

New
Specification



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ADVANCED
General Certificate of Education
2018

Centre Number

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Candidate Number

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Chemistry

StemUp Model Solution

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet B (Theory)



[ACH32]

ACH32

WEDNESDAY 20 JUNE, MORNING

TIME

1 hour 15 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen.**

Answer **all six** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements (including some data) is provided.



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16ACH3202

1 Complete the table giving the observations and the name of the metal ion.

metal ion	colour of solution	addition of a few drops of dilute ammonia solution	addition of excess dilute ammonia solution
iron(II)	green	<i>green precipitate</i>	<i>green precipitate remains (insoluble)</i>
<i>cobalt(II)</i>	pink	blue precipitate	<i>dissolves to form a yellow solution (brown on standing)</i>
nickel(II)	<i>green</i>	green precipitate	<i>dissolves to form a blue solution</i>

[6]

[Turn over



- 2 Two-way paper chromatography can be used to separate a mixture of amino acids. The R_f values of the amino acids, in two different solvents, are shown in the table below.

amino acid	abbreviated name	R_f value	
		solvent 1	solvent 2
glycine	gly	0.26	0.20
leucine	leu	0.73	0.58
tyrosine	tyr	0.45	0.42

- (a) (i) Explain what is meant by the term **R_f value**.

Distance travelled by the spot (amino acid) from the origin

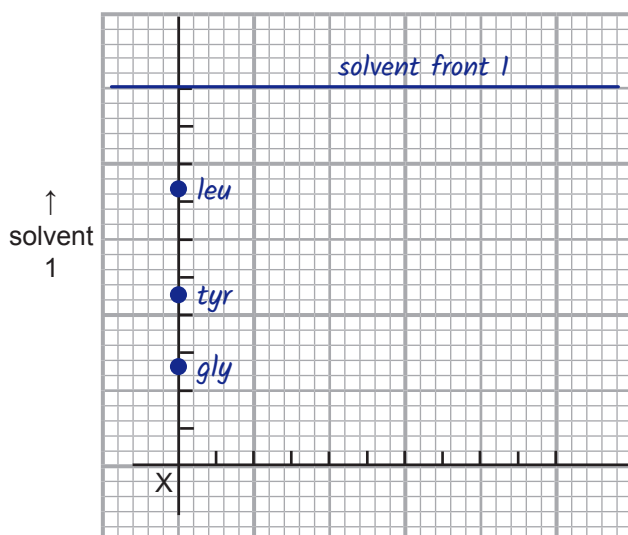
divided by the distance travelled by the solvent front.

[1]

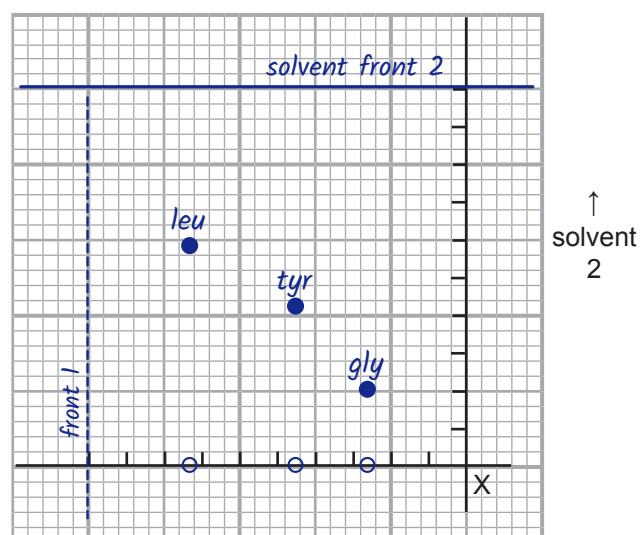
- (ii) On the chromatograms below mark:

the position of each solvent front at 5 cm, and
the position of each amino acid labelled with the abbreviated name for the 2-way chromatography of a mixture containing the three amino acids above.

Chromatogram 1



Chromatogram 2

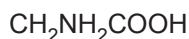


X is the origin

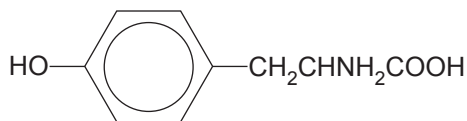
[3]



- (b) Amino acids can also be identified using infrared spectroscopy. The structures of glycine and tyrosine are shown below.



glycine



tyrosine

- (i) Using your data sheet identify the characteristic absorption ranges which will be seen on the infrared spectra of both glycine and tyrosine.

C-O 1000 to 1300 cm⁻¹; C=O 1650 to 1800 cm⁻¹ (acid)

O-H (acid) 2500 to 3200 cm⁻¹; N-H 3300 to 3500 cm⁻¹

C-H (alkyl) 2850 to 3000 cm⁻¹ [2]

- (ii) Using your data sheet identify the characteristic absorption range and the associated bond which will be seen on the infrared spectra of tyrosine but not glycine.

1450 to 1650 cm⁻¹, C=C in the arene (benzene ring) [1]

- (c) Amino acids react with nitrous acid and sodium carbonate.

- (i) Name the reagents and the conditions necessary to form nitrous acid.

Sodium nitrite and dilute hydrochloric acid,

kept below 10 °C (in an ice bath). [2]

- (ii) Describe what is observed when a solution of glycine is reacted separately with nitrous acid and with sodium carbonate solution.

Effervescence (bubbling, fizzing) is seen in both cases:

N₂ gas with nitrous acid and CO₂ gas with sodium carbonate. [1]

[Turn over



- 3 The formula of a metal hydroxide, $M(OH)_x$, can be determined using a thermometric titration. Different volumes of a solution of the metal nitrate and sodium hydroxide solution were mixed and the temperatures recorded. The following results were obtained.

volume of metal nitrate solution /cm ³	volume of sodium hydroxide solution /cm ³	initial temperature /°C	final temperature /°C	temperature rise /°C
20	80	18.6	21.1	2.5
30	70	18.3	22.2	3.9
40	60	18.8	24.0	5.2
60	40	19.0	25.0	6.0
70	30	18.2	22.9	4.7
80	20	19.0	22.8	3.8

- (a) Complete the table. [1]

- (b) The graph showing the temperature rise against the volume of the metal nitrate solution is shown opposite.

What is the temperature rise and the volume of metal nitrate solution at **X**?

Temperature rise: 6.8 °C

Volume of metal nitrate solution: 52.5 cm³

[1]

- (c) Point **X** is used to determine the formula of the metal hydroxide.

The concentration of the metal nitrate solution is 1.0 mol dm⁻³ and the concentration of sodium hydroxide is 3.25 mol dm⁻³.

Calculate the ratio of moles of the metal nitrate to sodium hydroxide at point **X** and use this to deduce the formula of the metal hydroxide, $M(OH)_x$.

Metal nitrate: $52.5 \times 1.0 \div 1000 = 0.0525 \text{ mol}$; NaOH: $47.5 \times 3.25 \div$

1000 = 0.154 mol

Ratio = 0.0525 : 0.154 = 1 : 3, so $M(OH)_3$

[3]

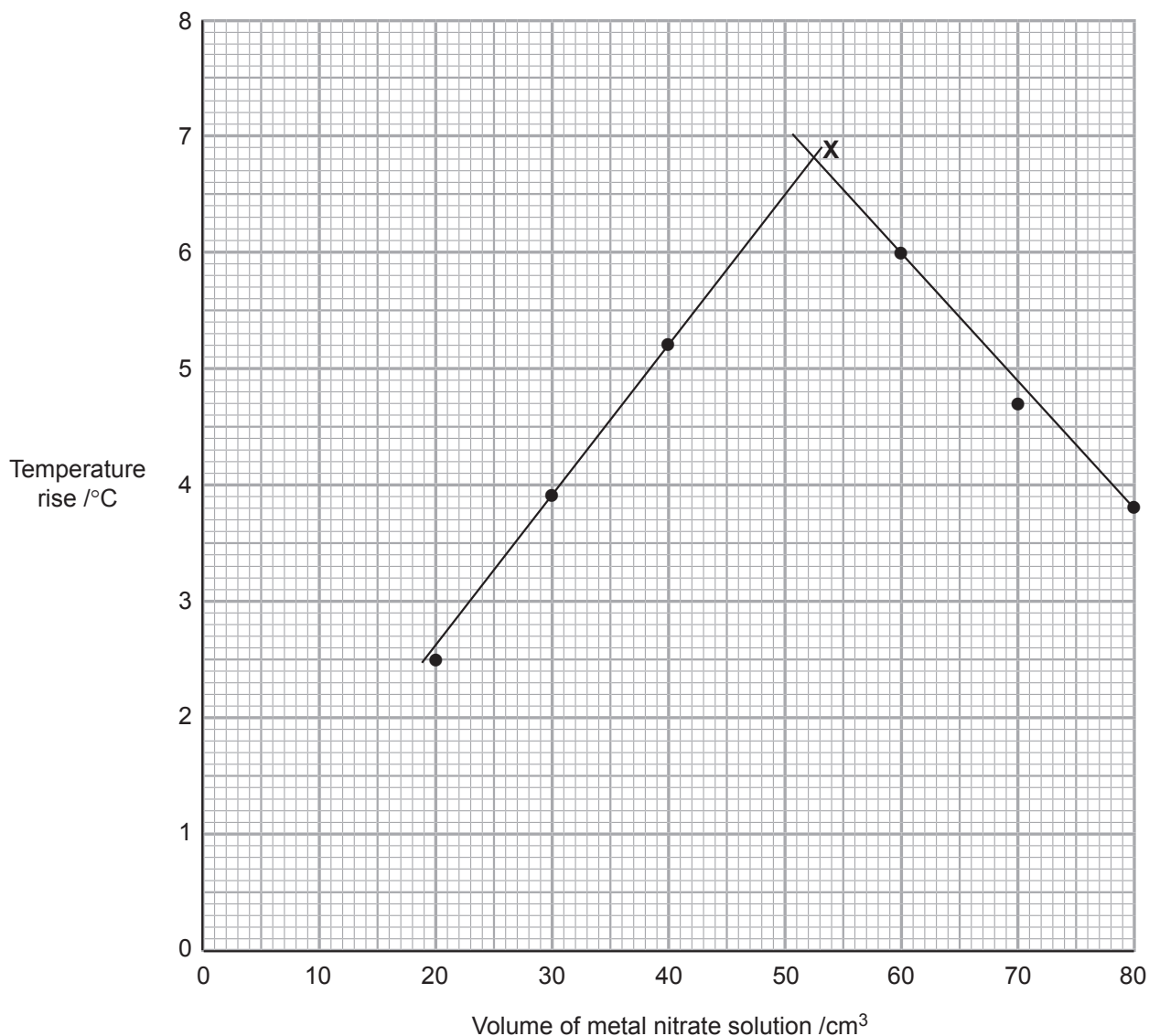


- (d) What differences would there be to the graph if 2.0 mol dm^{-3} sodium hydroxide solution had been used instead of the 3.25 mol dm^{-3} solution?

The temperature rise (maximum at X) would be smaller.

The peak X would be further to the left (at about 40 cm^3).

[2]



The two lines intersect at X

[Turn over]



4 Electrode potentials are measured using a standard hydrogen half-cell.

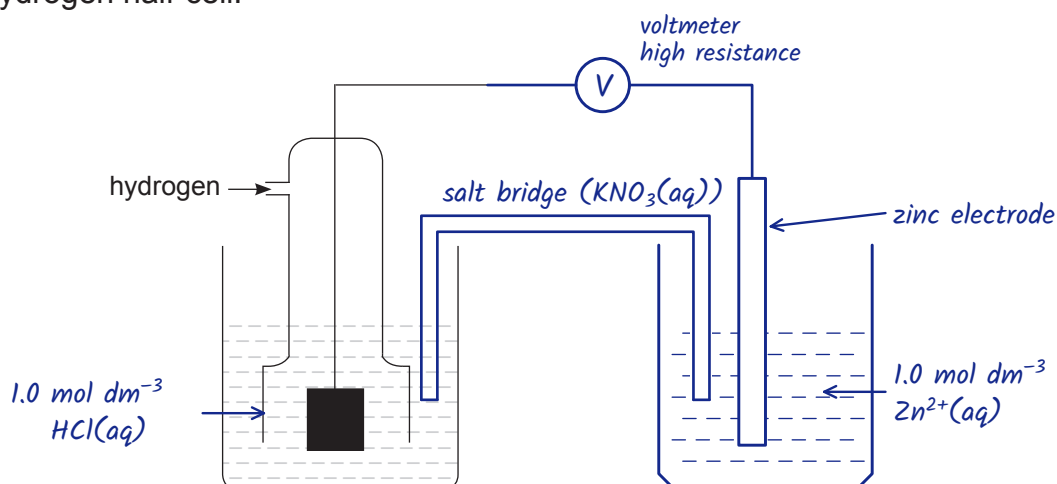
(a) State the conditions required for a standard hydrogen half-cell.

298 K (25 °C); hydrogen gas at 1 atm (100 kPa) pressure;

1.0 mol dm⁻³ H⁺(aq); platinum electrode.

[2]

(b) Complete and label the diagram below to show a cell in which the standard electrode potential of a zinc half-cell can be determined using a standard hydrogen half-cell.



[4]

(c) Ammonium metavanadate may be reduced using zinc.

(i) Describe how the reduction may be carried out in the laboratory.

Dissolve ammonium metavanadate in dilute sulfuric acid in a conical flask.

Add zinc granules, loosely stopper with cotton wool and swirl.

[2]



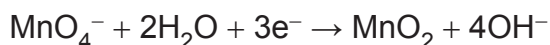
- (ii) Complete the table below giving the formula and colour of each of the four ions containing vanadium present during the reduction.

ion	colour
VO_2^+	yellow
VO^{2+}	blue
V^{3+}	green
V^{2+}	violet

[4]



- 5 Standard potassium manganate(VII) solution is reduced in the absence of acid to form an insoluble oxide.



- (a) (i) State the systematic name and suggest the colour of the MnO_2 formed.

Manganese(IV) oxide; brown/black solid [2]

- (ii) What mass of potassium manganate(VII), given to two significant figures, is required to make 250 cm^3 of $0.0050\text{ mol dm}^{-3}$ potassium manganate(VII) solution?

$$M_r(\text{KMnO}_4) = 158; \text{ moles} = 0.250 \times 0.0050 = 1.25 \times 10^{-3}$$

$$\text{Mass} = 1.25 \times 10^{-3} \times 158 = 0.1975 = 0.20\text{ g}$$
 [2]

- (b) Iron tablets used as a dietary supplement contain hydrated iron(II) sulfate, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$. The percentage of hydrated iron(II) sulfate in the tablets can be found by titration with acidified potassium manganate(VII).

Five iron tablets were weighed, dissolved in water and the solution made up to 250.0 cm^3 in a volumetric flask. 25.0 cm^3 aliquots of this solution were titrated against $0.0050\text{ mol dm}^{-3}$ acidified potassium manganate(VII) solution and the following results were obtained.

Mass of five iron tablets = 1.85 g

titration	initial burette reading $/\text{cm}^3$	final burette reading $/\text{cm}^3$
rough	0.0	15.2
1	15.2	29.8
2	29.8	44.6



- (i) What is the colour change at the end point?

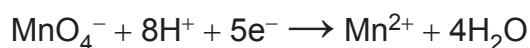
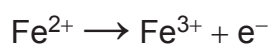
Colourless to (pale) pink [2]

- (ii) Calculate the average titre.

Titre 1 = 14.6 cm³, titre 2 = 14.8 cm³

Average titre = (14.6 + 14.8) ÷ 2 = 14.7 cm³ [1]

- (c) The half-equations for the reactions taking place are:



Write the overall ionic equation for the reaction.

$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$ [1]

- (d) Calculate the percentage mass, to two decimal places, of hydrated iron(II) sulfate in a tablet.

$\text{MnO}_4^{-} = 14.7 \times 0.0050 \div 1000 = 7.35 \times 10^{-5} \text{ mol}$

$\text{Fe}^{2+} \text{ in } 25.0 \text{ cm}^3 = 5 \times 7.35 \times 10^{-5} = 3.675 \times 10^{-4} \text{ mol}$

$\text{Fe}^{2+} \text{ in } 250.0 \text{ cm}^3 = 3.675 \times 10^{-3} \text{ mol}$

$\text{Mass of FeSO}_4 \cdot 7\text{H}_2\text{O} = 3.675 \times 10^{-3} \times 278 = 1.02 \text{ g}$

$\% = 1.02 \div 1.85 \times 100 = 55.14\% \text{ (same for one tablet)}$ [4]

[Turn over



- 6 The relative formula mass of a volatile dihalogenoalkane, Z, can be determined by the following method.

Two gas syringes are heated in an oven to 120°C. A small amount of propanone and Z were injected, separately, from hypodermic syringes, into each of the gas syringes. The following results were obtained:

Initial mass of propanone and hypodermic syringe = 17.26 g

Final mass of propanone and hypodermic syringe = 17.16 g

Volume of propanone in gas syringe = 51 cm³

Initial mass of Z and hypodermic syringe = 20.04 g

Final mass of Z and hypodermic syringe = 19.87 g

Volume of Z in gas syringe = 51 cm³

- (a) Suggest why the temperature and pressure of the oven are not required.

*Both vapours are at the same temperature and pressure, so these
affect both volumes equally and cancel out.*

[1]

- (b) (i) Calculate the mass of propanone and the mass of Z added to the gas syringes.

Propanone: *0.10 g*

Z: *0.17 g*

[1]

- (ii) Calculate the density of propanone and Z.

Propanone: *$0.10 \div 51 = 1.96 \times 10^{-3} \text{ g cm}^{-3}$*

Z: *$0.17 \div 51 = 3.33 \times 10^{-3} \text{ g cm}^{-3}$*

[2]

- (iii) The relative formula mass of propanone is 58. Calculate the relative formula mass of Z.

$$M_r(\text{Z}) \div 58 = 3.33 \times 10^{-3} \div 1.96 \times 10^{-3} = 1.699$$

$$M_r(\text{Z}) = 58 \times 1.699 = 98.5 \approx 99$$

[2]



(c) (i) What is meant by the term **dihalogenoalkane**?

An alkane in which two hydrogen atoms have been replaced by two halogen atoms.

[1]

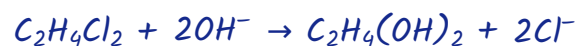
(ii) Use your answer to (b)(iii) to deduce the molecular formula of Z.



[1]

(d) (i) Explain how you could obtain the halide ion from the dihalogenoalkane.

Warm (reflux) the dihalogenoalkane with aqueous alkali, e.g. sodium hydroxide solution, which hydrolyses it:



[2]

(ii) Describe a chemical test to confirm the identity of the anion.

Add dilute nitric acid to neutralise the excess alkali.

Then add silver nitrate solution.

A white precipitate (AgCl) forms, which dissolves in dilute ammonia, so the anion is chloride.

[3]



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Question Number	Examiner Mark	Remark
1		
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