PMT

Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

1410U50-1E

Z22-1410U50-1E

FRIDAY, 20 MAY 2022 – MORNING

CHEMISTRY – A2 unit 5
Practical Methods and Analysis Task

1 hour

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**4**	
2.	**7**	
3.	**8**	
4.	**11**	
Total	**30**	

1410U501E 01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator, pencil and ruler;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid. You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 30.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

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Answer **all** questions.

1. Compound **W** is a simple inorganic salt containing one d-block metal cation and one anion.

Tests were carried out to identify compound **W**.

(a) Complete the table below. [3]

Test	Observation(s)	Inference
add compound **W** to water	....	Fe^{2+} or Cr^{3+} ions could be present
add aqueous sodium hydroxide dropwise to solution of compound **W**; then add excess sodium hydroxide	....	confirms Cr^{3+} ions present
add aqueous silver nitrate to solution of compound **W**	cream precipitate forms	....

(b) Write an **ionic** equation for the reaction between the solution of compound **W** and aqueous silver nitrate. Include state symbols. [1]

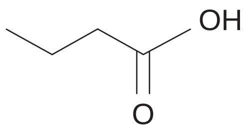
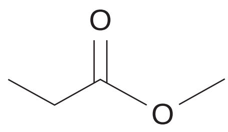
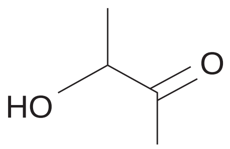
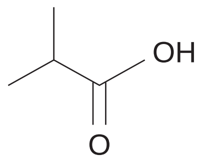
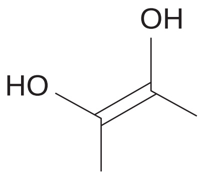
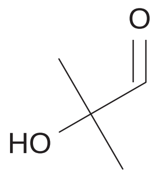
....

4

1410U501E 03

2. This question is about the chemistry of some of the many compounds which have the molecular formula $C_4H_8O_2$. They all have a relative molecular mass of 88.08.

The skeletal formulae of six compounds with this formula are shown below.

Compound **A**	Compound **B**
	
Compound **C**	Compound **D**
	
Compound **E**	Compound **F**
	

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(a) (i) State a chemical test that will give a positive result for compound **C** but **not** for compound **F**. Give the reagent(s) and observation(s). [1]

Reagent(s) ....

Observation(s) ....

(ii) State a chemical test that will give a positive result for compound **F** but **not** for compound **C**. Give the reagent(s) and observation(s). [1]

Reagent(s) ....

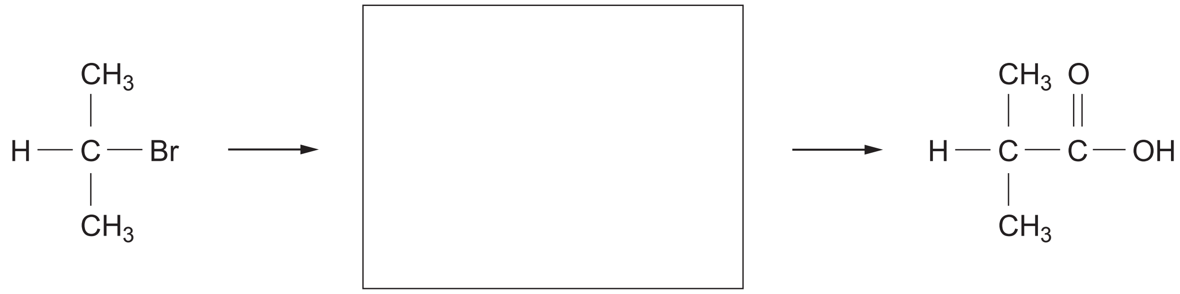
Observation(s) ....

(b) When 2.92 g of compound **E** reacted with an excess of bromine, 6.87 g of product was obtained. Calculate the percentage yield for this reaction. [2]

Percentage yield = ... %

(c) Compound **D** can be prepared from 2-bromopropane in a two-stage process.

Give the displayed formula of the product of the first stage. [1]



2-bromopropane | compound **D**

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(d) Compound **A** reacts with magnesium according to the following equation.

$$2CH_3CH_2CH_2COOH \quad + \quad Mg \longrightarrow (CH_3CH_2CH_2COO)_2Mg \quad + \quad H_2$$

Calculate the minimum length of magnesium ribbon needed to react completely with $10.0\,cm^3$ of a $0.825\,mol\,dm^{-3}$ solution of compound **A**. [2]

the mass per unit length of magnesium ribbon = $1.3 \times 10^{-2}\,g\,cm^{-1}$

Minimum length = ... cm

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3. A student was asked to determine the exact amount of iron in iron tablets purchased at a pharmacy. The label on the container stated that each tablet contains 14 mg of iron.

She put **five** of the tablets in approximately 100 cm^3 of deionised water, heating and stirring carefully until they had dissolved completely. After cooling, she transferred the solution to a volumetric flask and made the volume up to the 250 cm^3 mark with deionised water.

She then standardised a pre-prepared solution of potassium manganate(VII) by titrating against standard sodium ethanedioate solution. The concentration of the potassium manganate(VII) solution was found to be 0.00105 mol dm^{-3}.

Finally, 25.0 cm^3 portions of the iron tablet solution were titrated against the potassium manganate(VII) solution.

The results the student recorded are as follows.

	Rough	1	2
Initial burette reading / cm^3	0.15	24.30	0.30
Final burette reading / cm^3	23.30	47.00	23.10
Titre / cm^3	23.15	22.70	22.80
Mean titre / cm^3		22.75	

(a) State why the potassium manganate(VII) solution had to be standardised. [1]

....

....

(b) State why no indicator is required in this titration. [1]

....

....

(c) Suggest why the iron solution was made up using five tablets rather than just one tablet. Refer to the mean titre in your answer. [1]

....

....

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(d) (i) Combine the following half-equations to write the overall equation for the redox reaction between MnO_4^- and Fe^{2+}. [1]

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

(ii) Using the mean titre of potassium manganate(VII) and your equation from part (i), calculate the number of moles of iron present in 25.0 cm^3 of the solution and hence the number of moles present in one iron tablet. [2]

Number of moles of iron in one tablet = ... mol

(iii) Find the mass (in mg) of iron present in one iron tablet and use your knowledge of redox reactions to suggest an explanation for the difference between this value and that on the tablet container. [2]

Mass of iron in one tablet = ... mg

....

....

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4. Ethyl ethanoate undergoes hydrolysis to form ethanoic acid and ethanol.

$$CH_3COOCH_2CH_3(l) + H_2O(l) \rightleftharpoons CH_3COOH(l) + CH_3CH_2OH(l)$$

This hydrolysis reaction occurs spontaneously at room temperature, but in order to increase the rate at which equilibrium is attained, concentrated hydrochloric acid is added as a catalyst. The equilibrium position is not affected by the addition of the catalyst.

For this hydrolysis, the equilibrium constant, K_c, is given as

$$K_c = \frac{[CH_3COOH]\,[CH_3CH_2OH]}{[CH_3COOCH_2CH_3]\,[H_2O]}$$

In practice, it is difficult to determine the equilibrium concentration of all of these components. However, the ethanoic acid concentration is easily determined by titration with standardised aqueous sodium hydroxide. The equilibrium concentration of the ethanoic acid in the mixture can then be used to calculate the equilibrium constant, K_c.

A student determined the equilibrium constant as follows.

Preparation of the equilibrium mixture

Using burettes, the following components were added to a flask. The flask was stoppered and the mixture allowed to reach equilibrium over one week. The solution was labelled as solution **X**.

	$CH_3COOCH_2CH_3$	H_2O	Concentrated HCl
Starting volume / cm^3	54.00	2.00*	4.00
Density of liquid / $g\,cm^{-3}$	0.901	1.00	1.18
Concentration / $mol\,dm^{-3}$			11.00
Total volume of solution = 60 cm^3			

* The volume of water shown here is the water added from the burette only. It does not include the water from the concentrated hydrochloric acid.

Determination of the equilibrium concentrations – titration

1. A volumetric pipette was used to transfer 10.0 cm^3 out of the 60 cm^3 of solution **X** into a conical flask and 3–4 drops of phenolphthalein indicator were added.
2. The contents of the conical flask were titrated against 1.96 $mol\,dm^{-3}$ NaOH(aq) from a burette.
3. The volume of NaOH(aq) needed to reach the first permanent colour change was recorded.
4. The titration was repeated to obtain concordant results.
5. The mean volume of NaOH(aq) needed was 15.10 cm^3.

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(a) (i) Use the titration data to calculate the **total** number of moles of acid present at equilibrium in solution **X**. [2]

Total number of moles of acid = ... mol

(ii) Calculate the number of moles of concentrated HCl added as a catalyst during the preparation of the equilibrium mixture. Hence calculate the number of moles of ethanoic acid present at equilibrium in solution **X**. [1]

Moles of ethanoic acid = ... mol

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(b) The initial number of moles of water present is dependent on both the water added from the burette and that present in the concentrated hydrochloric acid added as a catalyst during the preparation of the equilibrium mixture.

Calculate the mass of water present in $4.00\,cm^3$ of the concentrated hydrochloric acid and hence show that the total mass of water initially present in solution **X** was 5.114 g.

You **must** show your working. [3]

You will need to calculate the total mass of the HCl solution and the mass of HCl present.

You will need to use the relationship

$$\text{mass} = \text{volume} \times \text{density}$$

in this part-question and in (c)(i).

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(c) To calculate the equilibrium constant, K_c, for the hydrolysis of ethyl ethanoate, the number of moles of each component present at equilibrium in solution **X** must be known.

(i) Calculate the mass and number of moles of ethyl ethanoate added initially. [2]

	Initial composition of solution **X**			
	$CH_3COOCH_2CH_3$	H_2O	CH_3COOH	CH_3CH_2OH
Starting volume / cm^3	54.00	2.00*	0.00	0.00
Density of liquid / $g\,cm^{-3}$	0.901	1.00		
Initial mass of component / g	=	5.114		
Initial moles of component	=	0.284		

(ii) Use your answer to part (a)(ii) to complete the following table. [2]

	Equilibrium composition of solution **X**			
	$CH_3COOCH_2CH_3$	H_2O	CH_3COOH	CH_3CH_2OH
Moles of component at equilibrium	=	=	=	= ....

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(iii) Hence calculate the equilibrium constant, K_c, for the hydrolysis of ethyl ethanoate. [1]

You can use the number of moles of each component in place of the concentration in the K_c expression because the volume is the same throughout.

K_c = ...

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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