless	1

Question Number	Acceptable Answer		Reject	Mark
2(b)(iv)	Amount of MnO_4^- = 25.35 x 0.0195/1000	**(1)**		4
	$\quad$ = 4.94325 x 10^{-4} (mol) (ans*)			
	Amount of Fe^{2+} in 250 cm^3 $\quad$ = 5 x 10 x ans* (ans**)	**(1)**		
	$\quad$ = 0.024716 (mol)			
	Mass of 1 mol of $FeSO_4.xH_2O$ $\quad$ = 6.75 ÷ ans** $\quad$ = 273.10 (g) (ans***)	**(1)**		
	IGNORE SF except 1 SF up to this point			
	Correct molar mass with no working scores first 3 marks			
	Moles of water of crystallization = (ans*** − 151.9)/18 = 6.7333 = 6.7=7 **(1)**			
	If A_r(Fe) = 56, x = 6.7278			
	TE at each stage			
	Final answer = 7 with no working scores 0			

Question Number	Acceptable Answer	Reject	Mark
2(c)(i)	M_r ($FeSO_4.7H_2O$) = 277.9 uncertainty = 277.9 x 0.9/100 = ($\pm$)2.501 ALLOW M_r ($FeSO_4.7H_2O$) = 273 (from 3b(iv) is used (uncertainty = ($\pm$)2.458) OR M_r ($FeSO_4.7.1H_2O$) = 279.7 is used (uncertainty = ($\pm$)2.517) **(1)** ($\therefore$ answers = 277.9$\pm$2.5 are within experimental uncertainty) Using x = 7.1 gives M_r ($FeSO_4.7H_2O$) = 279.7 **and** this is within the uncertainty range **(1)** If neither mark is scored ALLOW Answer must be an integer so only needs to be in the range 6.6 to 7.4 for 1 mark IGNORE Calculations based on the percentage difference between 7.1 and 7		2

Question Number	Acceptable Answer	Reject	Mark
2(c)(ii)	The crystals were not dry OR Some of the iron(II) had been oxidized (to iron(III)) OR iron(II) / Fe^{2+} ions converted into iron(III) / Fe^{3+} ions IGNORE impurities / transfer errors / titration errors	Titration value too large	1

(Total for Question 2 = 21 marks)

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	SO_4^{2-} OR SO_4^{-2}	Sulfate HSO_4^-	1

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	(Dilute) hydrochloric (acid)/ HCl(aq) / nitric (acid) / HNO_3(aq) ALLOW HCl / HNO_3 Ignore concentrated/conc	Sulfuric acid H^+ / H_3O^+ Carboxylic acid Hydrogen chloride	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	Water and hydroxide can be in either order If name and formula are given, both must be correct Copper**(II)** hydroxide / $Cu(OH)_2$ / $Cu(H_2O)_4(OH)_2$ ALLOW $Cu(H_2O)_2(OH)_2$ IGNORE Copper hydroxide Square brackets in formula wherever they are	Any other numbers	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	Water and ammonia can be in either order If name and formula are given, both must be correct $[Cu(NH_3)_4]^{2+}$ OR $[Cu(H_2O)_2(NH_3)_4]^{2+}$ Charge must be included Outer brackets not required IGNORE order of ligands, but numbers must be correct	Any other numbers e.g. $[Cu(NH_3)_6]^{2+}$	1

Question Number	Acceptable Answers	Reject	Mark
3(c)	$Cu(H_2O)_6^{2+}$ OR $Cu(H_2O)_4^{2+}$ IGNORE Square brackets wherever they are	Cu^{2+} $Cu^{2+}(aq)$	1

Question Number	Acceptable Answers	Reject	Mark
3(d)	$CuSO_4$ / $Cu^{2+}SO_4^{2-}$ If charges given both must be given correctly	$CuSO_4.5H_2O$	1

Question Number	Acceptable Answers	Reject	Mark
3(e)	Mark independently **First mark** The (3)d sub-shell(s) / (3)d-orbital(s) cannot be split OR No d-d splitting OR No d-d transitions (1) **Second mark** No colour as no ligands present ALLOW No water (of crystallization) present OR Not hydrated / Anhydrous salt IGNORE Use of copper rather than copper ions (1) Reverse arguments involving the addition of water acceptable		2

(Total for Question 3 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)	Sulfuric acid reacts very exothermically with water ALLOW The reaction with acid is exothermic OR (Sulfuric) acid will shoot out of container OR The reaction of water with (sulphuric) acid is vigorous/splashes OR Prevent splashing of acid	nitric acid Prevent splash alone	1

Question Number	Acceptable Answers	Reject	Mark
4(b)	(Pale/straw-coloured) yellow / brown / red-brown	Red/purple/blue/black/blue-black/orange	1

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	(Freshly prepared) starch (solution)		1

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	(If starch is added too early) starch iodine complex formed (doesn't re-dissolve) ALLOW Iodide for iodine ALLOW (Black) solid/precipitate / complex forms OR Insoluble compound forms		1

Question Number	Acceptable Answers	Reject	Mark
4(c)(iii)	From blue-black to colourless ALLOW From blue / black/ dark blue/ deep blue to colourless	...to clear	1

Question Number	Acceptable Answers	Reject	Mark
4(d)(i)	24.1(0) 23.8(0) 23.55 23.45 (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
4(d)(ii)	The third and fourth / 23.55 and 23.45 (cm^3) **and** They are concordant OR Within ±0.2/0.1 (cm^3) IGNORE Anomalous		1

Question Number	Acceptable Answers	Reject	Mark
4(d)(iii)	23.5(0) (cm^3) ALLOW TE including second titre value, mean = 23.6(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
4(d)(iv)	Correct answer 74.6% / 75% OR 74.9% (TE from 23.60 average titre) Ignore SF except 1SF With no working **(5)** Number of mol of thiosulfate $\qquad = \dfrac{23.50 \times 0.200}{1000}$ (1) $\qquad = 4.70 \times 10^{-3}/0.00470$ **Second mark** EITHER Number of mol of iodine $\qquad = \dfrac{4.70 \times 10^{-3}}{2}$ $\qquad = 2.35 \times 10^{-3}/0.00235$ **AND** Number of moles of copper ion $\qquad = 2 \times 2.35 \times 10^{-3}$ (1) $\quad = 4.70 \times 10^{-3}/0.00470$ in 10 cm^3 OR From equations amount of iodine is half amount of thiosulfate and amount of copper is twice amount of iodine, so amount of copper equals amount of thiosulfate for this mark Number of moles of copper in solid		5

| | $= \quad 10 \times 4.70 \times 10^{-3}$ (1)
 $= \quad 4.70 \times 10^{-2}/0.0470$

 Mass of copper in solid
      $= \quad 4.70 \times 10^{-2} \times 63.5$ (g)

                       (1)
      $= \quad 2.9845$

 Percentage copper
      $= \quad \underline{2.9845 \times 100}$
               4.00

      $= \quad 74.6125$
      $= 74.6\%$
                       (1)

 Using 23.60 by averaging titres 2, 3 and 4

 $4.72 \times 10^{-3}/0.00472$
                       (1)

 $2.36 \times 10^{-3}0.00236$

 AND

 $4.72 \times 10^{-3}/0.00470$ (1)

 $4.72 \times 10^{-2}/0.0470$ (1)

 2.9972 (1)

 74.9% (1)

 Answers greater than 100% max 3 | | |

Question Number	Acceptable Answers	Reject	Mark
4(d)(v)	**First Mark** Uncertainty in titre value: $\dfrac{2 \times 0.05}{23.55} \times 100 =$ $\qquad (\pm)0.42/0.425/0.4246\%$ (1) **Second Mark** Uncertainty in the mass measurement: $\dfrac{2 \times 0.005 \times 100}{4.0} = (\pm)0.25\%$ **OR** $\dfrac{1 \times 0.005 \times 100}{4.0} = (\pm)0.125\%$ so it would / would not be worth using a 3 dp balance $\qquad$ (1) Ignore SF including 1 SF		2

(Total for Question 4 = 15 marks)