

Q1. Esters are used as raw materials in the production of soaps and biodiesel.

(a) A student prepared an ester by two different methods.

Method 1 alcohol + acid anhydride

Method 2 alcohol + acyl chloride

(i) An ester was prepared using method 1, by reacting $(\text{CH}_3)_2\text{CHOH}$ with $(\text{CH}_3\text{CO})_2\text{O}$

Write an equation for this reaction and give the IUPAC name of the ester formed.

Equation

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IUPAC name of the ester

(2)

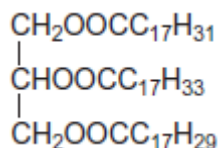
(ii) The same ester was prepared using method 2 by reacting $(\text{CH}_3)_2\text{CHOH}$ with CH_3COCl

Outline a mechanism for this reaction.

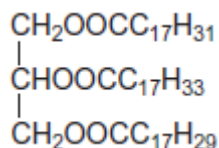
(4)

(b) The ester shown occurs in vegetable oils.

It can be hydrolysed to make soap and can also be used to produce biodiesel.



- (i) Write an equation for the reaction of this ester with sodium hydroxide to form soap.



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(2)

- (ii) Give the formula of the biodiesel molecule with the highest M_r that can be produced by reaction of this ester with methanol.

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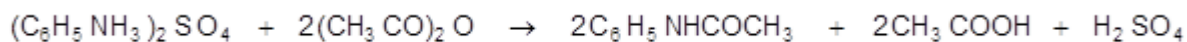
(1)

(Total 9 marks)

Q2. N-phenylethanamide is used as an inhibitor in hydrogen peroxide decomposition and also in the production of dyes.

N-phenylethanamide can be produced in a laboratory by the reaction between phenylammonium sulfate and an excess of ethanoic anhydride:

- (a) A student carried out this preparation using 1.15 g of phenylammonium sulfate ($M_r = 284.1$) and excess ethanoic anhydride.



- (i) Calculate the maximum theoretical yield of N-phenylethanamide that could be produced in the reaction. Record your answer to an appropriate precision.

Show your working.

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(3)

- (ii) In the preparation, the student produced 0.89 g of N-phenylethanamide.
Calculate the percentage yield for the reaction.

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(1)

- (b) The student purified the crude solid product, N-phenylethanamide, by recrystallisation.

- (i) Outline the method that the student should use for this recrystallisation.

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(4)

- (ii) Outline how you would carry out a simple laboratory process to show that the recrystallised product is a pure sample of N-phenylethanamide.

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(3)

(iii) Assume that the reaction goes to completion.

Suggest **two** practical reasons why the percentage yield for this reaction may **not** be 100%.

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2

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(2)

(c) The reaction to form N-phenylethanamide would happen much more quickly if the student used ethanoyl chloride instead of ethanoic anhydride.

Explain why the student might prefer to use ethanoic anhydride, even though it has a slower rate of reaction.

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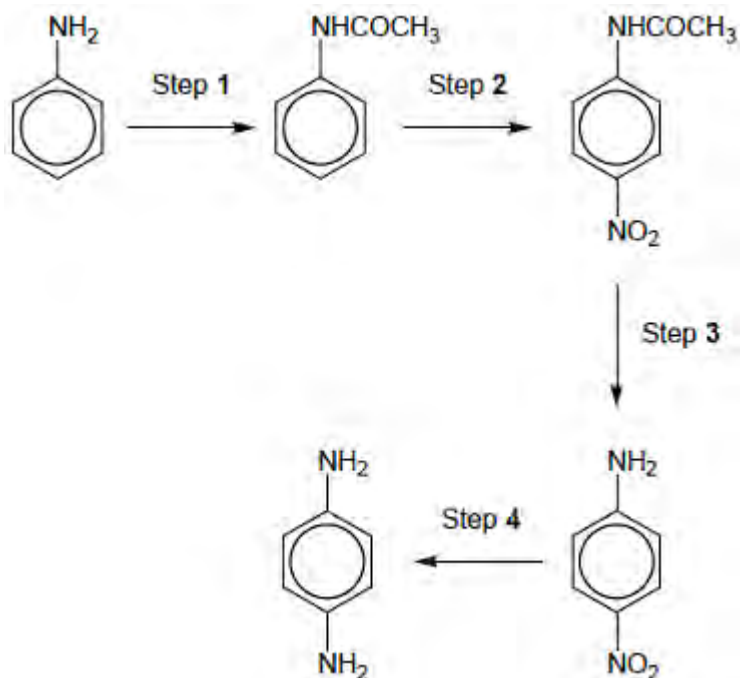
(2)

(Total 15 marks)

Q3. 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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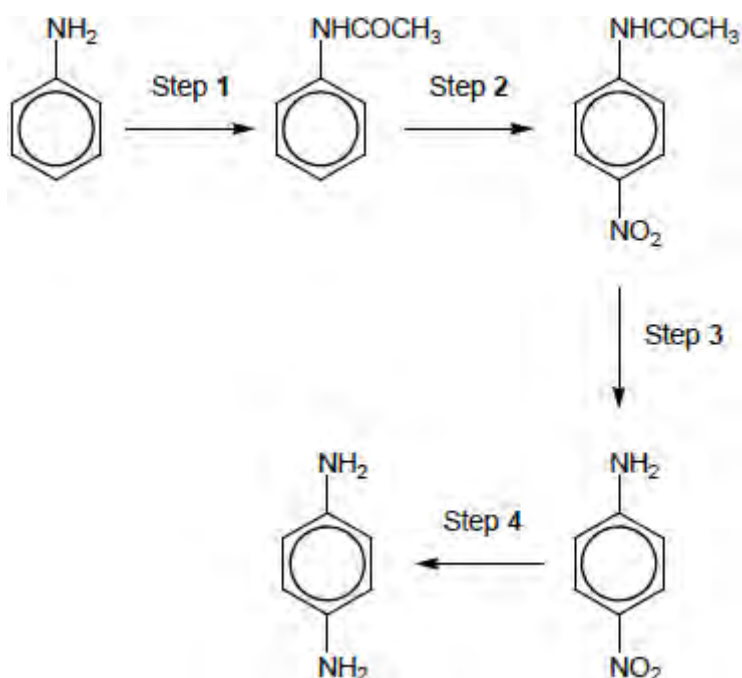
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(2)

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.

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(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)