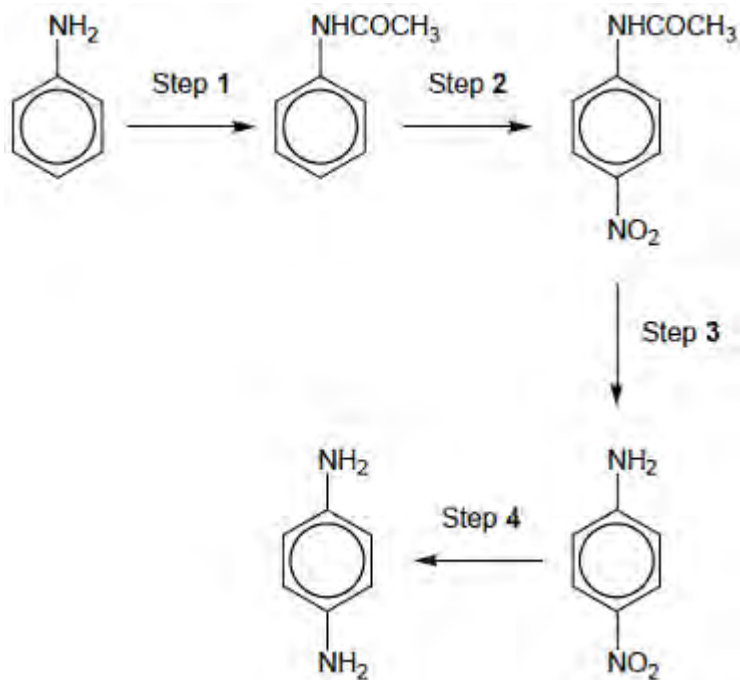


Q1. 1,4-diaminobenzene is an important intermediate in the production of polymers such as Kevlar and also of polyurethanes, used in making foam seating.

A possible synthesis of 1,4-diaminobenzene from phenylamine is shown in the following figure.



(a) A suitable reagent for step 1 is CH_3COCl

Name and draw a mechanism for the reaction in step 1.

Name of mechanism

Mechanism

(5)

(b) The product of step 1 was purified by recrystallisation as follows.

The crude product was dissolved in **the minimum quantity of hot water** and the hot solution was filtered through a hot filter funnel into a conical flask. This filtration removed any insoluble impurities. The flask was **left to cool to room temperature**. The crystals formed were filtered off using a Buchner funnel and a clean cork was used **to compress the crystals in the funnel. A little cold water was then poured through the crystals.**

After a few minutes, the crystals were removed from the funnel and weighed. A small sample was then used to find the melting point.

Give reasons for each of the following practical steps.

The minimum quantity of hot water was used

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The flask was cooled to room temperature before the crystals were filtered off

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The crystals were compressed in the funnel

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A little cold water was poured through the crystals

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(4)

- (c) The melting point of the sample in part (b) was found to be slightly lower than a data-book value.

Suggest the most likely impurity to have caused this low value and an improvement to the method so that a more accurate value for the melting point would be obtained.

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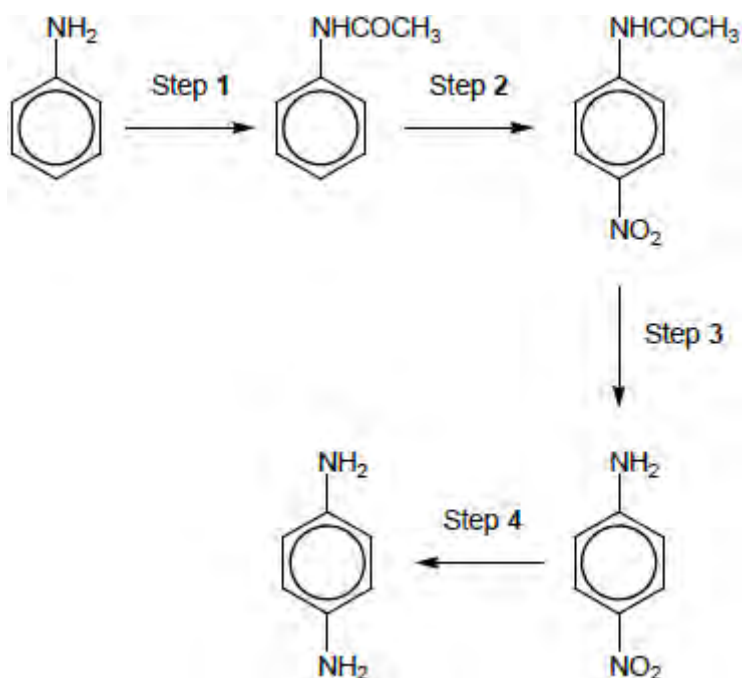
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(2)

The figure above is repeated here to help you answer the following questions.



- (d) In an experiment starting with 5.05 g of phenylamine, 4.82 g of purified product were obtained in step 1.

Calculate the percentage yield in this reaction.

Give your answer to the appropriate number of significant figures.

Percentage yield =%

(3)

- (e) A reagent for step 2 is a mixture of concentrated nitric acid and concentrated sulfuric acid, which react together to form a reactive intermediate.

Write an equation for the reaction of this intermediate in step 2.

.....

(1)

- (f) Name a mechanism for the reaction in step 2.

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(1)

- (g) Suggest the type of reaction occurring in step 3.

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(1)

- (h) Identify the reagents used in step 4.

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(1)

(Total 18 marks)

Q2. The alcohol 2-methylpropan-2-ol, $(\text{CH}_3)_3\text{COH}$, reacts to form esters that are used as flavourings by the food industry. The alcohol can be oxidised to produce carbon dioxide and water.

A student carried out an experiment on a pure sample of 2-methylpropan-2-ol to determine its enthalpy of combustion. A sample of the alcohol was placed into a spirit burner and positioned under a beaker containing 50 cm^3 of water. The spirit burner was ignited and allowed to burn for several minutes before it was extinguished.

The results for the experiment are shown in **Table 1**.

Table 1

Initial temperature of the water / $^{\circ}\text{C}$	18.1
Final temperature of the water / $^{\circ}\text{C}$	45.4
Initial mass of spirit burner and alcohol / g	208.80
Final mass of spirit burner and alcohol / g	208.58

- (a) Use the results from **Table 1** to calculate a value for the heat energy released from the combustion of this sample of 2-methylpropan-2-ol.
The specific heat capacity of water is $4.18 \text{ J K}^{-1} \text{ g}^{-1}$.
Show your working.

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(2)

- (b) Calculate the amount, in moles, of 2-methylpropan-2-ol burned in the experiment. Hence calculate a value, in kJ mol^{-1} , for the enthalpy of combustion of 2-methylpropan-2-ol.
Show your working.

(If you were unable to calculate an answer to part (a), you should assume that the heat energy released was 5580 J . This is **not** the correct value.)

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(3)

- (c) An equation for the combustion of 2-methylpropan-2-ol is



Table 2 contains some standard enthalpy of formation data.

Table 2

	$(\text{CH}_3)_3\text{COH}(\text{l})$	$\text{O}_2(\text{g})$	$\text{CO}_2(\text{g})$	$\text{H}_2\text{O}(\text{l})$
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-360	0	-393	-286

Use the data from **Table 2** to calculate a value for the standard enthalpy of combustion of 2-methylpropan-2-ol. Show your working.

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(3)

- (d) An accurate value for the enthalpy of combustion of 2-methylpropan-2-ol in which water is formed as a gas is $-2422 \text{ kJ mol}^{-1}$.

Use this value and your answer from part (b) to calculate the overall percentage error in the student's experimental value for the enthalpy of combustion of 2-methylpropan-2-ol.

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(1)

- (e) Suggest **one** improvement that would reduce errors due to heat loss in the student's experiment.

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(1)

- (f) Suggest **one** other source of error in the student's experiment. Do **not** include heat loss, apparatus error or student error.

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(1)

(Total 11 marks)

Q3. A student carried out an experiment to find the mass of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ in an impure sample, **X**. The student recorded the mass of **X**. This sample was dissolved in water and made up to 250 cm^3 of solution. The student found that, after an excess of acid had been added, 25.0 cm^3 of this solution reacted with 21.3 cm^3 of a $0.0150 \text{ mol dm}^{-3}$ solution of $\text{K}_2\text{Cr}_2\text{O}_7$.

- (a) Use this information to calculate a value for the mass of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ in the sample of **X**.

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(5)

- (b) The student found that the calculated mass of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ was greater than the actual mass of the sample that had been weighed out. The student realised that this could be due to the nature of the impurity.

Suggest **one** property of an impurity that would cause the calculated mass of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ in **X** to be greater than the actual mass of **X**.
Explain your answer.

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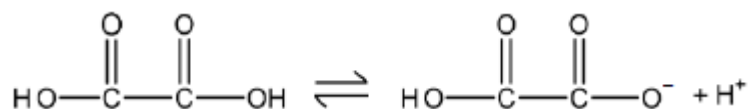
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(2)

(Total 7 marks)

Q4. Ethanedioic acid is a weak acid.

Ethanedioic acid acts, initially, as a monoprotic acid.



- (a) Use the concept of electronegativity to justify why the acid strengths of ethanedioic acid and ethanoic acid are different.

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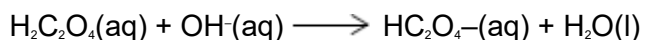
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(6)

- (b) A buffer solution is made by adding 6.00×10^{-2} mol of sodium hydroxide to a solution containing 1.00×10^{-1} mol of ethanedioic acid ($\text{H}_2\text{C}_2\text{O}_4$). Assume that the sodium hydroxide reacts as shown in the following equation and that in this buffer solution, the ethanedioic acid behaves as a monoprotic acid.



The dissociation constant K_a for ethanedioic acid is $5.89 \times 10^{-2} \text{ mol dm}^{-3}$.

Calculate a value for the pH of the buffer solution.

Give your answer to the appropriate number of significant figures.

pH =

(5)

- (c) In a titration, the end point was reached when 25.0 cm^3 of an acidified solution containing ethanedioic acid reacted with 20.20 cm^3 of $2.00 \times 10^{-2} \text{ mol dm}^{-3}$ potassium manganate(VII) solution.

Deduce an equation for the reaction that occurs and use it to calculate the original concentration of the ethanedioic acid solution.

Equation

Calculation

Original concentration = mol dm⁻³

(4)
(Total 15 marks)

Q5. Sodium phosphate and ammonia are formed when ammonium phosphate is heated with sodium hydroxide solution in a conical flask. There is **one** other product in this reaction.

- (a) Complete and balance the equation for the reaction of ammonium phosphate with sodium hydroxide.



(2)

- (b) Ammonia is an alkaline gas. Describe how you would use a named indicator to show that ammonia gas is released from the flask in this reaction. State the colour change that you would observe.

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(2)
(Total 4 marks)