Organic synthesis - 2021

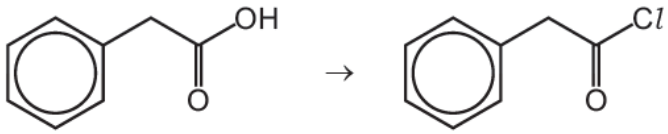
1. Nov/2021/Paper_41/No.9

Compound **T** is made by a three-stage synthesis.

(a) In stage 1, phenylethanoic acid reacts with a suitable reagent to form compound **R**.

phenylethanoic acid → **R**

stage 1



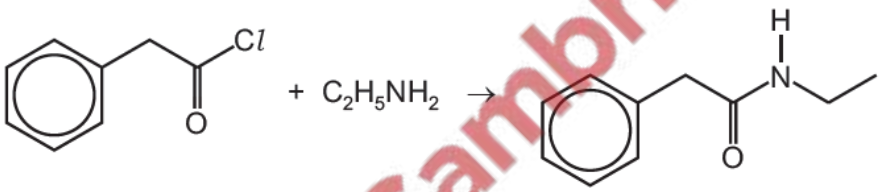
Suggest a suitable reagent for stage 1.

..... [1]

(b) In stage 2, compound **R** reacts with ethylamine to form compound **S**.

R + $C_2H_5NH_2$ → **S**

stage 2



(i) Name the functional group formed in stage 2.

..... [1]

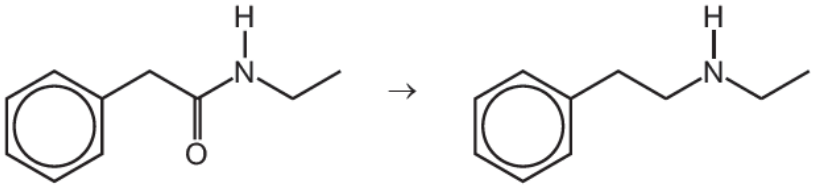
(ii) Identify the other product formed in stage 2.

..... [1]

(c) In stage 3, compound **S** reacts with a suitable reagent to form compound **T**.

S → **T**

stage 3



(i) State the formula of a suitable reagent for stage 3.

..... [1]

(ii) Name the type of reaction that occurs in stage 3.

..... [1]

(d) The relative abundance of the molecular ion peak in the mass spectrum of ethylamine is 62.

(i) Calculate the relative abundance of the M+1 peak in the mass spectrum of ethylamine.

relative abundance = ... [1]

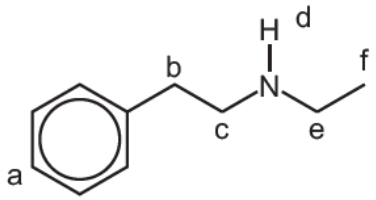
(ii) The mass spectrum of compound **T** contains several fragments. The *m*/*e* values of two of these fragments are 29 and 91.

Draw the structures of the ions responsible for these peaks.

m/*e*	structure of ion
29	
91	

[2]

(e) The proton (^{1}H) NMR spectrum of compound **T** shows hydrogen atoms in different environments. Six of these environments are shown on the structure using letters a, b, c, d, e and f.



Use the letters a, b, c, d, e and f to answer the questions that follow. The questions relate to the proton (^{1}H) NMR spectrum of **T**.

Proton d does not cause splitting of the peaks for protons c or e under the conditions used.

Each answer may be one, or more than one, of the letters a, b, c, d, e and f.

(i) Identify the proton or protons with a chemical shift (δ) in the range 6.0 to 9.0.

..... [1]

(ii) Identify the proton or protons whose peak will disappear if D_2O is added.

..... [1]

(iii) Identify the proton or protons whose peak is a triplet.

..... [1]

(iv) Identify the proton or protons with the lowest chemical shift (δ).

..... [1]

[Total: 12]

2. June/2021/Paper_41/No.9

The carbon-13 (^{13}C) NMR spectrum of compound **A**, $C_8H_8O_2$, contains six peaks.

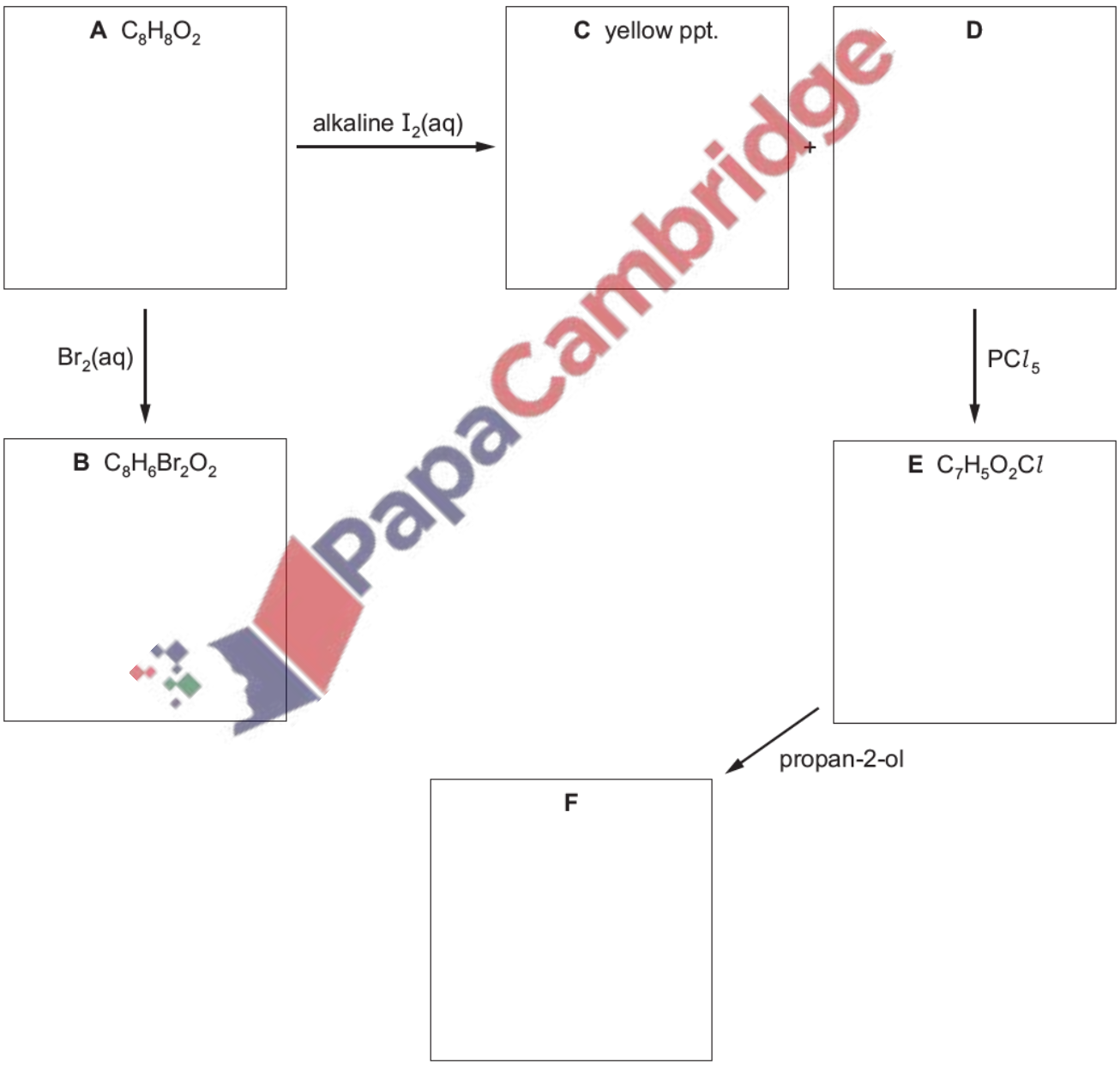
Compound **A** reacts with an excess of bromine water to give compound **B**, $C_8H_6Br_2O_2$.

Compound **A** reacts with alkaline aqueous iodine to form a yellow precipitate **C** and compound **D**.

Compound **D** reacts with PCl_5 to form compound **E**, $C_7H_5O_2Cl$.

Compound **E** reacts with propan-2-ol to form compound **F**.

Draw the structures of compounds **A**, **B**, **C**, **D**, **E** and **F** in the boxes.



[6]

3. June/2021/Paper_42/No.6

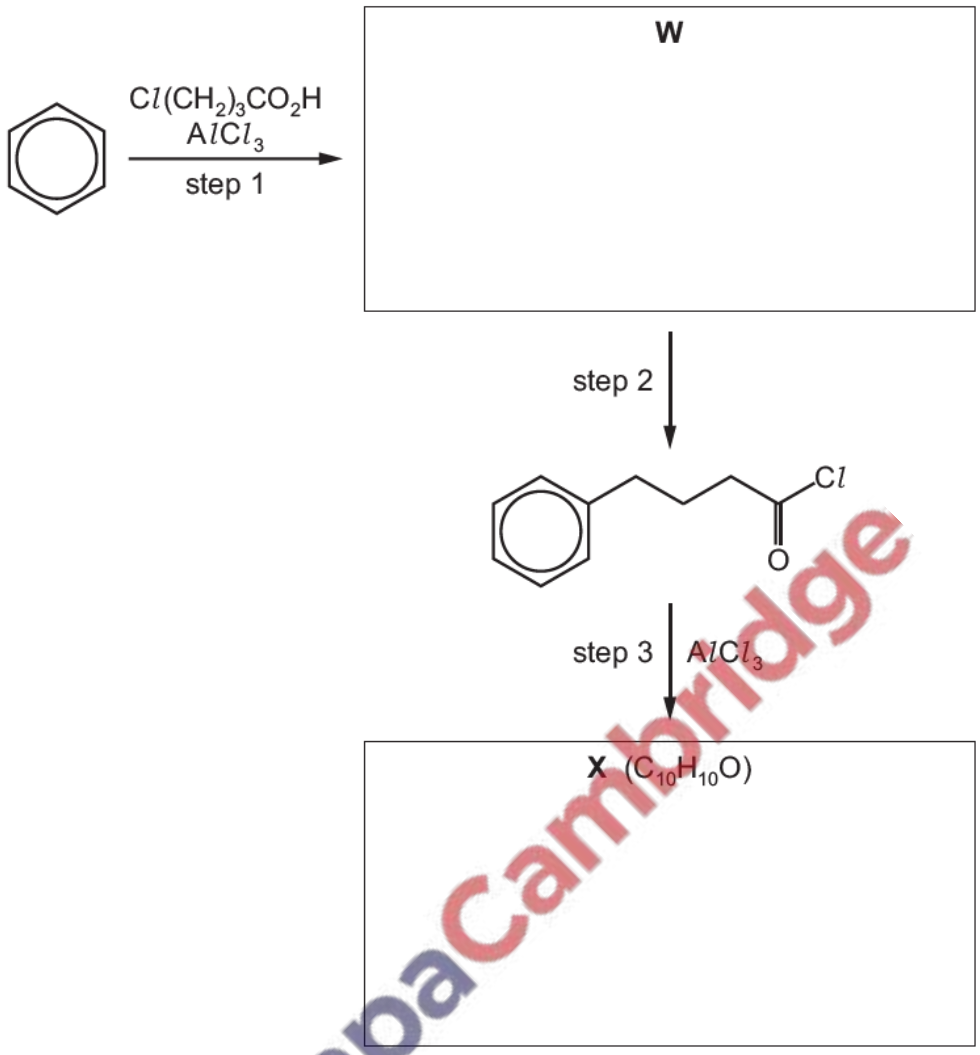
(a) There are four possible structural isomers of C_8H_{10} that contain a benzene ring.

Draw the **skeletal** formulae of the four structural isomers in the appropriate boxes. The number of peaks observed in the carbon-13 (^{13}C) NMR spectrum of each compound is given.

isomer 1 three peaks in ^{13}C NMR	isomer 2 four peaks in ^{13}C NMR
isomer 3 five peaks in ^{13}C NMR	isomer 4 six peaks in ^{13}C NMR

[4]

(b) A three-step synthesis of **X** ($C_{10}H_{10}O$) from benzene is suggested as shown.



(i) Step 1 is the alkylation of benzene by electrophilic substitution.
Use R–C*l* to represent $Cl(CH_2)_3CO_2H$.

Write an equation for the formation of an electrophile from R–C*l* and $AlCl_3$.

..... [1]

(ii) Deduce and draw the structures of **W** and **X** in the boxes. [2]

(iii) Suggest the reagents and conditions for step 2.

..... [1]

(iv) Complete the mechanism for the reaction of benzene with the electrophile formed in **(b)(i)**.

Include all relevant charges and curly arrows showing the movement of electron pairs.

Draw the structure of the intermediate.

[3]

[Total: 11]