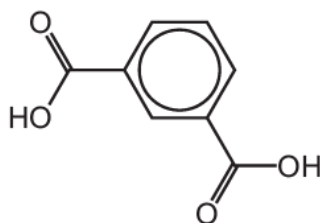


**1. Nov/2021/Paper\_42/No.7**

The structure of benzene-1,3-dicarboxylic acid is shown.

benzene-1,3-dicarboxylic acid



(a) State the empirical formula of benzene-1,3-dicarboxylic acid.

..... [1]

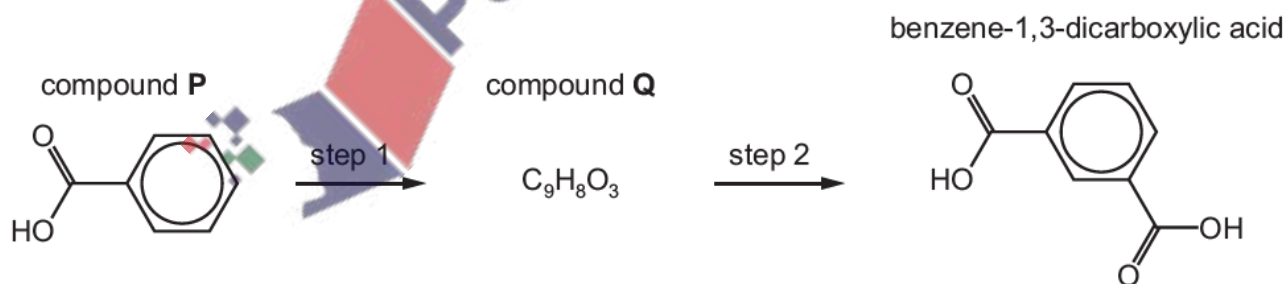
(b) Benzene-1,3-dicarboxylic acid is an isomer of benzene-1,4-dicarboxylic acid. These two isomers can be distinguished by carbon-13 ( $^{13}\text{C}$ ) NMR spectroscopy.

State the number of peaks in the carbon-13 ( $^{13}\text{C}$ ) NMR spectrum of each compound.

benzene-1,3-dicarboxylic acid	
benzene-1,4-dicarboxylic acid	

[2]

(c) Benzene-1,3-dicarboxylic acid can be made by the two-step synthesis shown below.



(i) Name compound P.

..... [1]

(ii) Explain why the major product of this two-step synthesis is benzene-1,3-dicarboxylic acid and **not** benzene-1,4-dicarboxylic acid.

..... [1]

(iii) The reagents used for step 1 are  $\text{CH}_3\text{COCl}$  and  $\text{AlCl}_3$ . These reagents give rise to  $\text{CH}_3\text{C}^+\text{=O}$  ions which react with compound **P**.

Name the mechanism of this reaction.

..... [1]

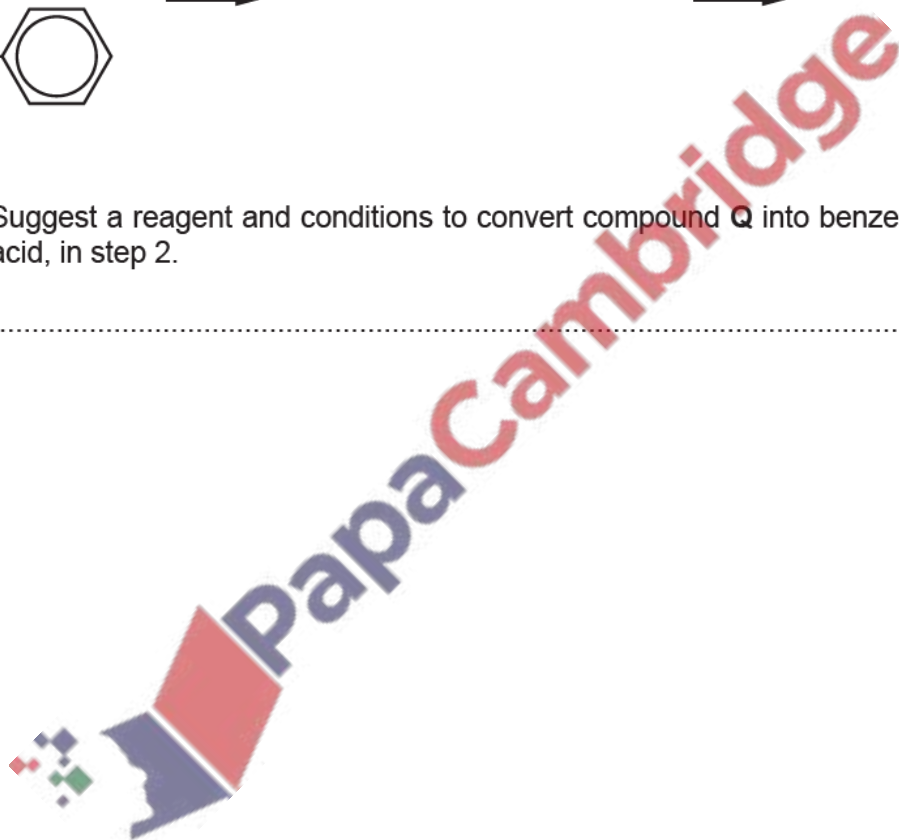
(iv) Draw the mechanism of the reaction of  $\text{CH}_3\text{C}^+\text{=O}$  ions with compound **P**. Include all relevant curly arrows and charges, the structure of the intermediate and the structure of compound **Q**.



(v) Suggest a reagent and conditions to convert compound **Q** into benzene-1,3-dicarboxylic acid, in step 2.

..... [1]

[Total: 10]



2. Nov/2021/Paper\_42/No.9

Butylamine,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ , can be synthesised from different organic compounds by using suitable reagents. Each reaction involves one step.

(a) Complete the table to describe three different syntheses.

- One of the three syntheses should involve a nucleophilic substitution reaction.
- The starting organic compound for each synthesis should contain a different functional group.
- A different reagent should be used for each synthesis.

starting organic compound	reagent and conditions

[6]

(b) Compare and explain the relative basicities of ammonia, butylamine and phenylamine.

..... > ..... > .....

most basic  least basic

.....

.....

.....

.....

.....

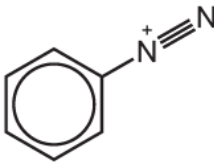
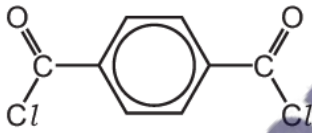
.....

..... [4]

[Total: 10]

3. Nov/2021/Paper\_42/No.10

(a) Complete the table to show the structure of the organic product from each reaction of phenol,  $C_6H_5OH$ .

reaction	reaction mixture	structure of organic product
1	phenol + NaOH(aq)	
2	phenol + Na(s)	
3	phenol +  (aq) + NaOH, at 4 °C	
4	an excess of phenol + 	

[4]

(b) Identify **two** reactions from the table in which ethanol would behave in a similar way to phenol.

..... [1]

[Total: 5]