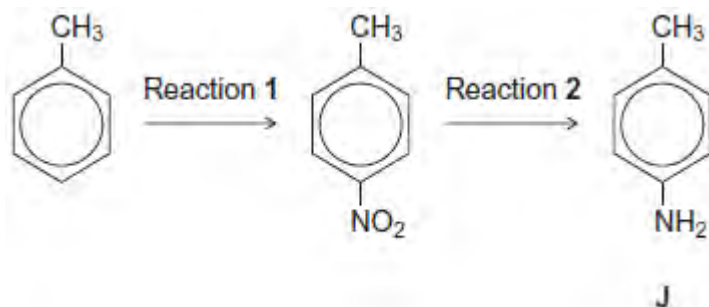


Q1. Consider the following reaction sequence starting from methylbenzene.



(a) Name the type of mechanism for reaction 1.

.....

(1)

(b) Compound **J** is formed by reduction in reaction 2.

(i) Give a reducing agent for this reaction.

.....

(1)

(ii) Write an equation for this reaction. Use [H] to represent the reducing agent.

.....

(1)

(iii) Give a use for **J**.

.....

(1)

(c) Outline a mechanism for the reaction of bromomethane with an excess of compound **J**.

You should represent **J** as RNH_2 in the mechanism.

(4)

(d) Compound **K** ($C_6H_5CH_2NH_2$) is a structural isomer of **J**.

Explain why **J** is a weaker base than **K**.

.....

.....

.....

.....

.....

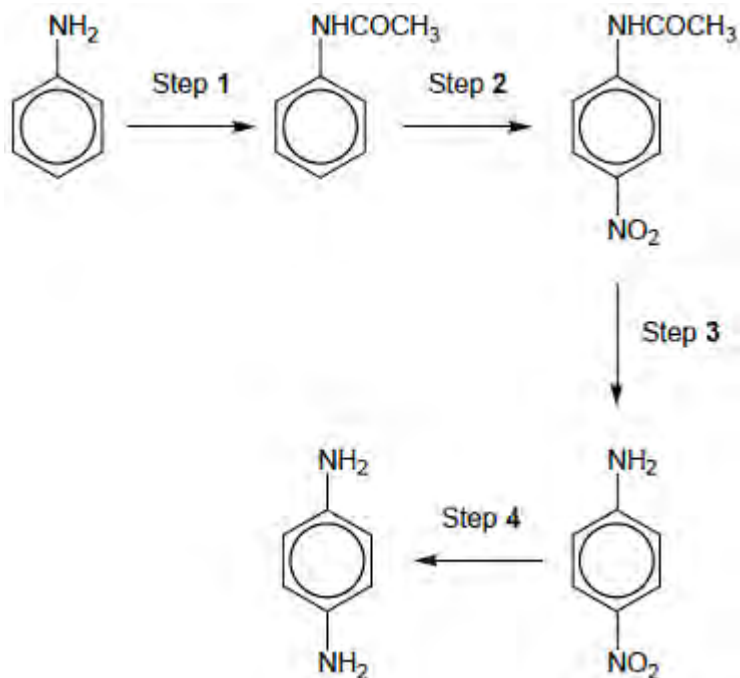
.....

(3)

(Total 11 marks)

Q2. 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

.....
.....
.....

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

.....
.....
.....

The crystals were compressed in the funnel

.....
.....
.....

A little cold water was poured through the crystals

.....
.....
.....

(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.

.....

.....

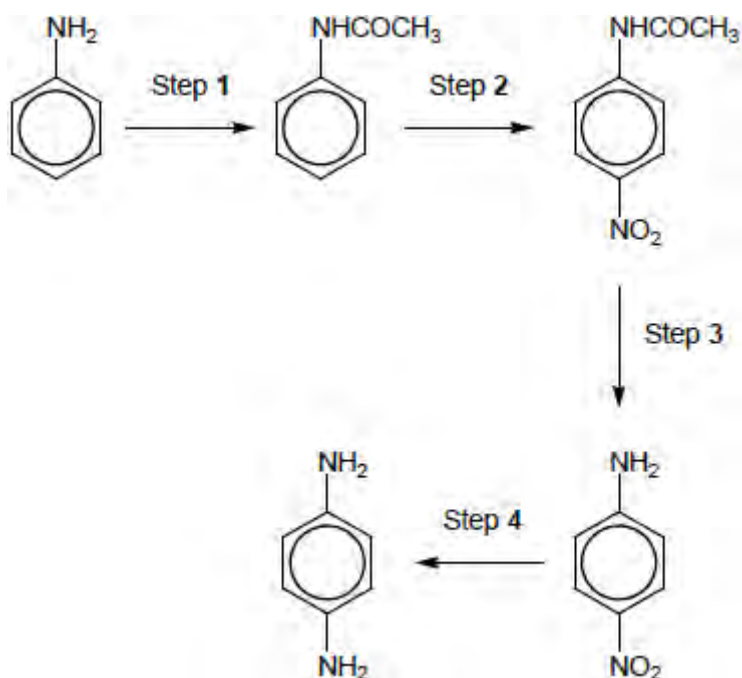
.....

.....

.....

(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.

.....

(1)

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

.....

(1)

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

.....

(1)

(Total 18 marks)

Q3. Benzene reacts with ethanoyl chloride in a substitution reaction to form $C_6H_5COCH_3$. This reaction is catalysed by aluminium chloride.

- (a) Write equations to show the role of aluminium chloride as a catalyst in this reaction.

Outline a mechanism for the reaction of benzene.

Name the product, $C_6H_5COCH_3$.

.....
.....
.....

(6)

- (b) The product of the substitution reaction ($C_6H_5COCH_3$) was analysed by mass spectrometry. The most abundant fragment ion gave a peak in the mass spectrum with $m/z = 105$.
Draw the structure of this fragment ion.

(1)

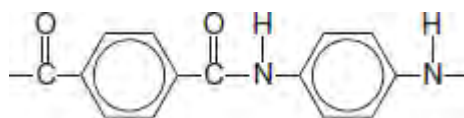
- (c) When methylbenzene reacts with ethanoyl chloride and aluminium chloride, a similar substitution reaction occurs but the reaction is faster than the reaction of benzene.
Suggest why the reaction of methylbenzene is faster.

.....
.....
.....
.....
.....
.....

(2)

(Total 9 marks)

Q4. Kevlar is a polymer used in protective clothing.
The repeating unit within the polymer chains of Kevlar is shown.

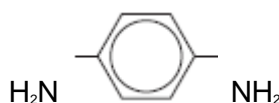


(a) Name the strongest type of interaction between polymer chains of Kevlar.

.....

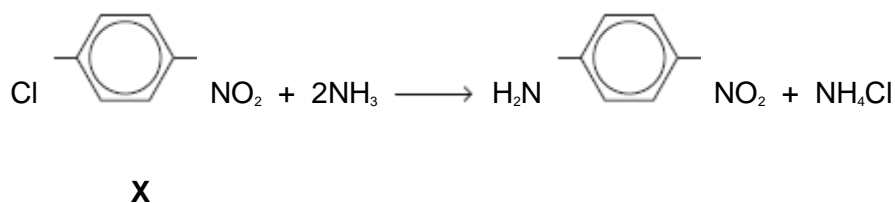
(1)

(b) One of the monomers used in the synthesis of Kevlar is



An industrial synthesis of this monomer uses the following two-stage process starting from compound **X**.

Stage 1



Stage 2



(i) Suggest why the reaction of ammonia with **X** in Stage 1 might be considered unexpected.

.....

(2)

(ii) Suggest a combination of reagents for the reaction in Stage 2.

.....

(1)

(iii) Compound **X** can be produced by nitration of chlorobenzene.

Give the combination of reagents for this nitration of chlorobenzene.
Write an equation or equations to show the formation of a reactive intermediate from these reagents.

Reagents

.....

Equation(s)

.....

(3)

(iv) Name and outline a mechanism for the formation of **X** from chlorobenzene and the reactive intermediate in part (iii).

Name of mechanism

Mechanism

(4)

(Total 11 marks)

Q5. This question is about acylium ions, $[\text{RCO}]^+$

(a) The acylium ion $\text{H}_3\text{C}-\overset{+}{\text{C}}=\text{O}$ is formed in a mass spectrometer by fragmentation of the molecular ion of methyl ethanoate.

Write an equation for this fragmentation.

Include in your answer a displayed formula for the radical formed.

.....

(2)

(b) The acylium ion $\text{H}_3\text{C}-\overset{+}{\text{C}}=\text{O}$ can also be formed from ethanoyl chloride. The ion reacts with benzene to form $\text{C}_6\text{H}_5\text{COCH}_3$

(i) Write an equation to show the formation of this acylium ion by the reaction of ethanoyl chloride with **one** other substance.

.....

(2)

(ii) Name and outline a mechanism for the reaction of benzene with this acylium ion.

Name of mechanism

Mechanism

(4)

(iii) Ethanoic anhydride also reacts with benzene to form $\text{C}_6\text{H}_5\text{COCH}_3$

Write an equation for this reaction.

.....

(1)

(Total 9 marks)