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

1 Determination of the kinetics of a redox reaction

Equation 1 represents the reaction between iodide ions and acidified hydrogen peroxide.

equation 1 $2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(s) + 2H_2O(l)$

If $[H^+]$ is kept constant, a simplified rate equation can be used.

$$\text{rate} = k'[I^-]^a[H_2O_2]^b \qquad \text{where } k' \text{ is } k[H^+]$$

When starch is added to the reaction mixture, a blue colour is immediately seen due to the formation of an iodine–starch complex.

If a small amount of sodium thiosulfate, $Na_2S_2O_3$, is also present in the reaction mixture, the formation of the blue colour is delayed. The $Na_2S_2O_3$ reacts with I_2 as shown in equation 2.

equation 2 $I_2(s) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

FA 1 is 0.100 mol dm^{-3} potassium iodide, KI.
FA 2 is 0.255 mol dm^{-3} hydrogen peroxide, H_2O_2.
FA 3 is 2.50×10^{-3} mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 4 is an aqueous mixture of ethanoic acid, CH_3CO_2H, and sodium ethanoate, CH_3CO_2Na.
Solution S is starch solution.

You will perform a series of three experiments. You will add a fixed amount of sodium thiosulfate, **FA 3**, to each of your experiments. You will add an amount of deionised water so that the total volume is 100 cm^3. The time taken for the blue colour to form allows the reaction rate to be determined.

(a) Fill Table 1.1 with the volume of deionised water needed in each experiment.

Table 1.1

experiment	**FA 1** / cm^3	**FA 2** / cm^3	**FA 3** / cm^3	**solution S** / cm^3	**FA 4** / cm^3	deionised water / cm^3	time, t / s
1	15.0	10.0	10.0	5.0	20.0	40.0	17.0
2	10.0	10.0	10.0	5.0	20.0	45.0	25.8
3	5.0	40.0	10.0	5.0	20.0	20.0	12.9

[4]

Experiment 1

The end-point of the reaction is the **first** appearance of a blue colour.

Note: Insufficient stirring of the reaction mixture may lead to a blue colour appearing before the true end-point is reached.

1. Use an appropriate measuring cylinder to transfer 15.0 cm^3 of **FA 1** into a 250 cm^3 beaker. Place the beaker on the white tile.

2. Using appropriate measuring cylinders, transfer to the beaker

   - 10.0 cm^3 of **FA 3**,
   - 5.0 cm^3 of **solution S**,
   - 20.0 cm^3 of **FA 4**.

3. Use a measuring cylinder to add the appropriate volume of deionised water recorded in Table 1.1.

4. Stir the contents of the beaker using a glass rod.

5. Use the measuring cylinder labelled **FA 2** to transfer 10.0 cm^3 of **FA 2** to the beaker. Start the stopwatch during this addition.

6. Mix the contents in the beaker by **thoroughly** stirring.

7. Stop the stopwatch when the solution **first** turns blue.

8. Record the time taken, *t*, to the nearest 0.1 s in Table 1.1.

9. Carefully wash out the beaker. Stand it upside down on a paper towel to drain.

Experiments 2 and 3

Repeat experiment 1 using the volumes of **FA 1**, **FA 2**, **FA 3**, **solution S**, **FA 4** and deionised water given in Table 1.1.

You should alternate the use of the two 250 cm^3 beakers.

Record all values of *t* in Table 1.1.

(b) Calculate the ratio of the time taken in experiment 2, $t_{expt\ 2}$, to the time taken in experiment 1, $t_{expt\ 1}$, using the expression shown.

Record your answer to one decimal place.

ratio 1 = $\frac{t_{expt\ 2}}{t_{expt\ 1}}$ = $\frac{25.8}{17.0}$ = 1.5 (1d.p.)

.....

Similarly, calculate and record the ratio of reaction time given below.

ratio 2 = $\frac{t_{expt\ 2}}{t_{expt\ 3}}$ = $\frac{25.8}{12.9}$ = 2.0 (1d.p.)

.....

[3]

(c) The simplified rate equation for the reaction shown in equation 1 is

$$\text{rate} = k'[I^-]^a[H_2O_2]^b$$

(i) Deduce the order, *a*, with respect to $[I^-]$. Explain your deduction in terms of your experimental results.

a = 1

explanation rate of reaction ($\propto \frac{1}{time\ taken}$), rate 1 = 0.0588, rate 2 = 0.0388

Comparing experiments 1 & 2, $[H_2O_2]$ and $[H^+]$ is kept constant.

when $[I^-] \times 1.5$, the rate of reaction also $\times$ 1.5.

Hence, we can deduce it is first order w.r.t. I^- [1]

(ii) Deduce the order, *b*, with respect to $[H_2O_2]$. Explain your deduction in terms of your experimental results.

b = 1

explanation Let rate = k'$[I^-]$ $[H_2O_2]^b$ and rate = (1/time taken)

comparing expt 2 & 3, $\frac{rate\ 3}{rate\ 2} = \frac{1/12.9}{1/25.8} = \frac{k' \times 5 \times (40)^b}{k' \times 10 \times (10)^b}$

$4 = \frac{(40)^b}{(10)^b}$

b = 1

Hence, complete the expression for the simplified rate equation.

rate = *k'* $[I^-]$ $[H_2O_2]$

[2]

(d) Suggest why $[H^+]$ remains constant in the experiments you performed.

The reaction mixture has a buffer solution containing CH_3COOH and its conjugate base CH_3COO^- (from FA4). When $[H^+]$ decreases, CH_3COOH dissociates to produce some H^+ to maintain the $[H^+]$ in the mixture. [1]

[Total: 11]

Note: The question is asking about **why** $[H^+]$ **remains** constant in ALL the experiments, implying that it is referring to the entire duration of each experiment. The question is NOT about why it is important to keep initial $[H^+]$ constant across the experiments.

2 Determination of the concentrations of two solutions by graphical analysis

Baryta water, $Ba(OH)_2(aq)$, is a strong base which neutralises both sulfuric acid and hydrochloric acid.

In this question, you will prepare four mixtures, each containing the same volume of baryta water but with different volumes of sulfuric acid added. In each mixture, the solution remains alkaline and is neutralised by titration with hydrochloric acid.

Graphical analysis of your results will enable you to determine the ratio of the acid concentrations. You will also determine the actual concentrations of the baryta water and the sulfuric acid.

Each titration is to be performed **once only**, so great care should be taken that you do not overshoot the end-points.

FA 5 is aqueous barium hydroxide (baryta water), $Ba(OH)_2$.
FA 6 is dilute sulfuric acid, H_2SO_4.
FA 7 is 0.150 mol dm^{-3} hydrochloric acid, HCl.
Solution T is thymolphthalein indicator.

You are also provided with **FA 5 (new)** in a stoppered container. **FA 5 (new)** is a sample of freshly prepared baryta water.

Prepare a table in the space provided on page 8 in which to record, to an appropriate level of precision:

- volume of **FA 6** added in each mixture, $V_{FA\,6}$,
- all burette readings,
- volume of **FA 7** added, $V_{FA\,7}$.

(a) Pour all the **FA 5 (new)** into a 100 cm^3 beaker. Leave the beaker to stand for use in **2(f)**.

(b) Experiment 1

Note: For all experiments, the containers of FA 5 and solution T should be capped when not in use.

1. Fill the burette labelled **FA 6** with **FA 6**.
2. Fill the other burette with **FA 7**.
3. Pipette 25.0 cm^3 of **FA 5** into a 250 cm^3 conical flask.
4. Add a few drops of **solution T** to the conical flask.
5. Add 5.50 cm^3 of **FA 6** from the burette into the conical flask.
6. Titrate the mixture in the conical flask with **FA 7**. The end-point for this titration is reached when the blue colour **just** disappears.
7. Record $V_{FA\,6}$, all burette readings and $V_{FA\,7}$, to an appropriate level of precision, in your table.

Experiment 2

In this experiment, a very small volume of **FA 7** will be required.

8. Repeat points 3 to 7 but, at point 5, add 21.00 cm^3 of **FA 6**.

Experiments 3 and 4

9. Select **two** other suitable volumes of **FA 6**. Your selected volumes must be **between** 5.50 cm^3 and 21.00 cm^3.

10. Repeat points 3 to 7 using your selected volumes of **FA 6** at point 5.

Results

Experiment	1	2	3	4
FA6 Final Burette Reading /cm^3	5.50	26.50	36.50	15.00
FA6 Initial Burette Reading /cm^3	0.00	5.50	26.50	0.00
Volume of FA6 used /cm^3	5.50	21.00	10.00	15.00
FA7 Final Burette Reading /cm^3	26.20	40.70	20.20	34.30
FA7 Initial Burette Reading /cm^3	0.00	35.00	0.00	21.00
Volume of FA7 used /cm^3	26.20	5.70	20.20	13.30

[3]

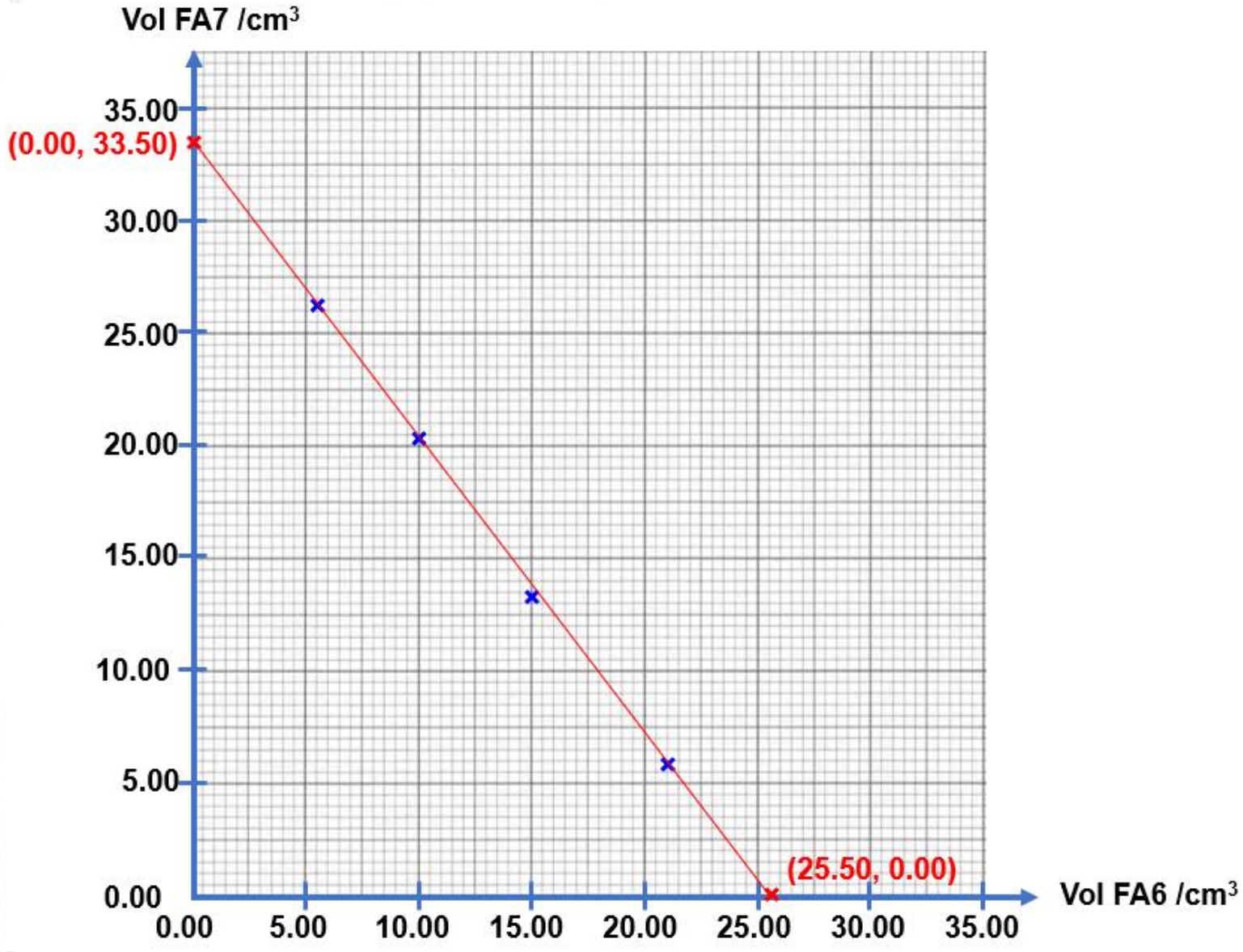
Note:
Labelling of headers with units
Readings recorded to 2 d.p. for burette readings

(c) (i) Plot a graph of $V_{FA\,7}$ on the *y*-axis against $V_{FA\,6}$ on the *x*-axis.

The scales for both axes must be chosen to provide an origin and to allow the graph line to be extrapolated (extended) to both axes.

Draw the best-fit straight line taking into account all of your plotted points.

Extrapolate (extend) your line until it touches **both** axes.



[3]

(ii) Calculate the gradient of the line to three significant figures, showing clearly how you did this.

Gradient = $\frac{33.50 - 0.00}{0.00 - 25.50} = -1.31$

Note: Can use any two points from the straight line to calculate gradient.

Must include -ve sign for the gradient

gradient = ... [2]

(iii) Use your answer from **2(c)(ii)** to deduce a value for the ratio of the concentration of hydrochloric acid in **FA 7** to the concentration of sulfuric acid in **FA 6**.

- Gradient is $\frac{\text{Vol FA7}}{\text{Vol FA6}}$, magnitude is 1.31

Total amount of H^+ from 33.50 cm^3 of HCl in FA7 = Total amount of H^+ from 25.50 cm^3 of H_2SO_4 in FA6

Note: 1 mol of H_2SO_4 produces 2 mol of H^+

[FA7] × Vol FA7 = [FA6] × Vol FA6 × 2

$\frac{[FA7]}{[FA6]} = \frac{\text{Vol FA6}}{\text{Vol FA7}} \times 2$

$= \frac{1}{1.31} \times 2 = 1.53$

$\frac{\textbf{[FA 7]}}{\textbf{[FA 6]}}$ = ... [1]

(d) **(i)** Read from your graph, and record, the volume of **FA 6**, $V_{FA\,6}$(max), required to exactly neutralise 25.0 cm^3 of **FA 5**.

$V_{FA\,6}$(max) = 25.50 cm^3 .....

Read from your graph, and record, the volume of **FA 7**, $V_{FA\,7}$(max), required to exactly neutralise 25.0 cm^3 of **FA 5**.

$V_{FA\,7}$(max) = 33.50 cm^3 .....

[2]

(ii) Calculate the concentration of barium hydroxide in **FA 5**.

25.0 cm^3 of FA5 requires 33.50 cm^3 of FA7 for complete neutralisation

$Ba(OH)_2 + 2\ HCl \longrightarrow BaCl_2 + 2H_2O$

Total amount of HCl used = $0.150 \times \frac{33.50}{1000} = 0.005025$ mol

Amount of $Ba(OH)_2$ = ½ × 0.005025 = 0.002513 mol

Concentration of $Ba(OH)_2 = \frac{0.002513}{25.0/1000} = 0.101$ mol dm^{-3}

concentration of barium hydroxide in **FA 5** = ... [2]

(iii) Using your answer in **2(c)(iii)** or otherwise, calculate the concentration of sulfuric acid in **FA 6**.

$\frac{[FA7]}{[FA6]} = 1.53$

$[FA6] = \frac{0.150}{1.53} = 0.0980$ mol dm^{-3}

Alternatively,

$Ba(OH)_2 + H_2SO_4 \longrightarrow BaSO_4 + 2H_2O$

25.0 cm^3 of 0.101 mol dm^{-3} $Ba(OH)_2$ reacts with 25.50 cm^3 of H_2SO_4

Amount of $Ba(OH)_2$ used = $0.101 \times \frac{25.0}{1000} = 0.002525$ mol = Amount H_2SO_4

Concentration of $H_2SO_4 = \frac{0.002525}{25.50/1000} = 0.0990$ mol dm^{-3}

concentration of sulfuric acid in **FA 6** = ... [4]

(e) Explain, in terms of the chemistry involved, the direction of the slope of your graph.

Total amount of H^+ required to neutralise $Ba(OH)_2$ = H^+ from FA6 + H^+ from FA7

As volume of FA6 used increases, greater amount of H^+ is contributed by FA6. Lesser amount of FA7 is required to complete the neutralisation and hence vol of FA7 required decreases. [1]

(f) **(i)** Record your observations of the solution of **FA 5 (new)** in the beaker prepared in **2(a)**.

White precipitate is formed in the colourless solution.

..... [1]

(ii) Write an equation, including state symbols, to explain your observation in **(f)(i)**.

$Ba(OH)_2\,(aq) + CO_2\,(g) \longrightarrow BaCO_3\,(s) + H_2O\,(l)$ **similar to reaction of $Ca(OH)_2$ with $CO_2(g)$**

..... [1]

(g) A student poured a 2 cm depth of **FA 5** into two test-tubes and left them open to the air for several days. The student carried out the following experiments and recorded the observations in Table 2.1.

Consider the observations in Table 2.1. There is no need to perform these experiments, the tests have been carried out for you and the observations recorded.

Table 2.1

test	observations
To the 2 cm depth of **FA 5** in a test-tube add **FA 7**, slowly with shaking, until no further change is seen.	Bubbles are seen, and the gas gives a positive test with limewater. The white precipitate dissolves.
To the 2 cm depth of **FA 5** in a test-tube add **FA 6**, slowly with shaking, until no further change is seen.	Bubbles are seen, and the gas gives a positive test with limewater. The white precipitate does not dissolve.

(i) Write **two** equations, including state symbols, that explain the student's observations recorded in Table 2.1.

Reaction with FA7: $BaCO_3(s) + 2HCl(aq) \longrightarrow BaCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction with FA6: $BaCO_3(s) + H_2SO_4(aq) \longrightarrow BaSO_4(s) + H_2O(l) + CO_2(g)$

[2]

(ii) A student performed **Experiment 1** in **2(b)** but left the open conical flask containing the **FA 5** to stand for some time before titrating with **FA 7**.

Suggest what effect, if any, leaving the flask to stand would have on the volume of **FA 7** required to neutralise the mixture. Explain your answer.

effect Volume of FA7 required would be the same.

explanation For every 1 mol of $Ba(OH)_2$ or $BaCO_3$, 2 mol of HCl is required for complete reaction. Even though some $Ba(OH)_2$ is converted to $BaCO_3$, the mixture would still require the same amount of HCl for reaction.

[1]

[Total: 23]

Note: Both $Ba(OH)_2$ and $BaCO_3$ are still in the conical flask to react with HCl

3 Organic Analysis

In this question you will deduce the identities of four organic compounds.

FA 8, **FA 9**, **FA 10** and **FA 11** have the molecular formulae shown.

FA 8	$C_2H_4O_2$
FA 9	C_3H_8O
FA 10	C_3H_6O
FA 11	C_3H_6O

(a) You are provided with aqueous samples of three of these compounds, **FA 8**, **FA 9** and **FA 10**.

You will perform some of the tests described in Table 3.1.

Using the observations in Table 3.1, and the given molecular formulae, you will then deduce the identities of **FA 8**, **FA 9**, **FA 10** and **FA 11**.

In addition to having access to the usual bench reagents, you are also provided with the following:

- magnesium turnings,
- iodine solution.

Perform the tests described in Table 3.1. Some of the observations have been completed for you. There is no need to carry out those tests. Record your observations in Table 3.1.

Test and identify any gases evolved. If there is no observable change, write **no observable change**.

Use a fresh sample of each solution in each test.

Table 3.1

	observations with **FA 8**, $C_2H_4O_2$	observations with **FA 9**, C_3H_8O	observations with **FA 10**, C_3H_6O	observations with **FA 11**, C_3H_6O
1. Add 1 cm depth of the **FA** solution to a test-tube. Add 5 cm depth of 2,4-dinitrophenylhydrazine solution to the test-tube.	no observable change	no observable change	yellow precipitate formed	yellow precipitate formed
2. Add about 1 cm depth of **FA 8** in a test-tube. Add, using the tip of a spatula, a small portion of magnesium turnings to this test-tube. **Repeat using FA 10 instead of FA 8.**	Effervescence of colourless, odourless gas that 'pop' with a lighted split. $H_2(g)$ evolved. Mg(s) dissolves	no observable change	No observable change	no observable change
3. Add about 1 cm depth of **FA 8** in a test-tube. To this test-tube add 8 drops of sodium hydroxide solution followed by iodine solution, dropwise, until a permanent orange/red colour is present. Warm the mixture in a beaker of hot water for two minutes.	After warming, the solution remains orange.	After warming, yellow ppt formed in brown solution.	After warming, yellow ppt formed in brown solution.	solution **FA 11** turns orange
Add sodium hydroxide solution using a teat pipette until no further change is seen. **Repeat using FA 9 and then using FA 10 instead of FA 8.**	Orange solution turns pale yellow	Brown solution turns pale yellow. Yellow ppt remains	Brown solution turns pale yellow. Yellow ppt remains	solution **FA 11** turns colourless
4. Add 1 cm depth of aqueous silver nitrate to a test-tube. Then slowly add 1 cm depth of aqueous sodium hydroxide. Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. You may use a clean glass rod to stir the mixture and help dissolve the precipitate. Add 1 cm depth of **FA 10** to this mixture, shake the tube and place it in the test-tube rack to stand.	no observable change	no observable change	Brown ppt on addition of NaOH(aq). Brown ppt dissolves in $NH_3(aq)$ to give colourless solution. Upon adding FA10, no silver mirror formed upon standing	silver mirror formed

[5]

(b) Complete Table 3.2 with the identities of **FA 8**, **FA 9**, **FA 10** and **FA 11**.

Give evidence from the observations in Table 3.1 to support your conclusions.

Table 3.2

	identity	evidence
FA 8	CH_3COOH	FA8 contains a −COOH functional group as it undergoes acid-metal reaction with Mg(s) to produce $H_2(g)$
FA 9	$CH_3CH(OH)CH_3$	FA9 contains a $-CH(OH)CH_3$ functional group as it undergoes oxidation reaction with alkaline I_2 to produce yellow ppt of CHI_3
FA 10	CH_3COCH_3	FA10 contains a ketone functional group as it undergoes condensation reaction with 2,4−DNPH to give a yellow ppt but no reaction with Tollens' reagent. FA10 also contains a $-COCH_3$ functional group as it undergoes oxidation reaction with alkaline I_2 to produce yellow ppt of CHI_3.
FA 11	CH_3CH_2CHO	FA11 contains an aldehyde functional group as it undergoes condensation reaction with 2,4−DNPH to give a yellow ppt and oxidation reaction with Tollens' reagent to give Ag(s).

[4]

[Total: 9]

4 Planning

Nitrobenzene, $C_6H_5NO_2$, is a yellow liquid at room temperature. Both nitrobenzene and benzene are almost insoluble in water.

Nitrobenzene is manufactured in large quantities by nitration of benzene. This reaction is highly exothermic.

A teacher prepared nitrobenzene as a class demonstration. The equation for this reaction is shown.

$$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$$

A nitrating mixture containing 8.0 cm^3 of concentrated nitric acid and 8.0 cm^3 of concentrated sulfuric acid was prepared.

A total of 8.0 cm^3 of benzene was then added to the mixture, with stirring, in four separate 2.0 cm^3 portions. The teacher ensured that the temperature of the mixture did not rise above 50 °C during this addition.

The temperature of the reaction mixture was then kept at 60 °C for 30 minutes.

The reaction mixture was then poured into 75 cm^3 of deionised water and thoroughly stirred. The upper water layer was poured away. The remaining oily layer was washed with 75 cm^3 of aqueous sodium carbonate, which was then poured away. The oily layer was then washed with a further 75 cm^3 of deionised water, which was also poured away.

The impure nitrobenzene was dried by adding anhydrous calcium chloride and leaving it for 20 minutes.

The nitrobenzene was then purified.

As with most organic reactions, the yield of this reaction is less than 100%. Using the procedure described, a yield of 70% can be expected.

Table 4.1 gives information about properties of benzene and nitrobenzene.

Table 4.1

chemical	M_r	density /g cm^{-3}	boiling point /°C	other properties
benzene	78	0.8765	80.1	flammable, toxic, carcinogenic
nitrobenzene	123	1.199	211	flammable, toxic, causes respiratory problems, eye irritant

(a) Calculate the mass of benzene needed to give an expected yield of **10.0 g** of nitrobenzene.

Amount of nitrobenzene in 10.0 g = $\frac{10.0}{123}$ = 0.08130 mol (70%)

Amount of nitrobenzene in 100% = $\frac{100}{70} \times 0.08130 = 0.1161$ mol

Amount of benzene required = 0.1161 mol

Mass of benzene required = 0.1161 × 78 = 9.06 g

mass of benzene = ... g [2]

(b) Plan a procedure for the preparation of **10.0 g** of pure and dry nitrobenzene starting from benzene.

You may assume that you are provided with:

- benzene, C_6H_6,
- concentrated nitric acid, HNO_3,
- concentrated sulfuric acid, H_2SO_4,
- the equipment normally found in a school or college laboratory.

In your plan you should include brief details of:

- an estimate of the quantities of the acids to be used to ensure a yield of **10.0 g** of nitrobenzene,
- the apparatus you would use,
- the procedure you would follow to obtain pure and dry nitrobenzene.

Volume of benzene required = $\frac{9.06}{0.8765}$ = 10.3 cm^3

1) Using separate 25.0 cm^3 measuring cylinders, a nitrating mixture containing 10.0 cm^3 of concentrated HNO_3 and 10.0 cm^3 of concentrated H_2SO_4 was prepared in **a round bottom flask submerged in a water bath, placed on an electronic hot plate/heating mantle.**

(Same vol ratio as benzene as shown in the example)

2) Using a 10.0 cm^3 measuring cylinders, a total of 10.0 cm^3 of benzene was added into the reaction mixture in the round bottom flask, with stirring, in four separate 2.5 cm^3 portions. During each of the addition, use a thermometer to monitor the temperature of the reaction mixture. When the temperature of the reaction mixture rises and approaches 50 °C, add some **ice water to the water bath** to cool down the mixture.

3) After the addition of benzene, **set the temperature of the electronic hot plate/heating mantle to 60 °C and leave the reaction mixture for 30 minutes.**

4) Using a 100 cm^3 measuring cylinder, measure and transfer 75 cm^3 of deionised water into a separatory funnel. Pour the reaction mixture into the separatory funnel, shake the mixture and allow it to settle into 2 distinct layers. Open the tap to collect the bottom oily organic layer in a 100 cm^3 beaker. (Nitrobenzene has higher density than water, hence lower layer)

5) Using another 100 cm^3 measuring cylinder, measure and transfer 75 cm^3 of $Na_2CO_3(aq)$ into another separatory funnel. Pour the oily organic liquid into the separatory funnel, shake the mixture and allow it to settle into 2 distinct layers. Open the tap to collect the bottom oily organic layer in a 100 cm^3 beaker. (Nitrobenzene has higher density than water, hence lower layer)

6) Repeat step 4 and collect the bottom organic layer in a 100 cm^3 beaker.

7) Add anhydrous calcium chloride into the organic liquid and leaving it for 20 minutes. (To dry the mixture)

8) Using a filter funnel with filter paper, filter the suspension and collect the filtrate in a round bottom flask.

9) Place the round bottom flask in an **oil bath** (water bath can only reach 100°C) with electronic hot plate/heating mantle, connect the round bottom flask to a simple distillation setup. Heat the organic liquid to 200-220 °C and collect the distillate at 209 - 213°C in a conical flask (± 2 °C from boiling point of 211 °C). Pure nitrobenzene is collected as the distillate.

[7]

(c) Explain why aqueous sodium carbonate is added during the washing process.

$Na_2CO_3(aq)$ is used to react with any remaining acid (HNO_3 and H_2SO_4) in the reaction mixture.

[1]

(d) Identify two **different** safety issues, relating to the properties of the reactants, in this procedure. In each case, explain the precaution you would take to minimise the issue.

safety issue 1 Benzene is flammable

precaution The reaction mixture should be maintained at 60 °C in a water bath using electronic hot plate/heating mantle. Do not use Bunsen burner.

safety issue 2 Benzene is toxic

precaution The reaction must be carried out inside the fume cupboard and gloves to be worn when conducting the experiment.

[2]

Concentrated acids are highly corrosive.

The reaction must be carried out inside the fume cupboard and gloves to be worn when conducting the experiment.

[Total: 12]