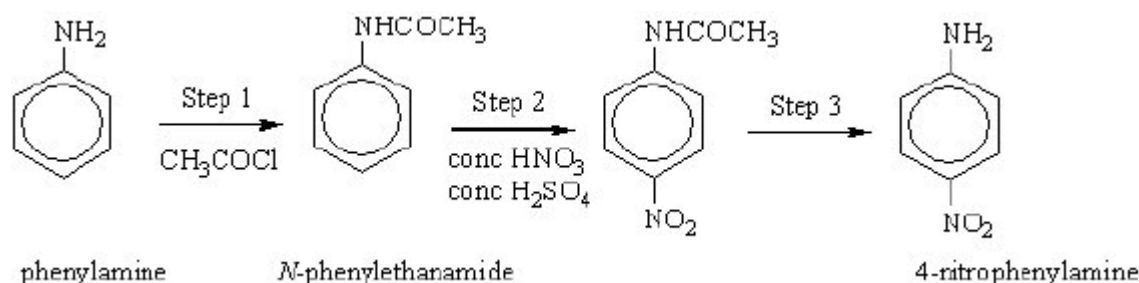


**Q1.** Synthetic dyes can be manufactured starting from compounds such as 4-nitrophenylamine.

A synthesis of 4-nitrophenylamine starting from phenylamine is shown below.



(a) An equation for formation of *N*-phenylethanamide in Step 1 of the synthesis is shown below.



(i) Calculate the % atom economy for the production of *N*-phenylethanamide ( $M_r = 135.0$ ).

(ii) In a process where 10.0 kg of phenylamine are used, the yield of *N*-phenylethanamide obtained is 5.38 kg.

Calculate the percentage yield of *N*-phenylethanamide.

(iii) Comment on your answers to parts (i) and (ii) with reference to the commercial viability of the process.

(7)

(b) Name and outline a mechanism for the reaction in Step 1.

(5)

(c) The mechanism of Step 2 involves attack by an electrophile. Write an equation showing the formation of the electrophile. Outline a mechanism for the reaction of this electrophile with benzene.

(4)

(Total 16 marks)

Q2. In which one of the following reactions is the role of the reagent stated correctly?

	Reaction	Role of reagent
A	$\text{TiO}_2 + 2\text{C} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4 + 2\text{CO}$	$\text{TiO}_2$ is an oxidising agent
B	$\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$	$\text{HNO}_3$ is a Brønsted-Lowry acid
C	$\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$	$\text{AlCl}_3$ is a Lewis base
D	$2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$	$\text{CO}$ is a reducing agent

(Total 1 mark)

Q3. In a reaction which gave a 27.0% yield, 5.00 g of methylbenzene were converted into the explosive 2,4,6-trinitromethylbenzene (TNT) ( $M_r = 227.0$ ). The mass of TNT formed was

- A 1.35 g
- B 3.33 g
- C 3.65 g
- D 12.34 g

(Total 1 mark)

Q4. (a) Name and outline a mechanism for the reaction between propanoyl chloride,  $\text{CH}_3\text{CH}_2\text{COCl}$ , and methylamine,  $\text{CH}_3\text{NH}_2$ . Draw the structure of the organic product.

(6)

(b) Benzene reacts with propanoyl chloride in the presence of aluminium chloride. Write equations to show the role of aluminium chloride as a catalyst in this reaction. Outline a mechanism for this reaction of benzene.

(5)

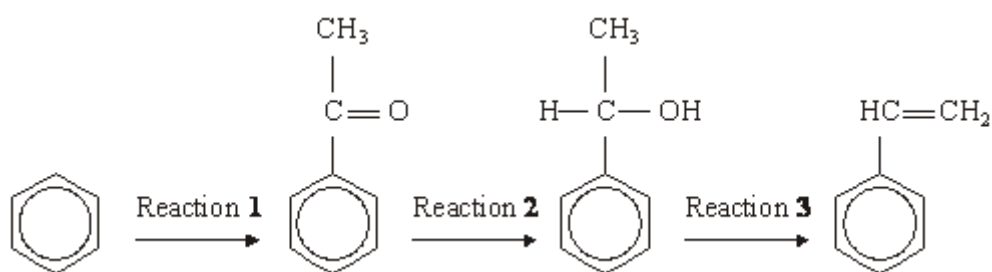
(c) Write an equation for the reaction of propanoyl chloride with water. An excess of water is added to 1.48 g of propanoyl chloride. Aqueous sodium hydroxide is then

added from a burette to the resulting solution.

Calculate the volume of  $0.42 \text{ mol dm}^{-3}$  aqueous sodium hydroxide needed to react exactly with the mixture formed.

(5)  
(Total 16 marks)

**Q5.** A possible synthesis of phenylethene (*styrene*) is outlined below.



- (a) In Reaction 1, ethanoyl chloride and aluminium chloride are used to form a reactive species which then reacts with benzene.

Write an equation to show the formation of the reactive species.

Name and outline the mechanism by which this reactive species reacts with benzene.

(6)

- (b)  $\text{NaBH}_4$  is a possible reagent for Reaction 2.

Name and outline the mechanism for the reaction with  $\text{NaBH}_4$  in Reaction 2.

Name the product of Reaction 2.

(6)

- (c) Name the type of reaction involved in Reaction 3 and give a reagent for the reaction.

(2)

(Total 14 marks)