

1

A peptide is hydrolysed to form a solution containing a mixture of amino acids. This mixture is then analysed by silica gel thin-layer chromatography (TLC) using a toxic solvent. The individual amino acids are identified from their R_f values.

Part of the practical procedure is given below.

1. **Wearing plastic gloves to hold a TLC plate**, draw a pencil line 1.5 cm from the bottom of the plate.
2. Use a capillary tube to apply a very small drop of the solution of amino acids to the mid-point of the pencil line.
3. Allow the spot to dry completely.
4. In the developing tank, add the developing solvent to **a depth of not more than 1 cm**.
5. Place your TLC plate in the developing tank.
6. Allow the developing solvent to rise up the plate **to the top**.
7. Remove the plate and quickly mark the position of the solvent front with a pencil.
8. Allow the plate to dry **in a fume cupboard**.

(a) Parts of the procedure are in bold text.

For each of these parts, consider whether it is essential and justify your answer.

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(b) Outline the steps needed to locate the positions of the amino acids on the TLC plate and to determine their R_f values.

.....
.....
.....
.....
.....
.....
.....
.....
.....

(4)

(c) Explain why different amino acids have different R_f values.

.....
.....
.....
.....
.....

(2)

(Total 10 marks)

2

(a) A co-ordinate bond is formed when a transition metal ion reacts with a ligand.
Explain how this co-ordinate bond is formed.

.....
.....
.....
.....
.....

(2)

- (b) Describe what you would observe when dilute aqueous ammonia is added dropwise, to excess, to an aqueous solution containing copper(II) ions.

Write equations for the reactions that occur.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)

- (c) When the complex ion $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ reacts with 1,2-diaminoethane, the ammonia molecules but not the water molecules are replaced.

Write an equation for this reaction.

.....

(1)

- (d) Suggest why the enthalpy change for the reaction in part (c) is approximately zero.

.....

.....

.....

.....

.....

(2)

- (e) Explain why the reaction in part (c) occurs despite having an enthalpy change that is approximately zero.

.....
.....
.....
.....
.....

(2)
(Total 11 marks)

3

- (a) When aqueous ammonia was added to an aqueous solution of cobalt(II) sulfate, a blue precipitate **M** was formed. Identify the cobalt-containing species present in aqueous cobalt(II) sulphate and in the precipitate **M**.

Cobalt-containing species

Precipitate M

(2)

- (b) Precipitate **M** dissolved when an excess of concentrated aqueous ammonia was added. The solution formed was pale brown due to the presence of the cobalt-containing species **P**. Identify **P**.

.....

(1)

- (c) On standing in air, the colour of the solution containing **P** slowly darkened as the cobalt-containing species **Q** was formed. State the type of reaction occurring when **P** changes into **Q** and identify the reactant responsible for this change.

Type of reaction

Reactant responsible

(2)

- (d) When potassium iodide was added to the solution containing **Q** and the mixture was acidified, a dark brown solution due to the presence of **R** was formed. On addition of starch solution the mixture turned blue-black.

Identify **R** and explain its formation.

Identity of R

Explanation

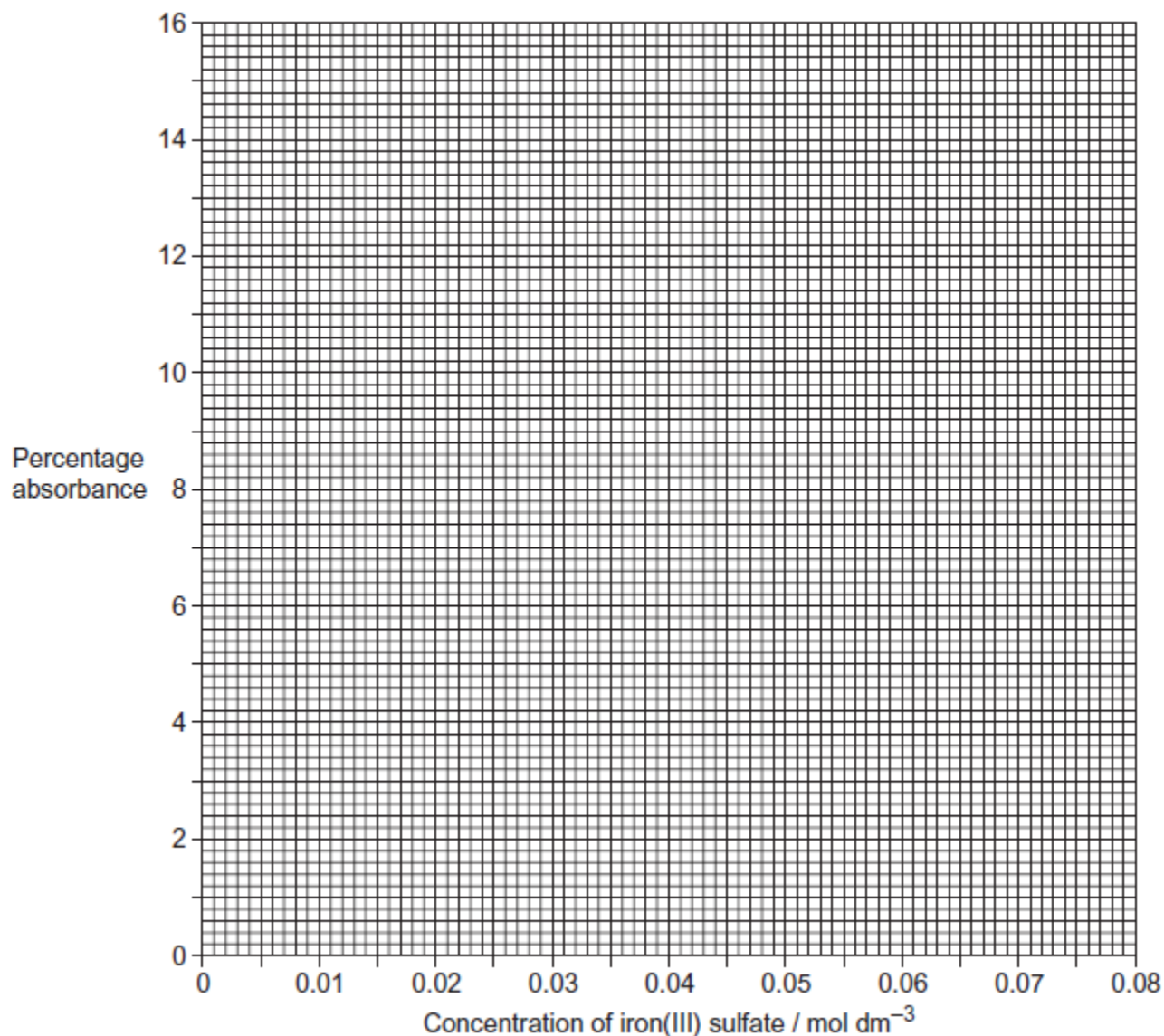
(2)
(Total 7 marks)

4

The concentration of iron(III) ions in a dilute solution can be determined by visible spectrometry. The absorption of light of a particular frequency by solutions of iron(III) sulfate of different concentrations was measured. The results are shown in the table below.

Percentage absorbance	Concentration of iron(III) sulfate / mol dm ⁻³
1.0	7.5×10^{-3}
2.5	14.0×10^{-3}
5.0	27.5×10^{-3}
7.0	37.5×10^{-3}
10.0	54.0×10^{-3}
12.0	65.0×10^{-3}

- (a) Use these results to plot a graph of percentage absorbance (y-axis) against concentration of iron(III) sulfate on the grid below. Draw a straight line of best fit.



(2)

- (b) Use your graph to determine the concentration of an iron(III) sulfate solution that has a percentage absorbance of 14.0%.

.....

(1)

(Total 3 marks)

5

A green solution, **X**, is thought to contain $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions.

- (a) The presence of these ions can be confirmed by reacting separate samples of solution **X** with aqueous ammonia and with aqueous sodium carbonate.

Write equations for each of these reactions and describe what you would observe.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

(4)

- (b) A 50.0 cm³ sample of solution **X** was added to 50 cm³ of dilute sulfuric acid and made up to 250 cm³ of solution in a volumetric flask.

A 25.0 cm³ sample of this solution from the volumetric flask was titrated with a 0.0205 mol dm⁻³ solution of KMnO₄

At the end point of the reaction, the volume of KMnO₄ solution added was 18.70 cm³.

- (i) State the colour change that occurs at the end point of this titration and give a reason for the colour change.

.....
.....
.....
.....

(2)

(ii) Write an equation for the reaction between iron(II) ions and manganate(VII) ions.

Use this equation and the information given to calculate the concentration of iron(II) ions in the original solution **X**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

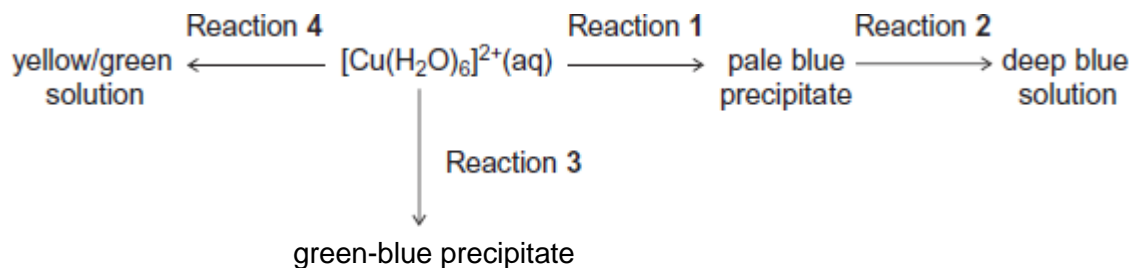
.....

.....

(5)
(Total 11 marks)

6

Consider the following reaction scheme that starts from aqueous $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions.



For each of the reactions **1** to **4**, identify a suitable reagent, give the formula of the copper-containing species formed and write an equation for the reaction.

(a) Reaction **1**

Reagent

Copper-containing species

Equation

(3)

(b) Reaction 2

Reagent

Copper-containing species

Equation

(3)

(c) Reaction 3

Reagent

Copper-containing species

Equation

(3)

(d) Reaction 4

Reagent

Copper-containing species

Equation

(3)

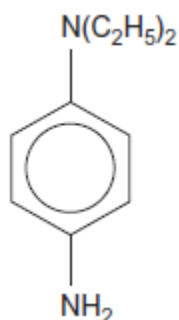
(Total 12 marks)

7

Chlorine can be found in water. One method for the determination of chlorine in water is to use colorimetry.

A colourless sample of water from a vase of flowers was analysed after the addition of compound Z as the addition of Z resulted in a purple solution.

Compound W



(a) Calculate the M_r of Compound W.

.....
.....
.....

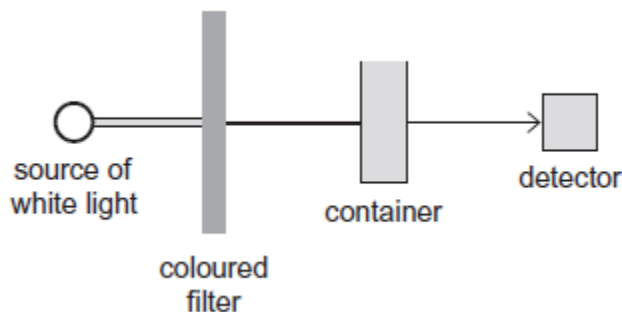
(1)

(b) Determine the percentage, by mass, of nitrogen in this compound.

.....
.....
.....

(1)

(c) A simplified diagram of a colorimeter is shown below.



(i) Suggest why it is important that the container for each sample has the same dimensions.

.....
.....

(1)

(ii) Suggest why the coloured filter is used.

.....
.....

(1)

(iii) Suggest **one** reason why a colorimetric method might be chosen in preference to titration.

.....

(1)

(Total 5 marks)

Mark schemes

1

(a) **Wear plastic gloves:**

Essential – to prevent contamination from the hands to the plate

1

Add developing solvent to a depth of not more than 1 cm³:

Essential – if the solvent is too deep it will dissolve the mixture from the plate

1

Allow the solvent to rise up the plate to the top:

Not essential – the R_f value can be calculated if the solvent front does not reach the top of the plate

1

Allow the plate to dry in a fume cupboard:

Essential – the solvent is toxic

Allow hazardous

1

(b) Spray with developing agent or use UV

1

Measure distances from initial pencil line to the spots (x)

1

Measure distance from initial pencil line to solvent front line (y)

1

R_f value = x / y

1

(c) Amino acids have different polarities

1

Therefore, have different retention on the stationary phase or different solubility in the developing solvent

1

[10]

2

(a) An electron pair on the ligand

1

Is donated from the ligand to the central metal ion

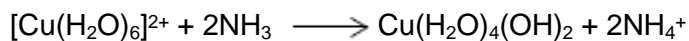
1

(b) Blue precipitate

1

Dissolves to give a dark blue solution

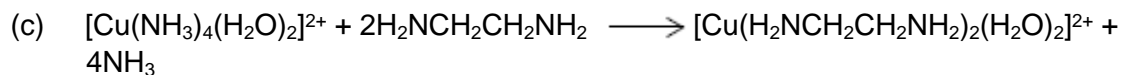
1



1



1



1

(d) Cu–N bonds formed have similar enthalpy / energy to Cu–N bonds broken

1

And the same number of bonds broken and made

1

(e) 3 particles form 5 particles / disorder increases because more particles are formed / entropy change is positive

1

Therefore, the free-energy change is negative

M2 can only be awarded if M1 is correct

1

[11]

3

(a) Species $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$

1

Precipitate $\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$

1

(b) $[\text{Co}(\text{NH}_3)_6]^{2+}$

1

(c) Reaction Oxidation

1

Reactant Oxygen in the air

1

(d) R Iodine

1

Explanation $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ oxidises I^- to I_2

1

[7]

4

(a) Plots all of the points correctly \pm one square

1

Straight line through the points is best fit

Candidate does not have to extrapolate line to the origin.

Line must pass through the origin ± 1 square.

Lose this mark if the candidate's line is doubled or kinked.

Allow line that doesn't pass through the origin if one or more points are misplotted.

1

(b) $7.6 \pm 0.1 \times 10^{-2}$ (mol dm⁻³)

Do not penalise precision, but at least 2 significant figures.

1

[3]

5

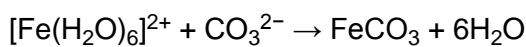
(a) $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow \text{Fe}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{NH}_4^+$

Allow equation with OH^- provided equation showing formation of OH^- from NH_3 given

1

Green precipitate

1



1

Green precipitate

effervescence incorrect so loses M4

1

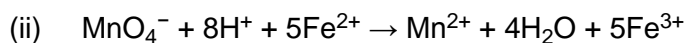
(b) (i) Colourless / (pale) green changes to pink / purple (solution)

Do not allow pale pink to purple

1

Just after the end-point MnO_4^- is in excess / present

1



1

Moles $\text{KMnO}_4 = 18.7 \times 0.0205 / 1000 = (3.8335 \times 10^{-4})$

Process mark

1

Moles $\text{Fe}^{2+} = 5 \times 3.8335 \times 10^{-4} = 1.91675 \times 10^{-3}$

Mark for M2 x 5

1

Moles Fe^{2+} in $250 \text{ cm}^3 = 10 \times 1.91675 \times 10^{-3} = 0.0191675$ moles in 50 cm^3

Process mark for moles of iron in titration (M3) x 10

1

Original conc $\text{Fe}^{2+} = 0.0191675 \times 1000 / 50 = 0.383 \text{ mol dm}^{-3}$

Answer for moles of iron (M4) x 1000 / 50

Answer must be to at least 2 sig. figs. (0.38)

1

[11]

6

(a) **Reaction 1**

General principles in marking this question

Square brackets are not essential

Penalise charges on individual ligands rather than on the whole complex

Reagent and species can be extracted from the equation

Ignore conditions such as dilute, concentrated, excess

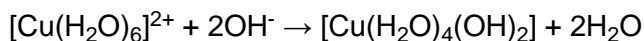
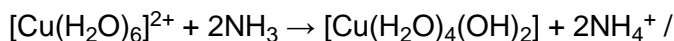
Reagent must be a compound NOT just an ion

Equations must start from $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ except in part (b)

Mark reagent, species and equation independently

ammonia (NH_3) (solution) / NaOH

1



Do not allow OH^- for reagent

Product 1, balanced equation 1

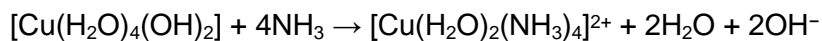
Allow either equation for ammonia

2

(b) **Reaction 2**

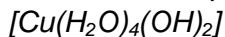
Ammonia (conc / xs)

1



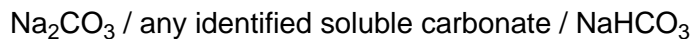
Product 1, balanced equation 1

Note that the equation must start from the hydroxide



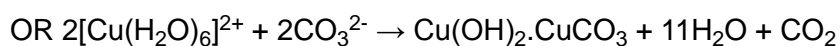
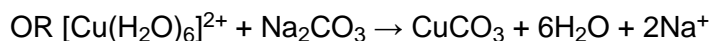
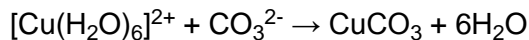
2

(c) **Reaction 3**

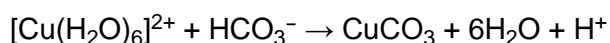


Do not allow NaCO₃ or any insoluble carbonate but mark on

1



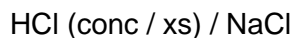
OR with NaHCO₃



Product 1, balanced equation 1

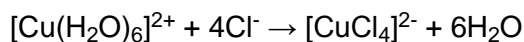
2

(d) **Reaction 4**



Allow any identified soluble chloride

1



Product 1, balanced equation 1

2

[12]

7

(a) 164.0

Must be 1 decimal place

1

(b) 17.1(%) (= 28.0 × 100 / Qa)

Consequential on their (a)

Ignore precision but must be to at least 2 sig fig.

(i.e. accept 17 or 17.07)

1

- (c) (i) Absorption depends on (proportional to) path length / distance travelled through solution
Do not allow size.
- (ii) To select the colour / frequency / wavelength that is (most strongly) absorbed (by the sample)
Allow the filter is chosen to complement the colour of the solution
- (iii) Quicker to analyse extracted samples than by titration / uses smaller volumes of solution

1

1

1

[5]