Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE A LEVEL

A410U30-1

S19-A410U30-1

WEDNESDAY, 19 JUNE 2019 – MORNING

CHEMISTRY – A level component 3
Chemistry in Practice

1 hour 15 minutes

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Question	**Maximum Mark**	**Mark Awarded**
1.	**5**	
2.	**15**	
3.	**17**	
4.	**6**	
5.	**17**	
Total	**60**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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

Answer **all** questions in the spaces provided.

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 60.

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

The assessment of the quality of extended response (QER) will take place in **Q.4**.

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.

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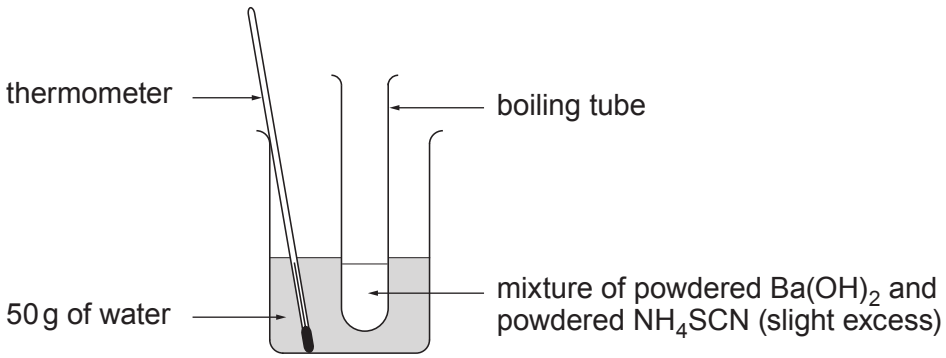
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Answer **all** *questions in the spaces provided.*

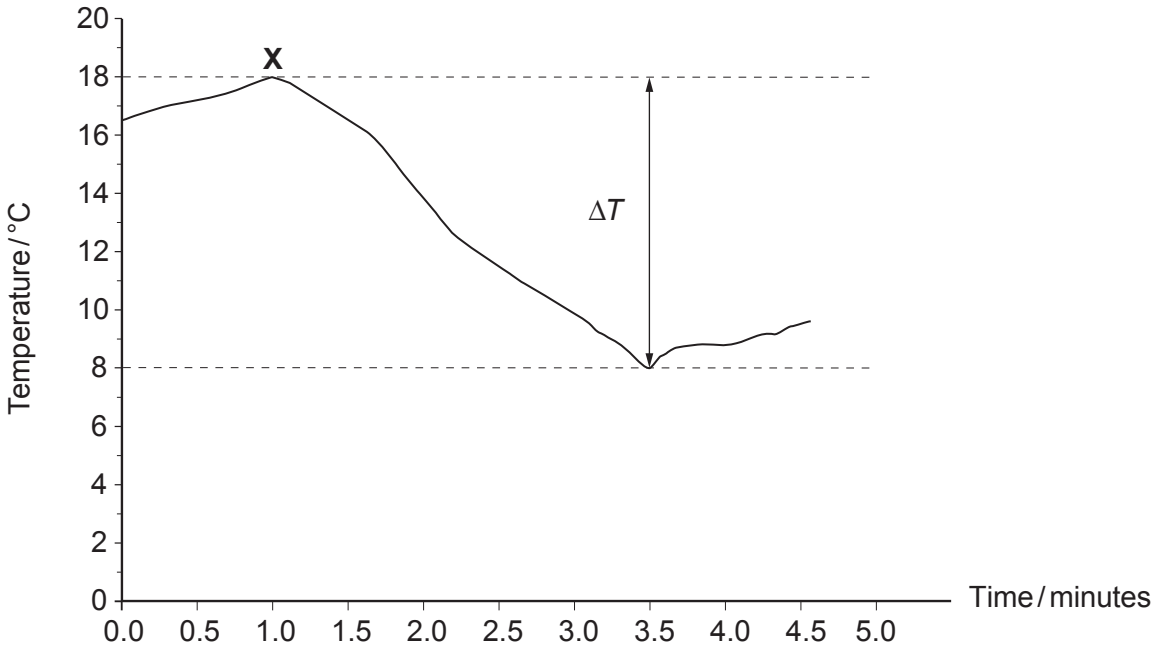
1. The reaction between solid barium hydroxide and solid ammonium thiocyanate is endothermic. The equation for the reaction is shown below.

$$Ba(OH)_2(s) + 2NH_4SCN(s) \longrightarrow 2NH_3(g) + 2H_2O(l) + Ba(SCN)_2(s)$$

A student carries out an experiment to determine the enthalpy change of reaction using the apparatus below.



The temperature / time curve shown below was plotted. A slight excess of ammonium thiocyanate was added to the barium hydroxide at point **X**.



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(a) The value of ΔT obtained was much lower than expected.

Briefly indicate **three** possible sources of error in the ΔT measurement from the information provided. [2]

Possible sources of error
1. *Glass beaker used / no insulation, so heat is gained from the surroundings.*
2. *Temperature of the water was not constant (it was rising) before mixing the solids.*
3. *No stirring of the reactants, so the reaction was incomplete.*

(b) The student measured a 10.0 °C temperature change on mixing both solids and used this value to calculate the enthalpy change of reaction as +10.5 kJ mol^{-1}.

Calculate the mass of powdered $Ba(OH)_2$ used in the experiment. [2]

$\Delta H = mc\Delta T \div n$, so $n = mc\Delta T \div \Delta H$

$n = (50 \times 4.18 \times 10.0) \div 10\,500$ J mol^{-1} = 0.199 mol

$M_r\ Ba(OH)_2 = 137.3 + 2(17.01) = 171.3$

$m = n \times M_r = 0.199 \times 171.3 = 34.1$ g

Mass = ... 34.1 ..... g

(c) Deduce the maximum temperature change if the experiment were repeated using 100 g of water rather than the 50 g used in the first experiment, with all other factors kept the same. Give a reason for your answer. [1]

5.0 °C, because the same amount of heat is absorbed by the reaction but it is spread through twice the volume (mass) of water.

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2. *(a)* The following pH values were measured during the titration of 25.0 cm^3 of aqueous ethanoic acid, of approximate concentration 0.1 mol dm^{-3}, with aqueous sodium hydroxide of concentration 0.0962 mol dm^{-3}.

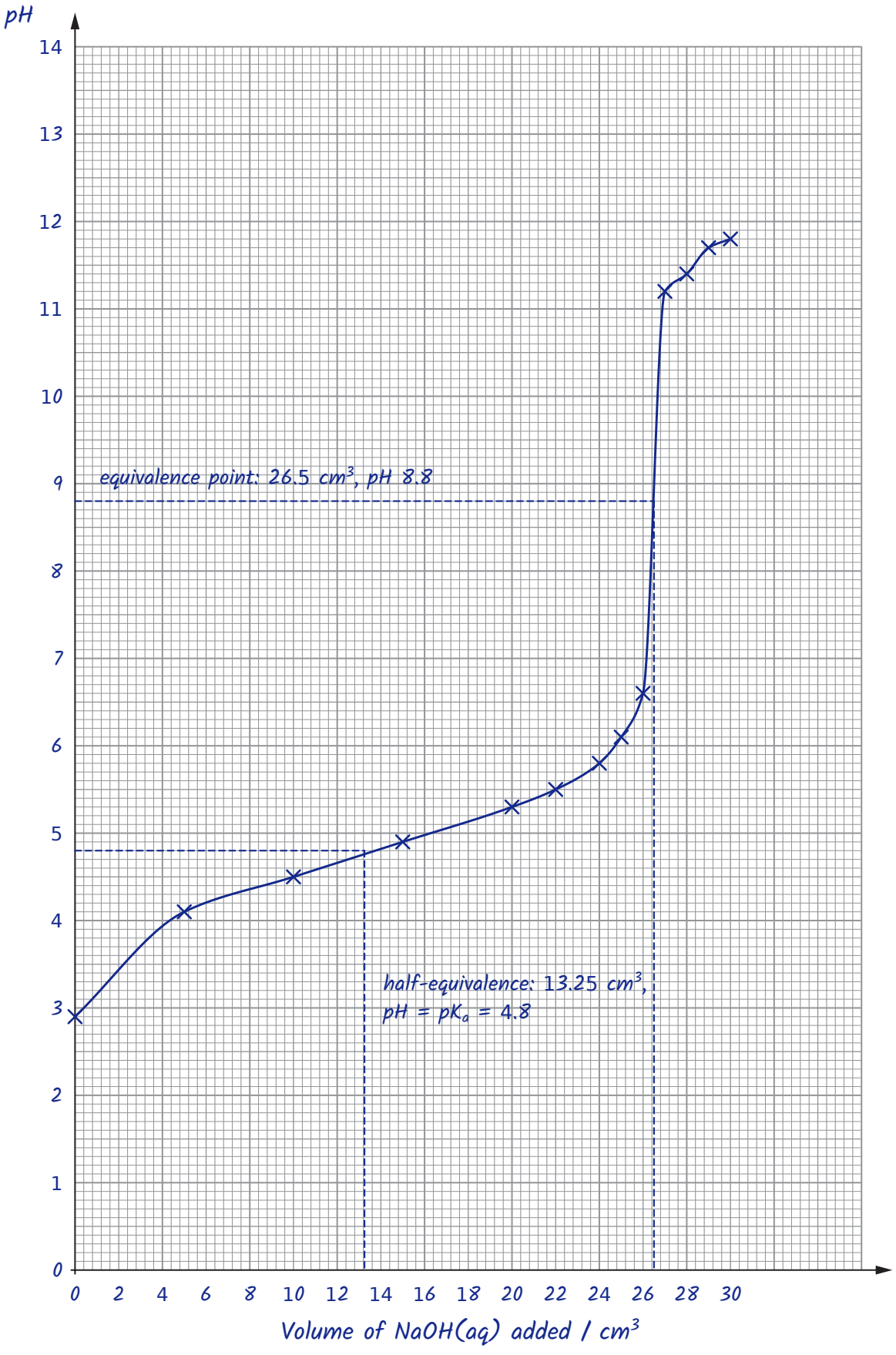
Volume of sodium hydroxide added / cm^3	pH
0.0	2.9
5.0	4.1
10.0	4.5
15.0	4.9
20.0	5.3
22.0	5.5
24.0	5.8
25.0	6.1
26.0	6.6
27.0	11.2
28.0	11.4
29.0	11.7
30.0	11.8

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(i) Plot the titration curve on the grid, clearly labelling the axes. [4]



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(ii) Use information from the titration curve in answering parts I-III.

I. Calculate the concentration, in mol dm^{-3}, of the aqueous ethanoic acid. [3]

Equivalence volume from the graph = 26.5 cm^3

$n(NaOH) = (26.5 \div 1000) \times 0.0962 = 0.00255$ mol

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ (1 : 1)

$n(CH_3COOH) = 0.00255$ mol in 25.0 cm^3

$[CH_3COOH] = 0.00255 \div 0.0250 = 0.102$ mol dm^{-3}

Concentration = 0.102 mol dm^{-3}

II. Determine the pH of the sodium ethanoate solution formed at the equivalence point. [1]

pH = 8.8

III. Calculate the acid dissociation constant, K_a, of the ethanoic acid. [2]

At the half-equivalence point (13.25 cm^3), $pH = pK_a = 4.8$

$K_a = 10^{-4.8} = 1.58 \times 10^{-5}$ mol dm^{-3}

K_a = 1.58×10^{-5} mol dm^{-3}

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(b) State the colour obtained if a few drops of the acid-base indicator methyl red are added to a sodium ethanoate solution. Give a reason for your answer. [1]

pH	Methyl red indicator colour
≤ 4.8	yellow
≥ 6.0	red

Red, because the pH at the equivalence point (sodium ethanoate solution) is 8.8, which is ≥ 6.0.

(c) Aqueous propanoic acid and sodium propanoate can form a buffer solution.

A student requires a buffer of pH 4.46 for an experiment. He adds solid sodium propanoate to 500 cm^3 of aqueous propanoic acid of concentration 0.210 $mol\,dm^{-3}$. Calculate the mass of sodium propanoate needed assuming no change in volume. [4]

(K_a for propanoic acid is 1.35×10^{-5} $mol\,dm^{-3}$)

$K_a = [H^+][X^-] \div [HX]$, so $[X^-] = K_a[HX] \div [H^+]$

$[H^+] = 10^{-4.46} = 3.47 \times 10^{-5}$ mol dm^{-3}

$[X^-] = (1.35 \times 10^{-5} \times 0.210) \div 3.47 \times 10^{-5} = 0.0817$ mol dm^{-3}

$n(CH_3CH_2COONa) = 0.0817 \times 0.500 = 0.0409$ mol in 500 cm^3

M_r $CH_3CH_2COONa = 96.1$

mass $= 0.0409 \times 96.1 = 3.93$ g

Mass = 3.93 g

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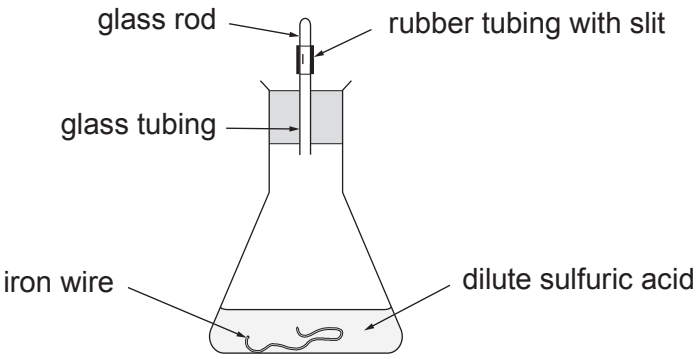
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3. A student carried out the following experiment to determine the percentage of iron in a wire.

Step 1 Preparation of a solution of iron(II) ions

2.78 g of the wire was placed in a conical flask. 100 cm^3 of dilute sulfuric acid (an excess) was added and the flask was warmed in order to maintain a steady reaction.

The diagram shows the apparatus used. The piece of rubber tubing with a slit in it lets hydrogen escape but stops any air entering the flask.



When all the iron had reacted the solution was transferred to a volumetric flask and made up to 500 cm^3 with deionised water.

(a) (i) Give the ionic equation for the reaction of iron with dilute acid. [1]

$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$

(ii) Describe a chemical test to show that the solution contains iron(II) ions. [3]

Reagent(s) aqueous sodium hydroxide, $NaOH(aq)$ / $OH^-(aq)$

Observation(s) green precipitate forms

Ionic equation $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

(b) Suggest why it was necessary to prevent any air from entering the flask. [1]

Air (oxygen) would oxidise the Fe^{2+} ions to Fe^{3+} ions, so this prevents the oxidation of Fe^{2+} to Fe^{3+}.

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Step 2 Titration of the iron(II) solution against a standard solution of potassium dichromate(VI)

Unlike manganate(VII), dichromate(VI) titrations require an indicator. One indicator that may be used is diphenylamine sulfonate. At the end-point, the indicator colour changes from green to violet on addition of one drop of the dichromate(VI) solution.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$

(c) (i) The student was asked to prepare a 0.0200 mol dm^{-3} standard solution of potassium dichromate(VI), $K_2Cr_2O_7$. Calculate the mass of potassium dichromate(VI) needed to prepare 250 cm^3 of this solution. [2]

$n(K_2Cr_2O_7) = 0.0200 \times 250 \div 1000 = 0.00500$ mol

$M_r\ K_2Cr_2O_7 = 2(39.1) + 2(52.0) + 7(16.0) = 294.2$

mass = $0.00500 \times 294.2 = 1.47$ g

Mass = 1.47 g

(ii) The student pipetted 25.0 cm^3 of the iron(II) solution into a conical flask. He added 25 cm^3 of dilute sulfuric acid and titrated against the 0.0200 mol dm^{-3} potassium dichromate(VI) solution.

Describe how the student should perform **one** titration to find the volume of potassium dichromate(VI) needed for complete reaction. You can assume that the dichromate(VI) solution is already in the burette. [4]

Record the initial burette reading of the dichromate(VI) solution.

Add 3 to 5 drops of diphenylamine sulfonate indicator to the flask.

Add dichromate(VI) from the burette, swirling, until the indicator starts to change colour; wash the flask sides down with distilled water.

Then add the dichromate(VI) drop by drop until the first permanent violet colour.

Record the final burette reading; the titre is the difference.

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(d) Four 25.0 cm^3 samples of the iron(II) solution were acidified and titrated against the dichromate(VI) solution. The mean volume of dichromate(VI) required for complete reaction was 19.85 cm^3.

(i) Why did the student carry out several titrations and then calculate a mean volume of potassium dichromate(VI) used? [1]

To identify any anomalous titres and obtain concordant results, so the mean titre is more accurate.

(ii) Write the equation for the reaction of iron(II) ions with dichromate(VI) ions in acid solution. [1]

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq)$

(iii) Calculate the percentage of iron in the wire. [3]

$n(Cr_2O_7^{2-}) = 0.0200 \times 19.85 \div 1000 = 3.97 \times 10^{-4}$ mol

$n(Fe^{2+}) = 6 \times 3.97 \times 10^{-4} = 2.38 \times 10^{-3}$ mol in 25.0 cm^3

$n(Fe^{2+}) = 2.38 \times 10^{-3} \times 20 = 0.0476$ mol in 500 cm^3

mass of Fe = $0.0476 \times 55.8 = 2.66$ g

percentage of Fe = $(2.66 \div 2.78) \times 100 = 95.7$ %

Percentage = 95.7 %

(iv) The balance used in weighing the wire has an uncertainty for each reading of ± 0.005 g. Estimate the maximum percentage error in weighing the wire. Show your working. [1]

two readings: $(2 \times 0.005 \div 2.78) \times 100 = 0.36$ %

Percentage error = 0.36 %

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4. A solid waste sample is known to contain only sodium carbonate, sodium nitrate and sodium sulfate.

Outline an experimental procedure to show that

- the sample contains sodium sulfate
- sodium sulfate makes up 25.7 % by mass of 4.55 g of the waste sample

Include relevant observations and equations for any reactions taking place and the gravimetric data that would be recorded in confirming the percentage by mass of sodium sulfate in the waste sample. [6 QER]

Test for sodium: dip a damp nichrome wire into the solid and hold it in a roaring Bunsen flame. A yellow (orange) flame shows Na^+ ions are present.

Weigh 4.55 g of the waste sample accurately, dissolve it in distilled water in a beaker. Add dilute hydrochloric acid (or dilute nitric acid) until no more fizzing is seen. The CO_3^{2-} ions react and are removed from solution as CO_2 gas: $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$. Nitrate ions do not interfere.

Test for sulfate: add barium chloride solution. A white precipitate of barium sulfate forms, showing SO_4^{2-} is present. Add an excess of $BaCl_2(aq)$ so that all the SO_4^{2-} is precipitated: $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$.

Filter off the solid $BaSO_4$ using weighed filter paper, wash it with distilled water to remove soluble impurities, then dry it in an oven and reweigh, repeating until constant mass.

Record: mass of sample (4.55 g), mass of filter paper, mass of filter paper + dry $BaSO_4$ (to constant mass), so mass of $BaSO_4$ by difference.

Expected: 25.7 % of 4.55 g = 1.17 g Na_2SO_4; $n = 1.17 \div 142.1 = 0.00823$ mol = $n(BaSO_4)$; mass of $BaSO_4 = 0.00823 \times 233.1 = 1.92$ g.

Obtaining 1.92 g of dry $BaSO_4$ confirms 25.7 % Na_2SO_4 by mass.

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5. You are given solutions of six organic compounds, labelled **A**-**F**, and the following reagents.

Reagent	Name
1	red litmus paper
2	I_2(aq) / NaOH(aq) or KI(aq) / NaClO(aq)
3	2,4-dinitrophenylhydrazine (2,4-DNPH)
4	dilute sodium hydroxide solution
5	sodium hydrogencarbonate solution

(a) Answer parts (i) and (ii) by completing the table opposite.

(i) Name compounds **D** and **F**. [2]

(ii) Give the results you would expect to observe on addition of reagents **2** and **3** to **each** of the compounds. Write 'NR' if there is no reaction.

Three of the compounds do not react with either of the reagents. [3]

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	Compound	Reagent: **2** Conditions: room temperature / gentle heat	Reagent: **3** Conditions: room temperature
A	$CH_3CH_2CH_2CH_2NH_2$ butylamine	*NR*	*NR*
B	$CH_3CH_2CH_2COOH$ butanoic acid	*NR*	*NR*
C	$CH_3CH_2CH_2CHO$ butanal	*NR*	*yellow-orange precipitate (solid)*
D	$CH_3CH_2CH_2CONH_2$ *butanamide*	*NR*	*NR*
E	$CH_3COCH_2CH_3$ butanone	*yellow precipitate (solid)*	*yellow-orange precipitate (solid)*
F	$CH_3CH(OH)CH_2CH_3$ *butan-2-ol*	*yellow precipitate (solid)*	*NR*

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(b) Explain the results observed for compound **F**. [1]

F has no carbonyl (C=O) group, so there is no reaction with 2,4-DNPH. With reagent 2 the $CH_3CH(OH)$ group is oxidised to a methyl carbonyl group (CH_3CO-), which then gives the yellow precipitate (CHI_3).

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(c) Devise a scheme of **three** further tests, using only reagents **1**, **4** and **5**, that would allow you to positively identify each of the **remaining** compounds.

(i) Complete the table below giving the reagent(s) and briefly describing each test. Give the observations made for each compound. Any test you suggest **must** lead to some observable result.

You do **not** need to include observations for compounds identified by a previous test. [4]

Compound	Reagent: 1	Reagent: 5	Reagent: 4 + 1
	Description of test: *Dip a piece of red litmus paper into each solution.*	Description of test: *Add a few drops of sodium hydrogencarbonate solution to each solution.*	Description of test: *Warm with dilute sodium hydroxide solution; hold damp red litmus paper above the tube.*
	Observations		
A	*red litmus paper turns blue*		
B	*NR*	*effervescence / fizzing*	
D	*NR*	*NR*	*red litmus paper turns blue (NH_3 gas evolved)*

(ii) Explain each of the positive results observed. [3]

A: the amine (NH_2) group is basic.

B: carboxylic acid group present; it reacts with $NaHCO_3$ giving CO_2.

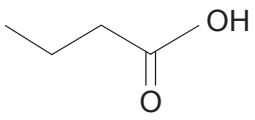
D: hydrolysis of the amide group releases ammonia (alkaline gas).

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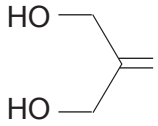
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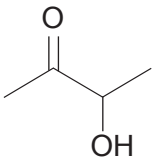
(d) $C_4H_8O_2$ has a number of different isomers, four of which are shown below.



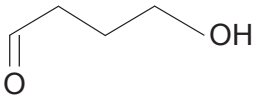
butanoic acid
compound **B**



2-methylenepropane-1,3-diol
compound **H**



3-hydroxybutanone
compound **I**



compound **J**

(i) Name compound **J**. [1]

4-hydroxybutanal

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Do not use any of the reagents used in parts (a)-(c) [shown below] in your answers to parts (ii)-(iv).

red litmus paper
I_2(aq) / NaOH(aq) or KI(aq) / NaClO(aq)
2,4-dinitrophenylhydrazine (2,4-DNPH)
dilute sodium hydroxide solution
sodium hydrogencarbonate solution

(ii) Give a chemical test which gives a positive result for compounds **H**, **I** and **J** but not for compound **B**. [1]

Reagent(s) *acidified potassium dichromate(VI) solution, warm*

Observation(s) *orange to green*

(iii) Give a chemical test which gives a positive result for compound **J** but not for compounds **B**, **H** and **I**. [1]

Reagent(s) *Tollens' reagent (ammoniacal silver nitrate), warm*

Observation(s) *silver mirror forms*

(iv) Give a chemical test which gives a positive result for compound **H** but not for compounds **B**, **I** and **J**. [1]

Reagent(s) *bromine water (bromine solution)*

Observation(s) *brown (orange) to colourless*

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