



A-Level Chemistry

Reactions of Benzene

Question Paper

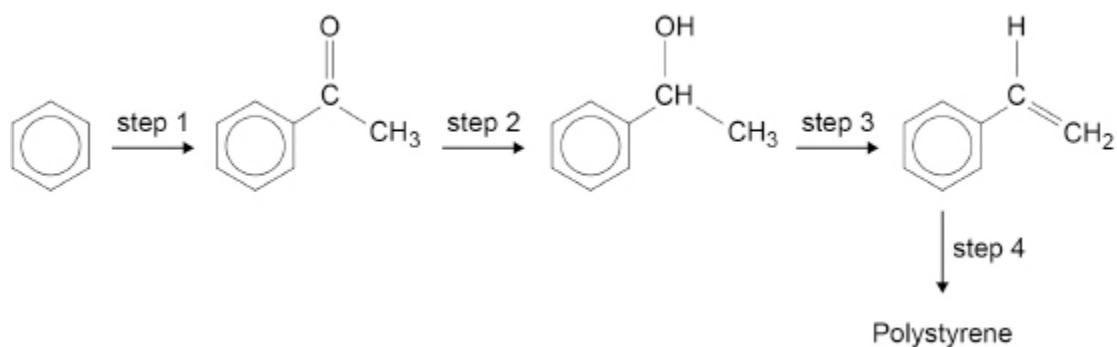
Time available: 71 minutes

Marks available: 66 marks

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1.

Polystyrene can be made from benzene in the series of steps shown.



- (a) State the type of reaction in step 1.

Identify the reagent(s) and conditions needed for step 1.

Type of reaction _____

Reagent(s) _____

Conditions _____

(3)

- (b) State the name of the mechanism for the reaction in step 2.

Identify the inorganic reagent needed for step 2.

Name the organic product of step 2.

Name of mechanism _____

Inorganic reagent _____

Name of organic product _____

(3)

- (c) The organic product of step 2 is reacted with concentrated sulfuric acid in step 3.

Outline the mechanism for step 3.

(3)

(d) Draw the repeating unit of polystyrene.

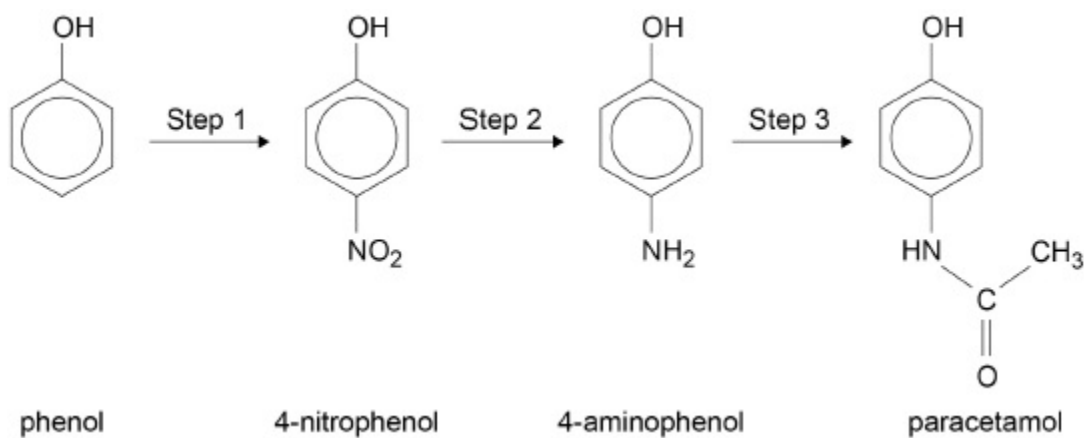
(1)

(Total 10 marks)

2.

Paracetamol is a medicine commonly used to relieve mild pain.

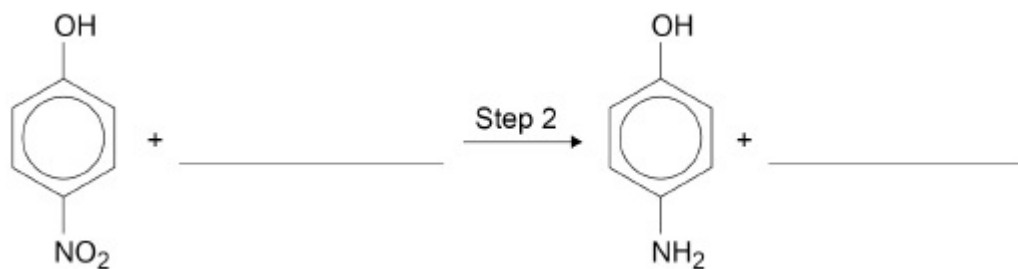
Traditionally, paracetamol has been made industrially in a three-step synthesis from phenol.



(a) Name the mechanism of the reaction in Step 1.

(1)

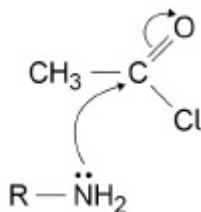
(b) Complete the equation for the reaction in Step 2.



(1)

- (c) In theory, either ethanoyl chloride or ethanoic anhydride could be used in Step 3.

Complete the mechanism for the reaction of 4-aminophenol with ethanoyl chloride. RNH_2 is used to represent 4-aminophenol in this mechanism.



(2)

- (d) In practice, ethanoic anhydride is used in the industrial synthesis rather than ethanoyl chloride.

Give **one** reason why ethanoyl chloride is **not** used in the industrial synthesis.

(1)

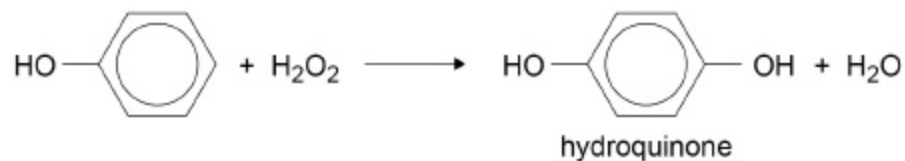
- (e) In Step 3 other aromatic products are formed as well as paracetamol.

Draw the structure of **one** of these other aromatic products.

(1)

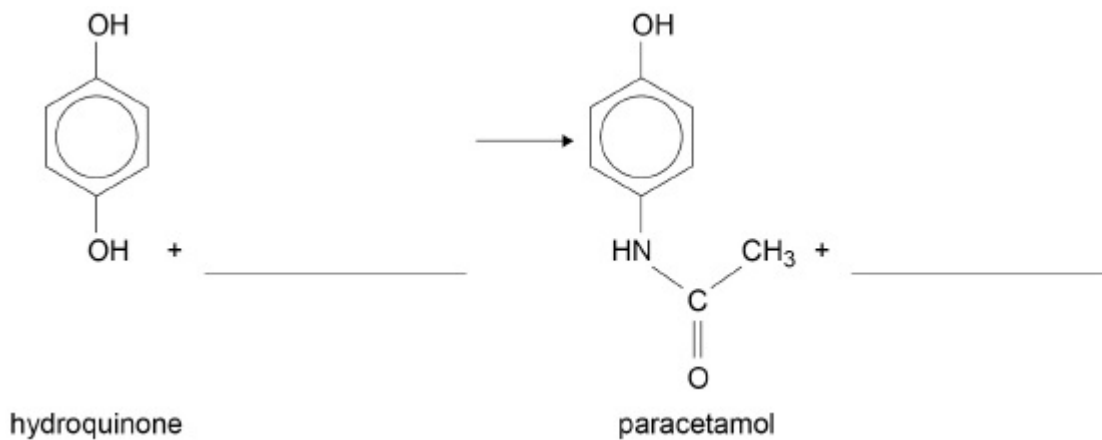
- (f) Chemists have recently developed a two-step process to produce paracetamol from phenol.

In the first step, phenol is oxidised to hydroquinone.



In the second step, hydroquinone reacts with ammonium ethanoate to form paracetamol.

Complete the equation for this second step.



(1)

- (g) Calculate the mass, in kg, of hydroquinone ($M_r = 110.0$) needed to produce 250 kg of paracetamol.

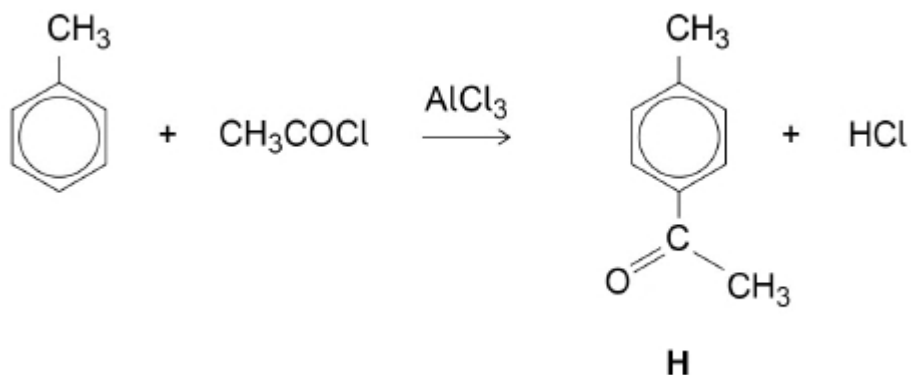
Mass _____ kg

(3)

(Total 10 marks)

3.

When methylbenzene reacts with ethanoyl chloride in the presence of aluminium chloride, the product, **H**, is formed.



- (a) Deduce the molecular formula of **H**.

(1)

- (b) Two other isomers are also produced in the reaction.

Draw the structure of **one** of the other isomers.

Name the type of structural isomerism shown by these three products.

Structure

Type of isomerism _____

(2)

- (c) Name and outline the mechanism for the reaction of ethanoyl chloride with methylbenzene to produce **H**.

Include an equation for the formation of the reactive intermediate that is involved in the reaction.

Name _____

Equation _____

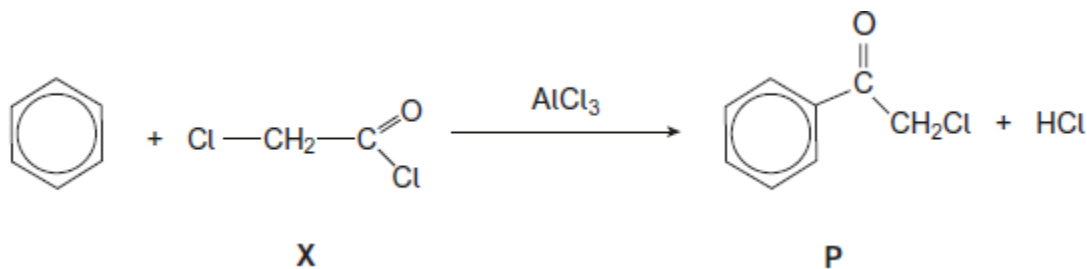
Mechanism

(5)
(Total 8 marks)

4.

Compound **X** (ClCH_2COCl) is used as a reagent in organic synthesis.

(a) One important reaction of **X** is in the preparation of compound **P** as shown.



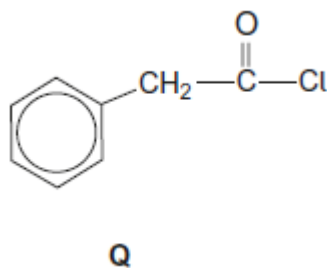
(i) Draw the structure of the electrophile formed by the reaction of **X** with AlCl_3 .

(1)

(ii) Outline the mechanism for the reaction of the electrophile from part **(a)(i)** with benzene in the preparation of **P**.

(3)

(b) Compound **Q** is an alternative product that could be formed when **X** reacts with benzene.



Describe how you could distinguish between **P** and **Q** by a test-tube reaction. Give the reagent used and the observation with each compound.

Reagent _____

Observation with **P** _____

Observation with **Q** _____

(3)

(c) **X** is also used to make the compound HOCH_2COOH . This compound is polymerised to form the polymer known as PGA. PGA is used in surgical sutures (stitches).

(i) Draw the repeating unit of PGA.

(1)

(ii) Production of PGA occurs via a cyclic compound. Two HOCH_2COOH molecules react together to form the cyclic compound and two molecules of water.

Draw the structure of this cyclic compound.

(1)

(d) Poly(propene) is also used in surgical sutures.

(i) Draw the repeating unit of poly(propene).

(1)

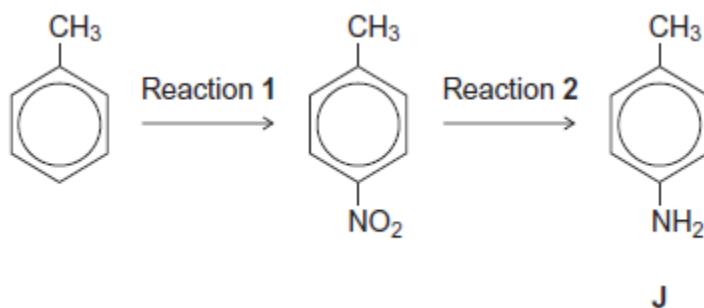
(ii) Suggest an advantage of surgical sutures made from PGA rather than from poly(propene).
Explain your answer.

(2)

(Total 12 marks)

5.

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** ($\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2$) is a structural isomer of **J**.

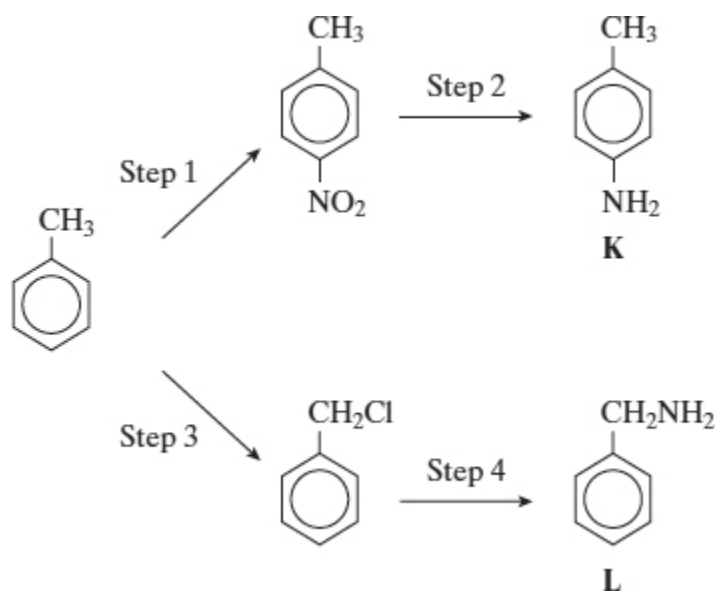
Explain why **J** is a weaker base than **K**.

(3)

(Total 11 marks)

6.

The following reaction scheme shows the formation of two amines, **K** and **L**, from methylbenzene.



- (a) (i) Give the reagents needed to carry out Step 1. Write an equation for the formation from these reagents of the inorganic species which reacts with methylbenzene.

Reagents _____

Equation _____

- (ii) Name and outline a mechanism for the reaction between this inorganic species and methylbenzene.

Name of mechanism _____

Mechanism

(7)

- (b) Give a suitable reagent or combination of reagents for Step 2.

(1)

- (c) (i) Give the reagent for Step 4 and state a condition to ensure that the primary amine is the major product.

Reagent _____

Condition _____

- (ii) Name and outline a mechanism for Step 4.

Name of mechanism _____

Mechanism

(7)
(Total 15 marks)