

Name of the Student: _____

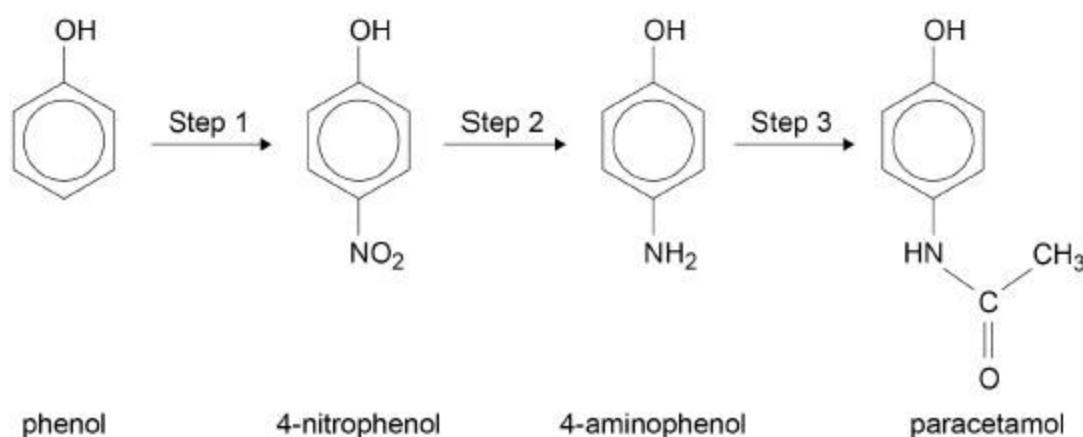
Max. Marks : 23 Marks

Time : 23 Minutes

Q1.

Paracetamol is a medicine commonly used to relieve mild pain.

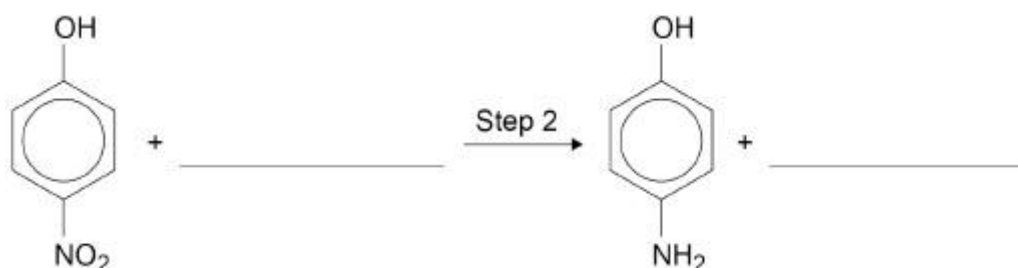
Traditionally, paracetamol has been made industrially in a three-step synthesis from phenol.



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

(1)

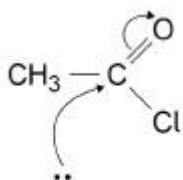
(b) Complete the equation for the reaction in Step 2.



(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.
RNH₂ 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.

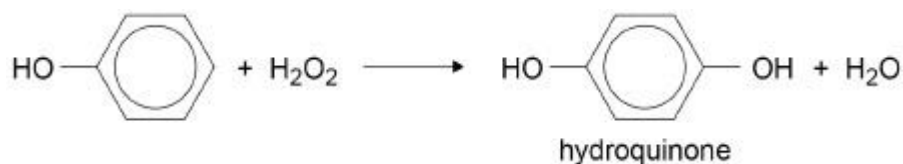
(1)

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

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

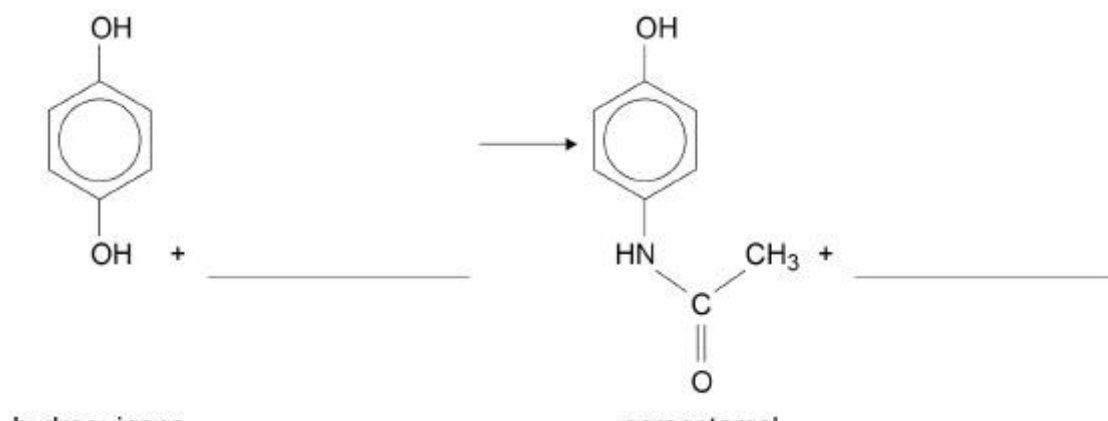
(1)

- (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

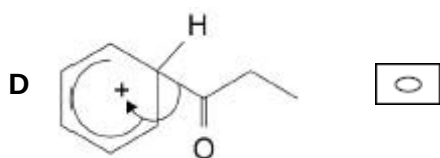
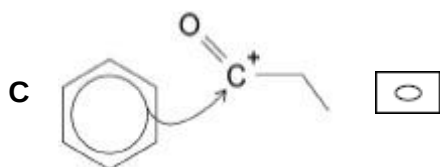
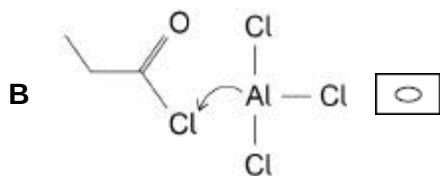
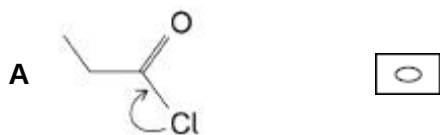
(3)

(Total 10 marks)

Q2.

The reaction between propanoyl chloride and benzene is an example of acylation.

Which is a correct representation of part of the mechanism of this reaction?



(Total 1 mark)

Q3.

This question is about nitrobenzenes.

- (a) Nitrobenzene reacts when heated with a mixture of concentrated nitric acid and concentrated sulfuric acid to form a mixture of three isomeric dinitrobenzenes.

Write an equation for the reaction of concentrated nitric acid with concentrated sulfuric acid to form the species that reacts with nitrobenzene.

(1)

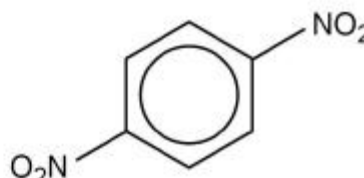
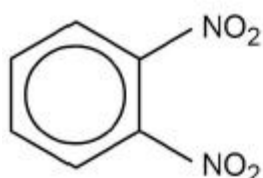
- (b) Name and outline a mechanism for the reaction of this species with nitrobenzene to form 1,3-dinitrobenzene.

Name of mechanism

Mechanism

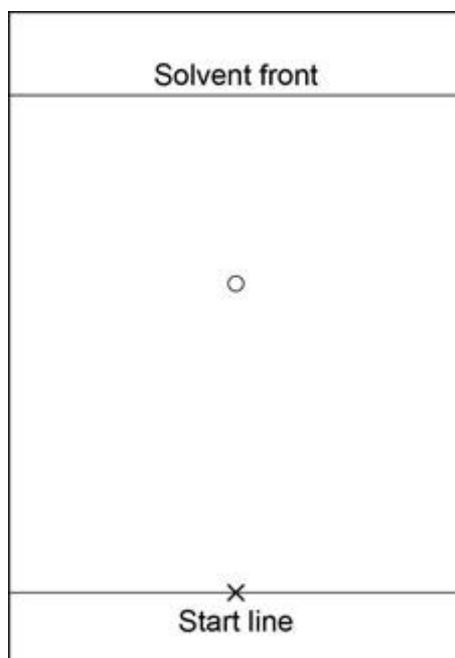
(4)

- (c) The dinitrobenzenes shown were investigated by thin layer chromatography (TLC).



In an experiment, carried out in a fume cupboard, a concentrated solution of pure 1,4-dinitrobenzene was spotted on a TLC plate coated with a solid that contains polar bonds. Hexane was used as the solvent in a beaker with a lid.

The start line, drawn in pencil, the final position of the spot and the final solvent front are shown on the chromatogram in the diagram below



Use the chromatogram in the diagram above to deduce the R_f value of 1,4-dinitrobenzene in this experiment.

Tick (✓) **one** box.

- | | | |
|----------|------|--------------------------|
| A | 0.41 | ☐ |
| B | 0.46 | ☐ |
| C | 0.52 | ☐ |
| D | 0.62 | ☐ |

(1)

- (d) State in general terms what determines the distance travelled by a spot in TLC.

(1)

- (e) To obtain the chromatogram, the TLC plate was held by the edges and placed in the solvent in the beaker in the fume cupboard. The lid was then replaced on the beaker.

Give one other practical requirement when placing the plate in the beaker.

(1)

- (f) A second TLC experiment was carried out using 1,2-dinitrobenzene and 1,4-dinitrobenzene.

An identical plate to that in part (c) was used under the same conditions with the same solvent. In this experiment, the R_f value of 1,4-dinitrobenzene was found to be greater than that of 1,2-dinitrobenzene.

Deduce the relative polarities of the 1,2-dinitrobenzene and 1,4-dinitrobenzene and explain why 1,4-dinitrobenzene has the greater R_f value.

Relative polarities

Explanation

(2)

- (g) A third TLC experiment was carried out using 1,2-dinitrobenzene. An identical plate to that in part (c) was used under the same conditions, but the solvent used contained a mixture of hexane and ethyl ethanoate.

A student stated that the R_f value of 1,2-dinitrobenzene in this third experiment would be greater than that of 1,2-dinitrobenzene in the experiment in part (f)

Is the student correct? Justify your answer.

(2)

(Total 12 marks)