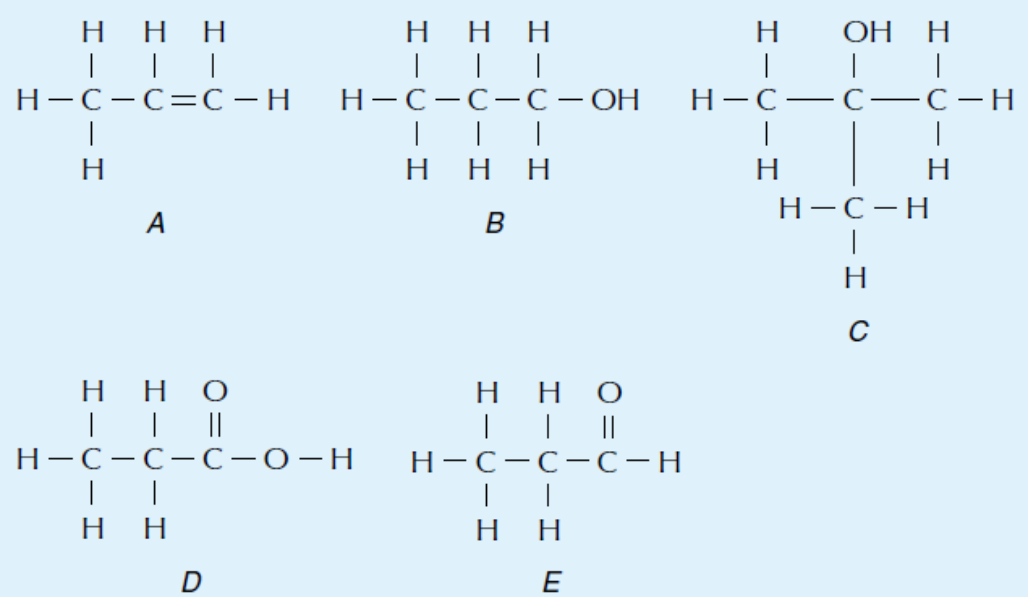
Quiz (Detecting the Presence of Functional Groups)

1. Suggest a chemical test to distinguish between each of the following pairs of compounds. For each test, state the expected observations and write a relevant chemical equation involved (if any).
   (a) Propene and propan-1-ol
   (b) Methylpropan-2-ol and butan-1-ol

2. There are four unlabelled bottles each containing a pure colourless organic liquid. The four liquids are *propanone, 3-methylpent-2-ene, 3-chlorobutanoic acid and pentan-2-ol*, respectively.
   (a) Write the structural formula for each of the four compounds.
   (b) Describe briefly how you could identify the unknown liquids using simple chemical tests.

3. Compound *A* is an aromatic compound and has a molecular formula of $C_8H_8O_2$. It reacts with ethanol in the presence of concentrated sulphuric acid under reflux to give *B*, which has a characteristic pleasant fruity smell. When *A* is first treated with lithium aluminium hydride in dry ether and then with a dilute acid, *C* is produced. *C* is then oxidized by acidified potassium dichromate solution to form *D*. *D* forms a silver mirror with Tollens' reagent.
   Deduce, with explanations, the structures of *A*, *B*, *C* and *D*.

4. Compound *X* is one of the following compounds:



   Chemical tests are carried out on *X* and the results are as follows.
   Test (1): *X* gives a negative result when tested with Tollens' reagent.
   Test (2): *X* gives a negative result when tested with bromine (dissolved in an organic solvent).
   Test (3): *X* gives a negative result when tested with sodium hydrogencarbonate solution.
   Test (4): *X* turns acidified potassium dichromate solution from orange to green.

(a) Deduce from the results of test (1) only, which of the above compounds is/are NOT likely to be *X*? Explain your answer.
(b) Deduce from the results of test (2) only, which of the above compounds is/are NOT likely to be *X*? Explain your answer.
(c) Deduce from the results of test (3) only, which of the above compounds is/are NOT likely to be *X*? Explain your answer.
(d) From your answers in (a)–(c) and the results of test (4), deduce what *X* should be. Explain your answer.

5. Suggest a chemical test to distinguish between each of the following pairs of compounds. For each test, state the expected observations.
(a) propan-1-ol and propanoic acid
(b) methanal and methanol
(c) propanal and propanone

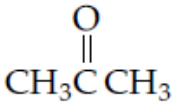
Suggested Answer

1. (a) Test with acidified potassium dichromate solution. Propan-1-ol changes the colour of the acidified potassium dichromate solution from orange to green while there is no observable change for propene.
$CH_3CH_2CH_2OH \xrightarrow{[O]} CH_3CH_2CHO \xrightarrow{[O]} CH_3CH_2COOH$

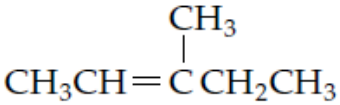
OR Test with bromine (dissolved in an organic solvent). Propene changes the colour of the bromine solution from red-orange to colourless rapidly while there is no observable change for propan-1-ol.
$CH_3CH{=}CH_2 + Br_2 \longrightarrow CH_3CHBrCH_2Br$

(b) Test with acidified potassium dichromate solution. Butan-1-ol changes the colour of the acidified potassium dichromate solution from orange to green while there is no observable change for methylpropane-2-ol.
$CH_3CH_2CH_2CH_2OH \xrightarrow{[O]} CH_3CH_2CH_2CHO \xrightarrow{[O]} CH_3CH_2CH_2COOH$

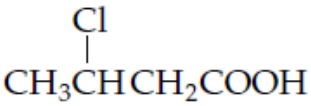
2. (a)



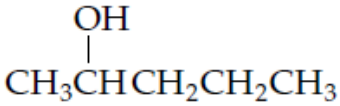
propanone



3-methylpent-2-ene



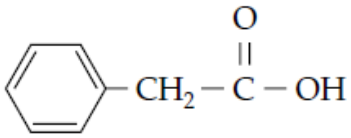
3-chlorobutanoic acid



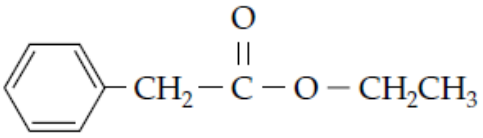
pentan-2-ol

(b) The four unknown liquids can be identified by the following procedure:
   1. Add each of the unknown liquids to bromine (dissolved in an organic solvent) separately. Only 3-methylpent-2-ene decolorizes the red-orange bromine.
   2. Add sodium hydrogencarbonate solution to each of the three remaining unknown liquids. Only 3-chlorobutanoic acid gives a colourless gas. The colourless gas turns limewater milky.
   3. Add each of the two remaining unknown liquids to acidified potassium dichromate solution separately. Only pentan-2-ol turns the solution from orange to green.
   4. Propanone, the remaining liquid, can be identified by reaction with 2,4-dinitrophenylhydrazine solution. An orange-yellow precipitate will form.

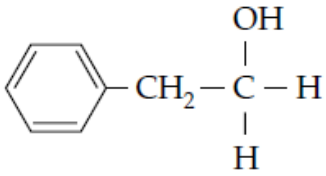
3. A:



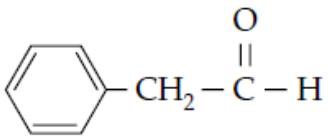
B:



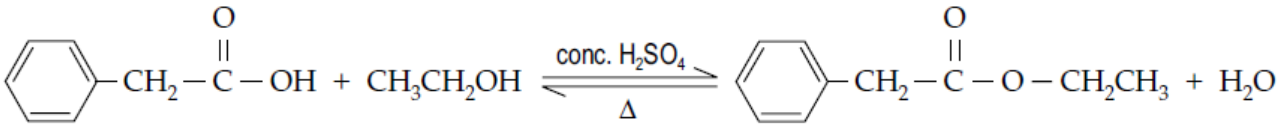
C:



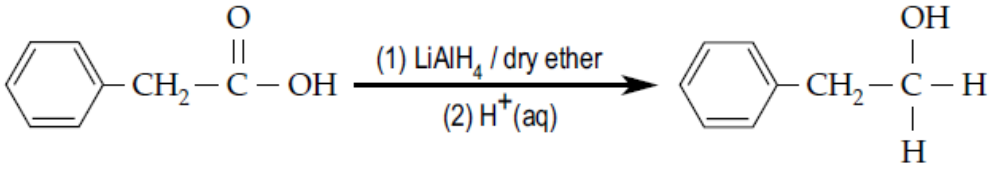
D:



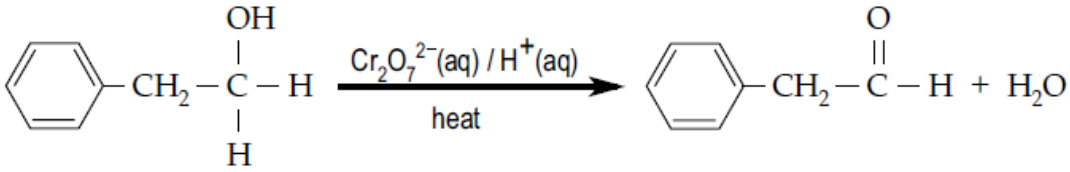
A undergoes esterification when heated under reflux with ethanol in the presence of concentrated H_2SO_4 to give the ester *B*. Hence, *A* is a carboxylic acid.



A is reduced by $LiAlH_4$ in dry ether to form *C* which is a primary alcohol.



C is oxidized by $K_2Cr_2O_7(aq)/H^+(aq)$ to give *D*. *D* forms a silver mirror with Tollens' reagent, so *D* is an aldehyde.



4. (a) X gives a negative result when tested with Tollens' reagent.
X should not be an aldehyde. Hence, compound E is not likely to be X.

(b) X gives a negative result when tested with bromine (dissolved in an organic solvent). X should not contain carbon-carbon double bond. Hence, compound A is not likely to be X.

(c) X gives a negative result when tested with sodium hydrogencarbonate solution. X should not be a carboxylic acid. Hence, compound D is not likely to be X.

(d) X gives a positive result when tested with acidified potassium dichromate solution. X should be a 1° alcohol, 2° alcohol or aldehyde. Compound C is not likely to be X as it is a 3° alcohol. Thus compound B should be X.

5. (a) Test with sodium hydrogencarbonate solution / sodium carbonate solution. Propanoic acid gives a colourless gas which turns limewater milky, while there is no observable change for propan-1-ol.

OR Test with acidified potassium dichromate solution. Propan-1-ol changes the colour of the acidified potassium dichromate solution from orange to green, while there is no observable change for propanoic acid.

(b) Test with Tollens' reagent. A silver mirror forms when methanol reacts with Tollens' reagent while there is no observable change for methanol.

OR Test with 2,4-dinitrophenylhydrazine. An orange precipitate forms when methanol reacts with 2,4-dinitrophenolhydrazine while there is no observable change for methanol.

(c) Test with Tollens' reagent. A silver mirror forms when propanal reacts with Tollens' reagent while there is no observable change for propanone.