(1) **1980 A/L (Optional)**

a) An organic compound contains 41.0% of carbon, 4.6% hydrogen and 54.4% of oxygen.

i) What is the empirical formula of the compound?

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ii) The relative molecular mass of the compound is approximately 180. What is the molecular formula of the compound?

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b) i) Indicate how you would convert the alkene, $CH_3CH = CHCH_2CH_3$ to $CH_3CH(OH)-CH(OH)CH_2CH_3$

N.B. Experimental details are not required. Reagents and conditions should be mentioned.

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ii) The compound $CH_3CH(OH)-CH(OH)CH_2CH_3$ is reacted with PBr_3. Write the IUPAC name of the product.

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iii) Which of the following would show cis – trans isomerism?

A B C

$(CH_3)_2C = CCl_2$; $CH_3CH = CHCl$; $Br_2C = CCl_2$; $C_6H_5-C(H)(CH_3)-CH=CH_2$ (D)

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iv) Which of the following compounds would show optical isomerism?

$C_6H_5CH_2Cl$; $C_6H_5CH(CH_3)_2$; $(C_6H_5)_2CClBr$; $CH_3CHBrCl$

L K M N

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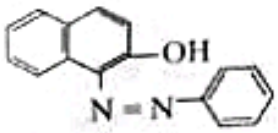
(2) **1981 A/L**

a) i) The organic compound *W* with the molecular formula $C_4H_{11}N$ shows optical isomerism. Draw the possible structures for the compound *W*

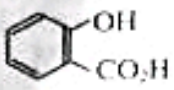
ii) When the organic compound *J* with the molecular formula C_4H_9Br was heated with alcoholic KOH solution, both cis and trans isomers of the compound *K* was resulted. Draw the structures of the isomers of *K* and the structure of the compound *J*.

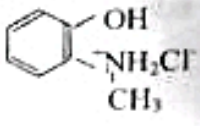
b) i) How can be the compound *D* produced using only 2 – naphthol and benzene? (State the necessary experimental conditions and reagents) Structure of *D* is given below.



ii) What are the products would form when propanal, heated with a solution of ammonical silver nitrate?

c) Give two chemical tests to distinguish the following two compounds.

(A) 

(B) 

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(3) **1981 A/L**

b) i) Write the IUPAC name of $CH_3CH(CHO)CH = CHCH_3$

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ii) Draw the structure of ethyl – 2 – chlorobutanoate.

iii) State how you would convert propanal into ethyl – 2 – chlorobutanoate.

(4) **1982 A/L**

a) i) When the organic compound *P* with the molecular formula $C_5H_{10}O_2$, was refluxed with conc. H_2SO_4, the optically active compound *Q* with the molecular formula $C_6H_{12}O_2$ was produced. Draw the possible structures for *P* and *Q*.

b) How can you distinguish the two compounds found in the following pairs, using chemical tests?

i) Formic acid and acetic acid.

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ii) Sodium phenate (C_6H_5ONa) and sodium benzoate (C_6H_5COONa)

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(5) **1983 A/L**

a) A chlorohydrocarbon named *Y* contains 65% of chlorine and 33% carbon by mass. (The vapor density of *Y* = 54.5 and RMM of *Y* = 109, RAM of (C = 12; H = 1; Cl = 35.5)

i) What is the empirical formula of *Y*?

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ii) *Y* produces a precipitate with ammonical cuprous chloride. Write the structure of *Y* and name it according to the IUPAC method.

b) Draw the structure of methyl 5-chloro-4-hydroxy-2-pentenoate

(6) **1984 A/L**

a) When a mole of an organic compound *Y*, containing only *C*, *H* and *O* was completely burnt, four moles of CO_2 and four moles of H_2O were produced. *Y* does not produce a precipitate with 2, 4-dinitrophenylhydrazine. *Y* produces a gas with sodium. *Y* shows cis – trans isomerism. Give the possible structures for *Y* and IUPAC name of *Y*. (the RMM of *Y* is 72, RAM) (C =12; O=16; H =1)

b) How can be the following compounds distinguish using only chemical tests?

i) propene and 2-butyne

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ii) Formaldehyde and benzaldehyde

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c) Under which conditions and how do $NaNO_2$/ HCl would react with aniline?

(7) **1985 A/L**

b) Write chemical tests which can be used to distinguish each of the compounds in the following pairs.

ii) Phenol and benzoic acid.

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c) State how and under which conditions propane reacts with HBr.

(8) **1986 A/L**

a) i) Give the names of the *A*, *B*, *C* isomers given below.

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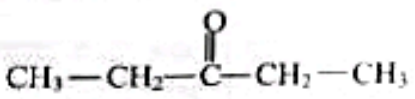
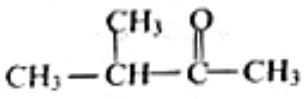
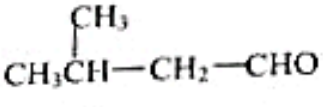


B



C



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ii) State how would you differentiate *A* and *C* using only one test.

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iii) Give the structures of the products when *A*, *B* and *C* react separately with CH_3MgI followed by hydrolysis.

iv) How can the products formed by *A* and *C* compounds in the above reaction iii) be distinguished?

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b) The compound *F* was produced by the following series of reactions

$$D\ (C_8H_{16}) \xrightarrow[(1\ \text{mole})]{} E \xrightarrow[(2\ \text{mol})]{C_6H_5 \cdot NH_2} F \left[\begin{matrix} CH_3 \\ \diagdown \\ C = N - C_6H_5 \\ \diagup \\ C_2H_5 \end{matrix} \quad (2\ \text{mol}) \right]$$

i) Identify *D* and *E*.

ii) Give the possible geometric isomers found in *D*.

iii) Give the necessary reagents and conditions to convert the compound *D* to *E*.

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(9) **1987 A/L**

a) i) A compound containing only *C*, *H* and *O* has 48.65% of carbon and 8.11% of hydrogen. Find the empirical formula of this compound.

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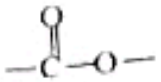
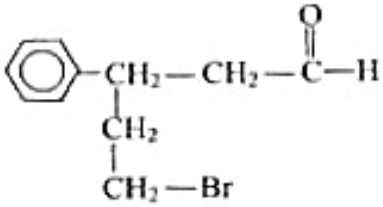
ii) Draw the structural formulae of the four isomers which have the functional group and the molecular formula $C_4H_8O_2$



b) i) Name the structure  according to the IUPAC nomenclature.

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ii) Compound *P* was formed when $C_6H_5CH_2CHO$ and dilute NaOH was reacted. When *P* is oxidized with $K_2Cr_2O_7$ and dilute H_2SO_4 , the organic compound *Q* is formed. Give your ideas about the expected isomerism of *Q*.
N.B. Reasons should be given for your answer.

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c) State how would be the compounds in the following pairs can be identified separately using chemical methods.
N.B. In each of the circumstances a single reaction or a series of reactions or a testing method can be used for the identification. The product resulted after the reaction can be seperated and can move in to the next reaction. Specific methods followed to seperate the products are not to be mentioned necessarily.
ii) $CH_3CH_2CH_2CH_2Cl$ and $(CH_3)_3CCl$

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(10) 1988 A/L

a) i) State clearly what is meant by the 'empirical formula' of a compound.

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ii) A compound containing only carbon, hydrogen, nitrogen has, 57.14% of carbon and 40.00% of nitrogen. What is the empirical formula of the compound?
(C = 12; H = 1; N = 14)

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b) The molecular formula of the compound *Y* is $C_8H_{11}N$. *Y* consists of a benzene ring and it is a primary ammine. But, the nitrogen atom in this molecule is not directly bound to the benzene ring. Draw all the possible structures for *Y*.

c) Name the structure, $CH_3-CH_2-\underset{\displaystyle COOH}{\overset{\displaystyle |}{C}}=CH-\underset{\displaystyle CH_3}{\overset{\displaystyle |}{CH}}-NH_2$ according to the IUPAC nomenclature.

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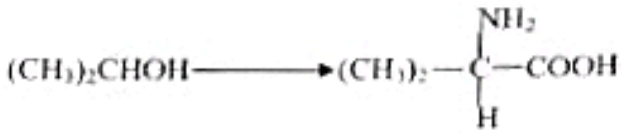
d) Indicate how the following synthesis could be affected. The necessary reagents and reaction conditions should be stated clearly at the appropriate places.
N.B. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) $C_2H_5I \longrightarrow C_2H_5-\underset{\displaystyle C_2H_5}{\overset{\displaystyle |}{C}}=CHCH_3$

ii)



(11) **1989 A/L**

a) A compound contains 42.6% of carbon, 3.6% of hydrogen, 21.3% of nitrogen and oxygen only. If the relative molecular mass of the compound is around 200, determine the molecular formula of the compound. (C= 12; H =1; N = 14; O = 16)

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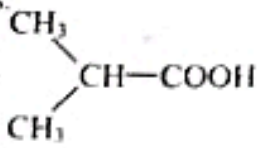
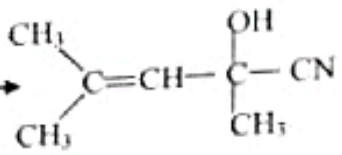
b) Draw all the possible isomers that can be exist for the molecular formula C_8H_7F.
N.B. Assume all the isomers contain benzene rings.

c) State how do the following conversions can be done. The necessary reagents and reaction conditions should be stated clearly at the appropriate places.
If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) $CH_3CH = CH_2 \longrightarrow$ 

ii) $CH_3COCH_3 \longrightarrow$ 

(12) **1990 A/L**

a) The compound A contains 51.7% of Carbon, 3.0% of Hydrogen 24.6% of Fluorine and Oxygen only. If the relative molecular mass of A is around 250, determine the molecular formula. (C = 12; H = 1; F = 19; O = 16)

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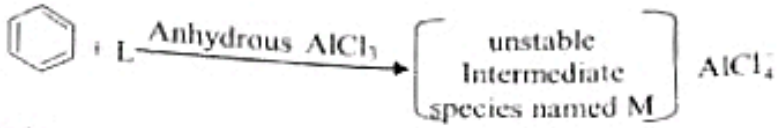
b) The molecular formula of a simple chain organic compound *B* is C_5H_8O. If *B* is an aldehyde, draw all the possible isomers of *B*.

c) i) Draw the structures of the compounds *X*, *Y*, *Z*, *L* and *N* relevant to the conversion series i) and ii) and the intermediate *M* in the boxes 1, 2, 3, 4, 5 and 6 given below.

i) $C_2H_2 + X \xrightarrow{Hg^{2+}/\ H_2SO_4} Y \xrightarrow[2)\ Heat]{1)\ Dilute\ NaOH} Z$

ii) 

iii) Stable compound made by M + Br_2 / NaOH → $CHBr_3$ + N + NaBr + H_2O

1) X 2) Y 3) Z

4) L 5) M 6) N

d) Indicate how you would chemically distinguish between the two compounds in the following pairs.

i) $C_6H_5CH_2CH_2CH_2 - NO_2$ and $C_6H_5-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-NO_2$

A B

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ii) $C_6H_5OCOCH_2CH_2CH_3$ and $C_6H_5CH_2OCOCH_2CH_3$

X Y

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(13) 1991 A/L

a) A certain organic compound contains 60.8% carbon, 35.4% nitrogen and hydrogen only. If the relative molecular mass of the compound is around 170, determine the molecular formula of the compound. (H = 1; C = 12; N = 14)

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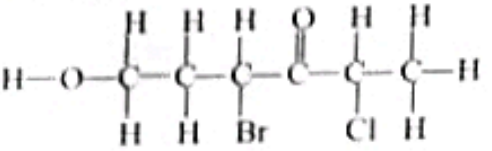
b) i) Molecular formula of the compound X is $C_8H_{11}N$. It contains a benzene ring and it is not a primary ammine. Draw all the possible structures for X

ii) Name the compound with the following structure in accordance with IUPAC nomenclature.



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c) Indicate how the following conversion could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) $CH_3CH = CH_2 \rightarrow (CH_3)_2CHCOOH$

ii) $C_2H_2 \longrightarrow CH_3 - \underset{\displaystyle Br}{\underset{|}{CH}} - CH_2 - \underset{\displaystyle OH}{\underset{|}{CH}} - C \equiv N$

(14) **1992 A/L**

a) A certain organic compound contains 31.4% of carbon, 1.3% hydrogen and 18.3% of nitrogen and oxygen only. The relative molecular mass of the compound is around 250. Determine the molecular formula of the compound.
(H = 1; C = 12; N = 14; O = 16)

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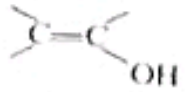
b) The molecular formula of the compound *A* is C_3H_6O. A does not contain the enol group.



A is not a cyclic structure. Draw all the possible structures for *A*.

c) Indicate how the following conversion could be effected.
N.B. the necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) $C_2H_4 \rightarrow CH_3CH(OH)COOCH_2CH_3$

ii) Indicate how you would attempt to synthesize, $CH_3CH_2CH_2NHCH_2CH_2CH_3$ using $CH_3CH_2CONH_2$ as the only starting material

$CH_3CH_2CONH_2 \longrightarrow CH_3CH_2CH_2NHCH_2CH_2CH_3$

(15) **1993 A/L**

a) ***A* is a compound with the molecular formula RCOOH. *R* contains only carbon and hydrogen. When *A* is completely burnt, CO_2 and H_2O were resulted in 44 : 9 mass ratio. If the relative molecular formula of *A* is around 160, determine the molecular formula of *A*. (C = 12; H = 1; O = 16)**

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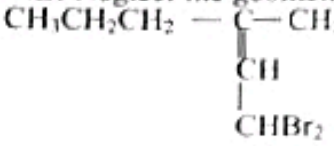
b) Name the compound with the following structure, in accordance with IUPAC nomenclature.
N.B. Neglect the geometric isomerism.



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c) In dicate how the following conversion could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unneccessarily long, you will not be awarded maximum marks.

i) $CH \equiv CH \longrightarrow CH_3-\underset{\displaystyle Br}{\overset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-CH_2COOH$

ii) $CH_3{}^{14}COOC_2H_5 \longrightarrow CH_3{}^{14}\overset{\displaystyle OH}{\overset{|}{C}}(C_6H_5)_2$

(16) 1994 A/L

a) Following is the stoichiometric equation for the combustion of the gaseous hydrocarbon with the molecular formula C_xH_y

$C_xH_y(g) + (x + y/4)\,O_2(g) \rightarrow x\,CO_2(g) + y/2\,H_2O(l)$

i) What is the ratio of the volume of CO_2 produced and the volume of hydrocarbon consumed in this combustion reaction?

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ii) In which number the gaseous molecules will reduce when this reaction is taken place?

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iii) A 5 cm^3 of the above gaseous hydrocarbon and 45 cm^3 of oxygen gas were mixed together. This mixture was ignited by an electrical method, and it was allowed to cool. Then it was observed that the total volume is 35 cm^3. When this gaseous mixture was treated with a solution of concentrated KOH, the new volume of the gaseous mixture turned to be 20 cm^3. Determine the molecular formula of the compound, assuming that all of the above volumes were measured at STP.

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b) Write the mechanism for the bromination of $C_6H_5CH_2Cl$ in the presence of sun light.

c) Indicate how the following conversions could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long you will not be awarded maximum marks.

i) $CH_3CHO \longrightarrow CH_3-\underset{OH}{\overset{H}{C}}-\underset{OH}{\overset{H}{C}}-CH_3$

ii) $CH_3CH_2COOH \rightarrow CH_3 - C \equiv CH$

(17) **1995 A/L**

a) The organic compound named *A* contains only *C*, *H* and *O*. A molecule of A contains two carboxylic groups and found no other functional groups. When A is burnt, CO_2 and H_2O were produced in 2 : 1 molar ratio. The relative molecular formula of *A* is around 115. Determine the molecular formula of *A*.
(C = 12; H = 1; O = 16)

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b) Indicate how you would chemically distinguish between the two compounds in the following pairs.

i) $H_2C = \overset{(A)}{C}(CH_3)_2$ and $H_2C = \overset{(B)}{C}HCH_3$

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c) Indicate how the following conversion could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) Synthesize $CH_3CONHCH_2CH_3$ using ethylamine as the only starting material.

ii) Synthesize $CH_3{}^{14}\underset{OH}{\underset{|}{C}}H{}^{14}CH_2CH_3$ using $CH_3{}^{14}CH_2OH$ as the only organic stating material.

(18) **1996 A/L**

a) The organic compound, *A* contains only *C*, *H* and *N*. When a certain mass of the compound A was subjected to appropriate combustion, carbon dioxide and water were obtained in the mole ratio of 4 : 3. Nitrogen was also obtained in this combustion. The accurate relative molecular mass of *A* is exactly 164. Determine the molecular formula of *A*. (C = 12; H = 1; N = 14)

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b) The molecular formula of the organic compound, *B* is C_7H_9N. Draw all the structures possible for B.

c) Indicate how the following synthesis could be affected. The essential reagents and reaction conditions should be clearly stated at the appropriate places.
N.B. If the method of synthesis proposed by you is unnecessarily long, you will not be awarded full marks.

i) The synthesis is $CH_3C \equiv CCOOH$, using $HC \equiv CH$ as the only starting organic compound.

ii) The synthesis is, $(CH_3CH_2)_2\overset{CH_3}{\underset{|}{C}}-OH$ using CH_3CH_2OH as the only starting organic compound.

(19) **1997 A/L**

a) The organic compound *P* contains 47.4% carbon, 2.63% hydrogen, 18.4% nitrogen and oxygen only. The relative molecular mass of P is about 150. Determine the molecular formula of P. (H = 1; N = 14; O = 16; C = 12)

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c) Indicate how you would chemically distinguish between the two compounds in the following pairs.

i) $CH_3CH_2\underset{(A)}{CH}=CH_2$ and $CH_3CH=\underset{(B)}{CH}CH_3$

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(20) **1998 A/L**

a) *Y* is a gaseous hydrocarbon 15 cm^3 of *Y* was mixed with excess of oxygen gas. This mixture was ignited by an electrical method, and it was allowed to attain normal temperature and pressure.
Then it was observed that the volume of the gaseous mixture decreased by 30cm^3. When this gaseous mixture was treated with a solution of concentrated KOH, the volume of the gaseous mixture decreased further by 45 cm^3. Calculate the molecular formula of *Y* in the usual manner.
N.B. Assume that all of the above volumes were measured at s.t.p.

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(21) **1999 A/L.**

a) The organic compound, *Y* contains *C*, *H* and *O* only. When *Y* is subjected to complete combustion, CO_2 and H_2O are obtained in the mole ratio of 2 : 1, respectively. The accurate relative molecular mass of *Y* is equal to 152. The percentage of *O* in *Y* is less than 40% by weight. Determine the molecular formula of *Y*.

The relevant relative atomic masses are as follows:
(C = 12.0; H = 1.00; O = 16.0)

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b) *A* and *B* are two alkynes. *A* and *B* were reacted as shown below, and *C* and *D* were obtained, respectively.

$$A \xrightarrow{H_2/Pd} C$$

$$B \xrightarrow{H_2/Pd} D$$

The molecular formula both *C* and *D* were C_4H_8. *C* and *D* reacted as follows.

$$C + HBr \xrightarrow[\text{conditions}]{\text{Under polar}} \text{An equi -molar mixture of optically active compounds}$$

$$D + HBr \xrightarrow[\text{conditions}]{\text{Under polar}} \text{The same equi-molar mixture of optically active compounds mentioned above}$$

i) You are supplied with a mixture containing both *A* and *B*. How would you attempt to obtain either pure *A* or pure B from this mixture by a chemical method?

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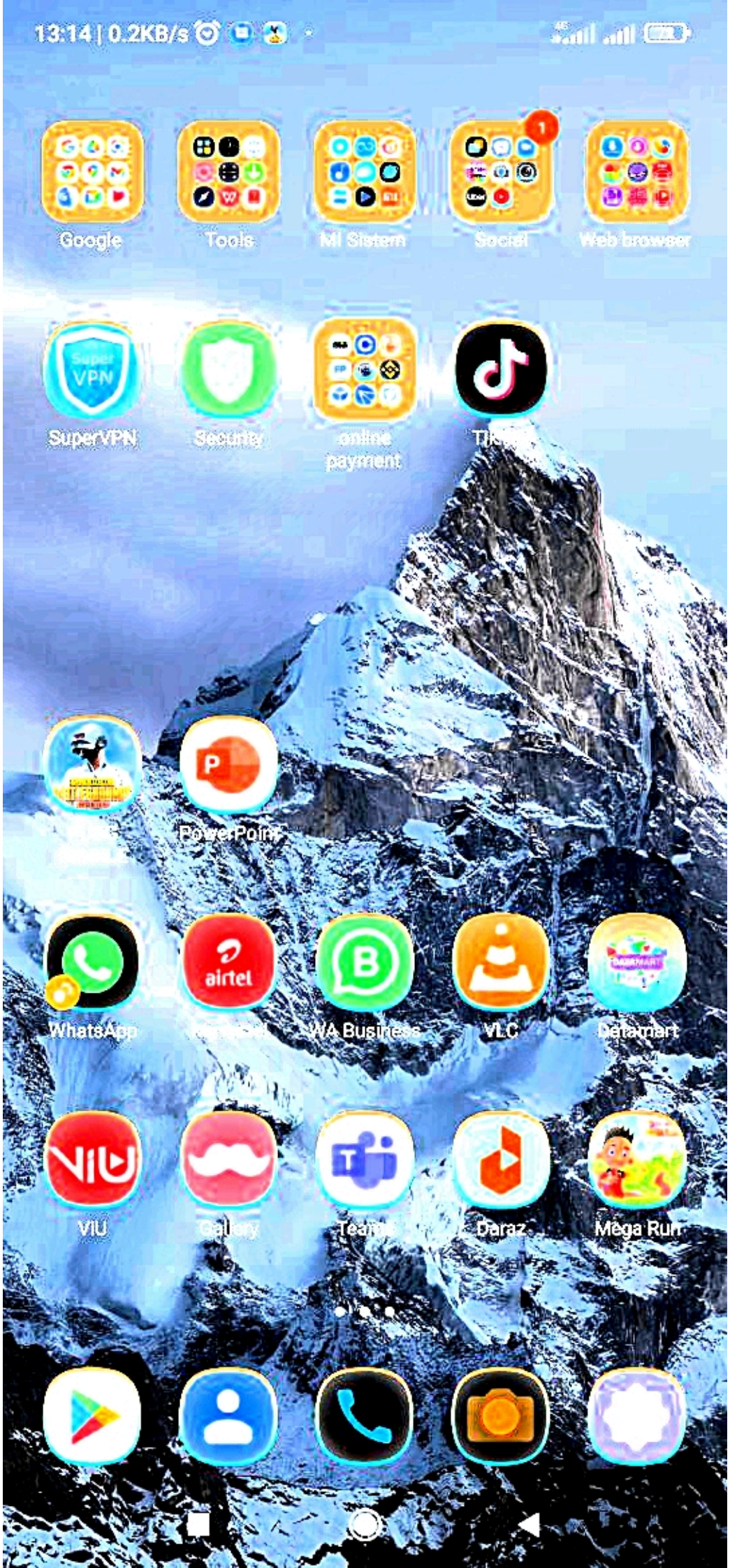
ii) Draw the structures possible for the compounds *C* and *D*.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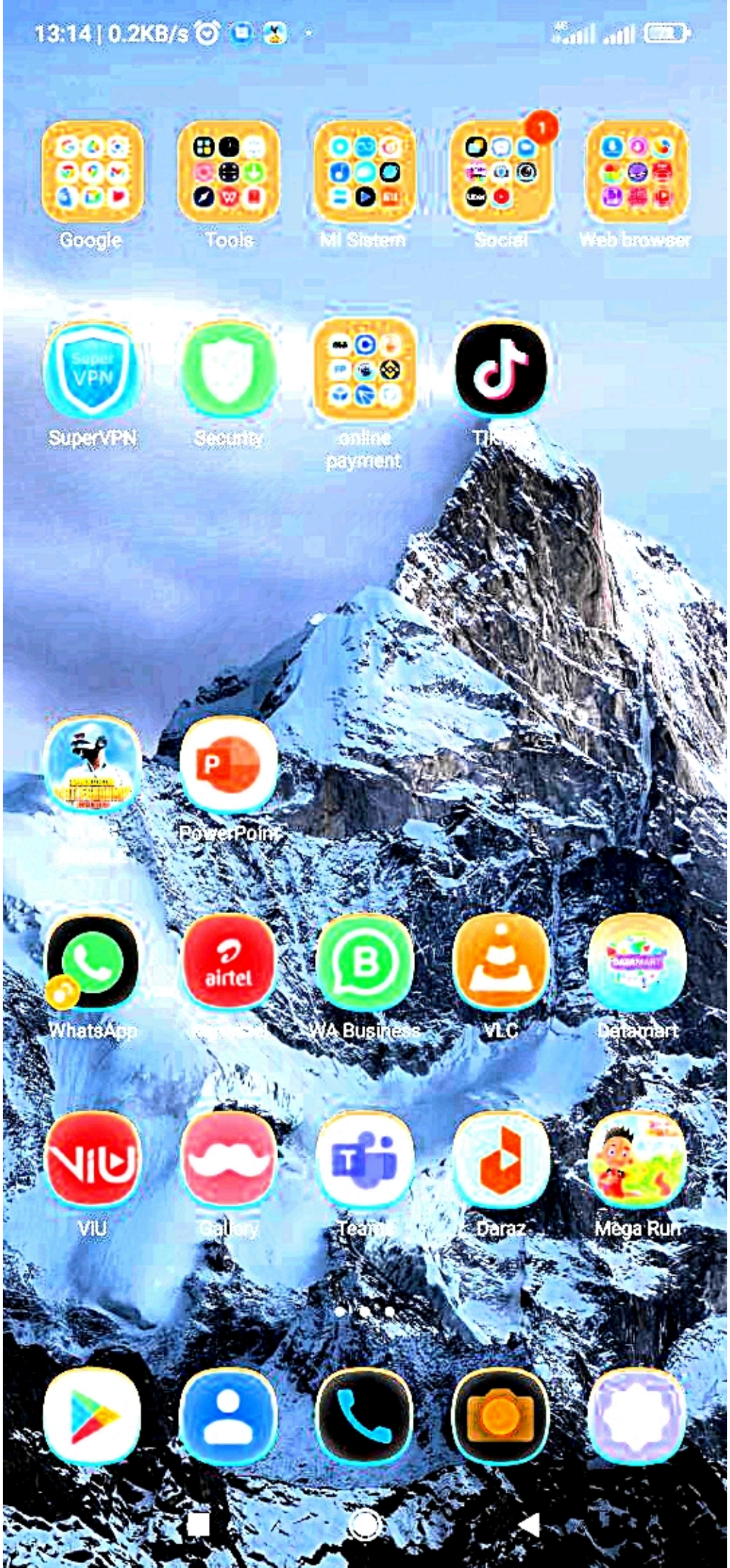
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online payment
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i) Write the structural formulae of the compounds *C*, *D*, *E*, *F* and *G* in the relevant boxes
ii) Write the reagents and conditions corresponding to *X* in the relevant box.
iii) Write the reagents corresponding to *Y* and *Z* in the relevant boxes.

(23) **2001 A/L**

a) A compound *X* of molecular formula $C_8H_{18}O_6$ contains hydroxyl groups. When *X* is reacted with excess ethanoyl chloride, the product obtained has a relative molecular mass of 378. Calculate the number of hydroxyl groups in *X*.
(Relative atomic masses : C = 12; H = 1; O = 16; Cl = 35.5)

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b) Three isomeric amines *A*, *B* and *C* (molecular formula $C_4H_{11}N$& on reaction with $NaNO_2$/ HCl produces three alcohols *D*, *E* and *F* (molecular formula $C_4H_{10}O$) respectively. Although *D* reacts quickly with Lucas reagent, *E* and *F* do not react with Lucas reagent at room temperature. *D* is not easily oxidized. *E* and *F* can be oxidized to *G* and H respectively. Both *G* and *H* form precipitates with Brady's reagent and also reduces Fehling's reagent. Write possible structures (see instruction box in page 1) for *A*, *B*, *C*, *G* and *H* in the relevant boxes below.

A

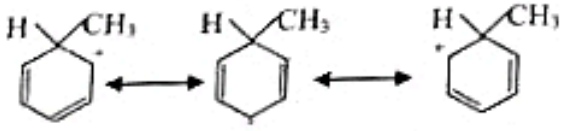
B

C

G

H

c) i) The intermediate represented by the resonance structures.



Occurs in a reaction leading to the synthesis of toluene
I) Write the reactants and reagents that give this intermediate.

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II) Write below a mechanism to explain the formation of the intermediate.

ii) Methyl chloride is formed as a major product, when equimolar amounts of CH_4 and Cl_2 are reacted in the presence of light.

I) Write two steps in the mechanism of the above reaction in which methyl chloride is a product (Methyl chloride should be a product in each of these two steps) Indicate electron movements.

II) "Ethane is also formed but only in a very small quantity in the above reaction." Explain this.

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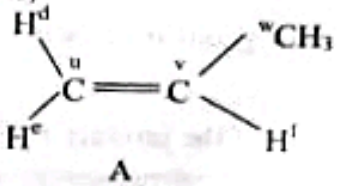
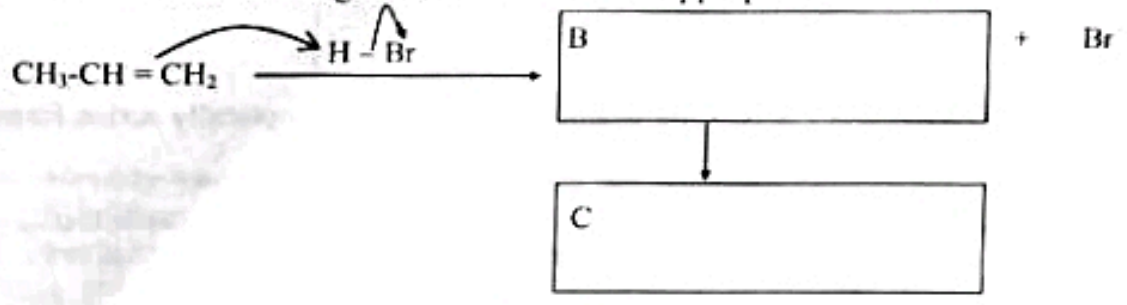
(24) **2002 A/L**

a) Consider the molecule *A* given below. (Superscripts *d*, *e*, *f*, *u*, *v* and *w* are used to label the *H* and *C* atoms)



A

i) A part of the mechanism of the reaction of *A* with HBr is depicted below. Writing the structures corresponding to B and C in the boxes below complete the mechanism using curved arrows where appropriate.



ii) The following statements refer to *A* and its reaction with HBr. Indicate whether each of these statements is correct (☑) or wrong (☒) in the appropriate box. If you are unable to evaluate any of these statements keep the box vacant.
N.B. For each correct answer 0.5 marks will be awarded.
For each incorrect answer 0.2 marks will be deducted.
If a box is kept vacant, no marks will be awarded or deducted.
However the minimum marks for this part [a) ii)] will be zero (0).

1) Carbon atom denoted by *u* is sp^2 hybridised. 1) ☐
2) Carbon atom denoted by *w* is sp^2 hybridised. 2) ☐
3) The double bond between *C* atoms denoted by *u* and *v* consists of a σ bond and π bond. 3) ☐
4) A π bond is formed by the lateral overlap of two sp^2 orbitals. 4) ☐
5) The bond between *C* atoms denoted by *v* and *w* is formed by the linear overlap of two hybridised orbitals. 5) ☐
6) All the atoms in A lie in the same plane. 6) ☐
7) In this reaction bonds undergo heterolytic cleavage. 7) ☐
8) A curved arrow (↷) indicates the movement of an atom or a group of atoms, from one position to another. 8) ☐
9) This reaction is a nucleophilic reaction. 9) ☐

b) i) Write down in the box below, the structure of the acyclic hydrocarbon $D(C_6H_{12})$ which is optically active.
N.B. : It is not necessary to draw the three dimensional structure.

D

ii) Does this compound show geometrical isomerism?

.....

iii) Write down the structure of the product *E* formed when *D* is treated with H_2/ Pt.

iv) Giving a reason state whether *E* could exist in optically active forms.

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.....

v) Write down the structure of the product *F* formed when *D* is treated with Br_2 / CCl_4.

F

vi) How many asymmetric carbon atoms are there in the molecule *F*?

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(25) **2003 A/L**

a) Consider the following :

$CH_3CH = CHCH_3$, C_3H_7Br, CH_3COCH_3, aqueous HCl, aqueous HBr, CH_3CO_2H, CH_3OH, H_2SO_4, C_2H_5MgBr, benzene, conc. HNO_3 / conc. H_2SO_4

Selecting relevant reactants and reagents from amongst those given above.

i) Write down the mechanism for a nucleophilic addition reaction.

ii) Write down the mechanism for an electrophilic substitution reaction.

b) Consider the scheme of reactions given below.

$$C_4H_8 \underset{\text{ethanolic KOH}}{\overset{HBr}{\rightleftharpoons}} C_4H_9Br \xrightarrow[NaOH]{\text{aqueous}} C_4H_{10}O$$

(A) (B) (C)

$$C_4H_8 \xrightarrow{H_2 / Pt} C_4H_{10}$$

(A) (D)

Compound *A* exhibits geometric isomerism while compound *B* exhibits optical isomerism.

i) Write down the structure *B*.

Identify each of the carbon atoms in *B* which underwent a change in hybridization in its formation from *A*. Mark these carbon atoms by drawing a circle around each of them in the structure of *B* written by you above.

ii) Strike out the incorrect terms / symbols within the brackets in the sentences given below. Note that these sentences refer to the carbon atoms circled by you in i) above.

I) The hybridization changes from [sp / sp^2 / sp^3] in A to [sp / sp^2 / sp^3] in B

II) The geometry around the carbon atoms changes from

[Linear / planar triangular / tetrahedral / octa hedral] in A to
[Linear / planar triangular / tetrahedral / octa hedral] in B

iii) Name the reaction mechanism that operates in the conversion of

I) A ⟶ B .....

II) B ⟶ C .....

(26) **2004 A/L**

Selecting appropriate chemicals and solvents for the chemical reactions only the following list, answer parts a) and b).

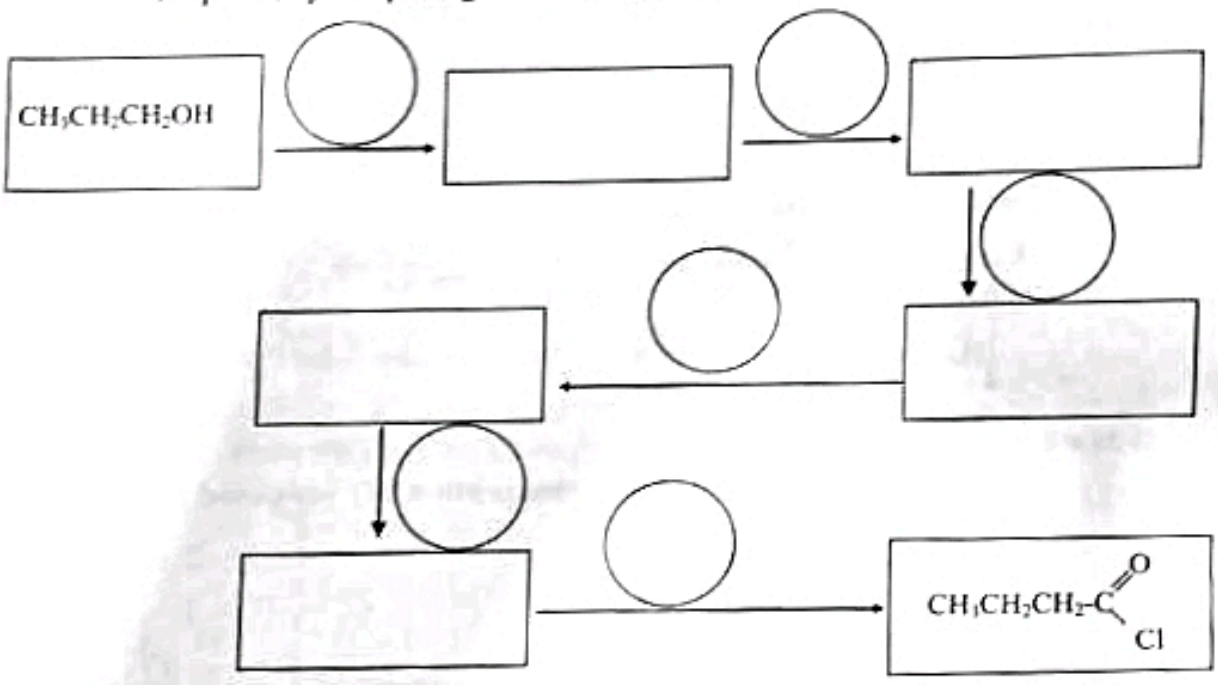
Conc. HCl, aqueous NaOH, aqueous NH_4OH, Mg, Fe, Zn(Hg), PBr_3, PCl_5, $AlCl_3$, Br_2, $KMnO_4$, $NaBD_4$, $NaBH_4$, Formaldehyde (HCHO), acetone (CH_3COCH_3) water, ethanol, ether CCl_4, D_2O (D = Deuterium)

Note

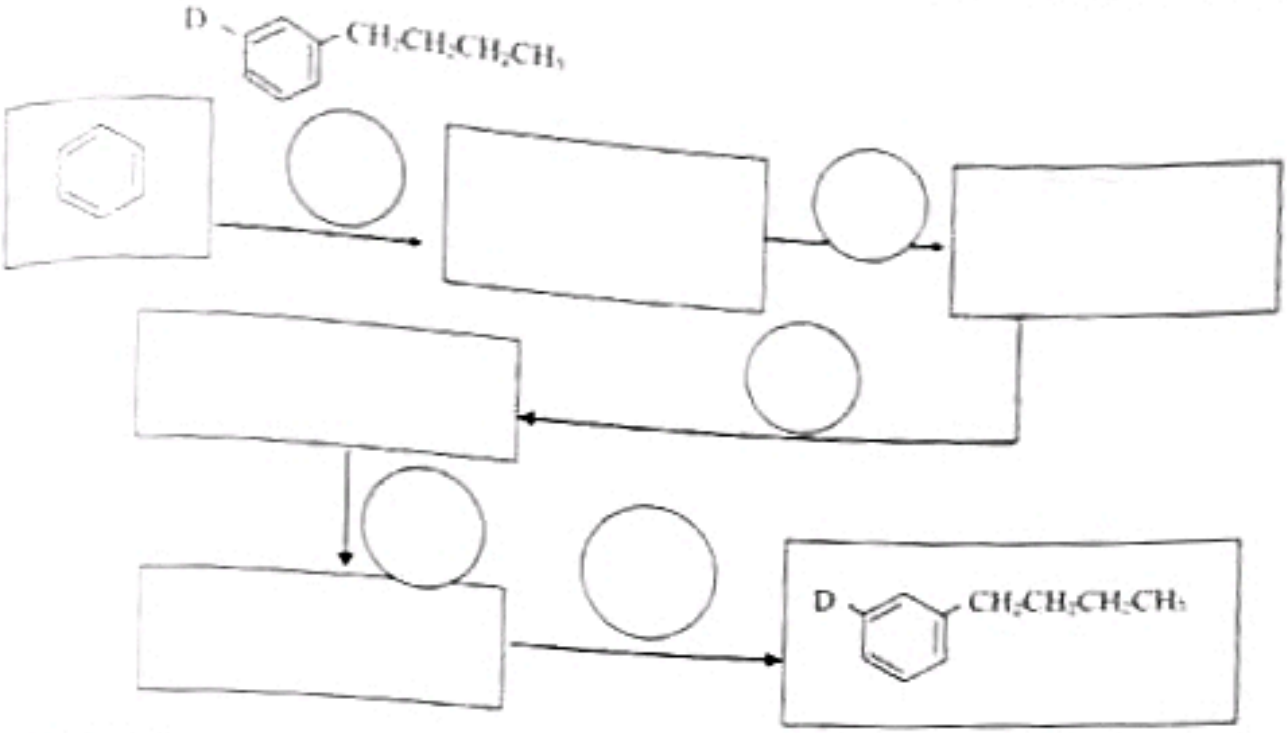
i) In the following schemes each arrow indicates a single reaction.

ii) Write in the boxes the structures of appropriate compounds and in the circles the appropriate reagents.

a) Show how you would prepare butanoyl chloride ($CH_3CH_2CH_2COCl$) from Propanol, by completing the scheme given below.

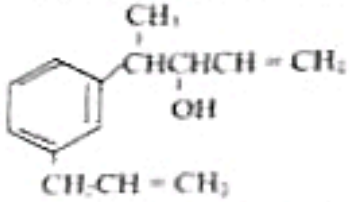


b) **Using butanoyl chloride** prepared in part a). Show how you would synthesize **the following compound** from benzene.



(27) **2005 A/L**

Selecting appropriate reagents and solvents only from the list below, show how you would synthesize the following compound.



List of reagents and solvents.

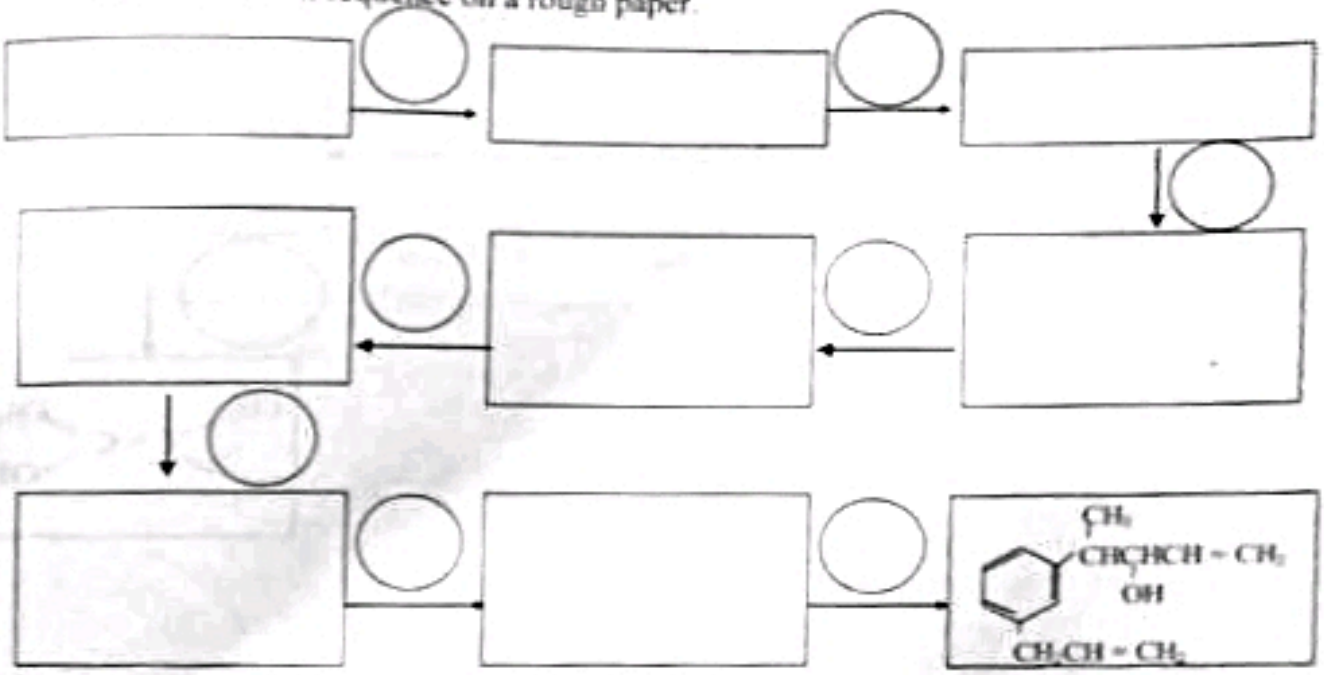
acetophenone ($C_6H_5COCH_3$)" Propenal ($CH_2 = CHCHO$) ,$AlCl_3$, PCl_5, Cl_2, I_2, $NaBH_4$, $KMnO_4$, Ag_2O, Mg, Zn(Hg), water, conc. HCl, aq. NaOH, acetone, ethanol, dry ether

Note

I In the following scheme each arrow indicates a single reaction.

II Write in the boxes the structures of the appropriate compounds and in the circles the reagents solvents required.

III Before filling the scheme on the answer script, you are advised to work out the correct reaction sequence on a rough paper.



(28) **2006 A/L**

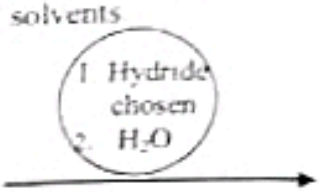
Selecting appropriate reagents and solvents for the chemical reactions involved only from the following list, answer parts a) and b)

acetone (CH_3COCH_3), aniline ($C_6H_5NH_2$)" bromobenzene (C_6H_5Br)" toluene ($C_6H_5CH_3$)" Mg, Fe, Pt, Br_2, PCl_5, NaCN, cuprous bromide (Cu_2Br_2)" $AlCl_3$, CH_3Cl, $NaBH_4$, $LiAlH_4$, $KMnO_4$, $NaNO_2$, conc. HNO_3, conc H_2SO_4, aq NaOH, dil. H_2SO_4 water, ethanol (C_2H_5OH), ether ($C_2H_5OC_2H_5$)

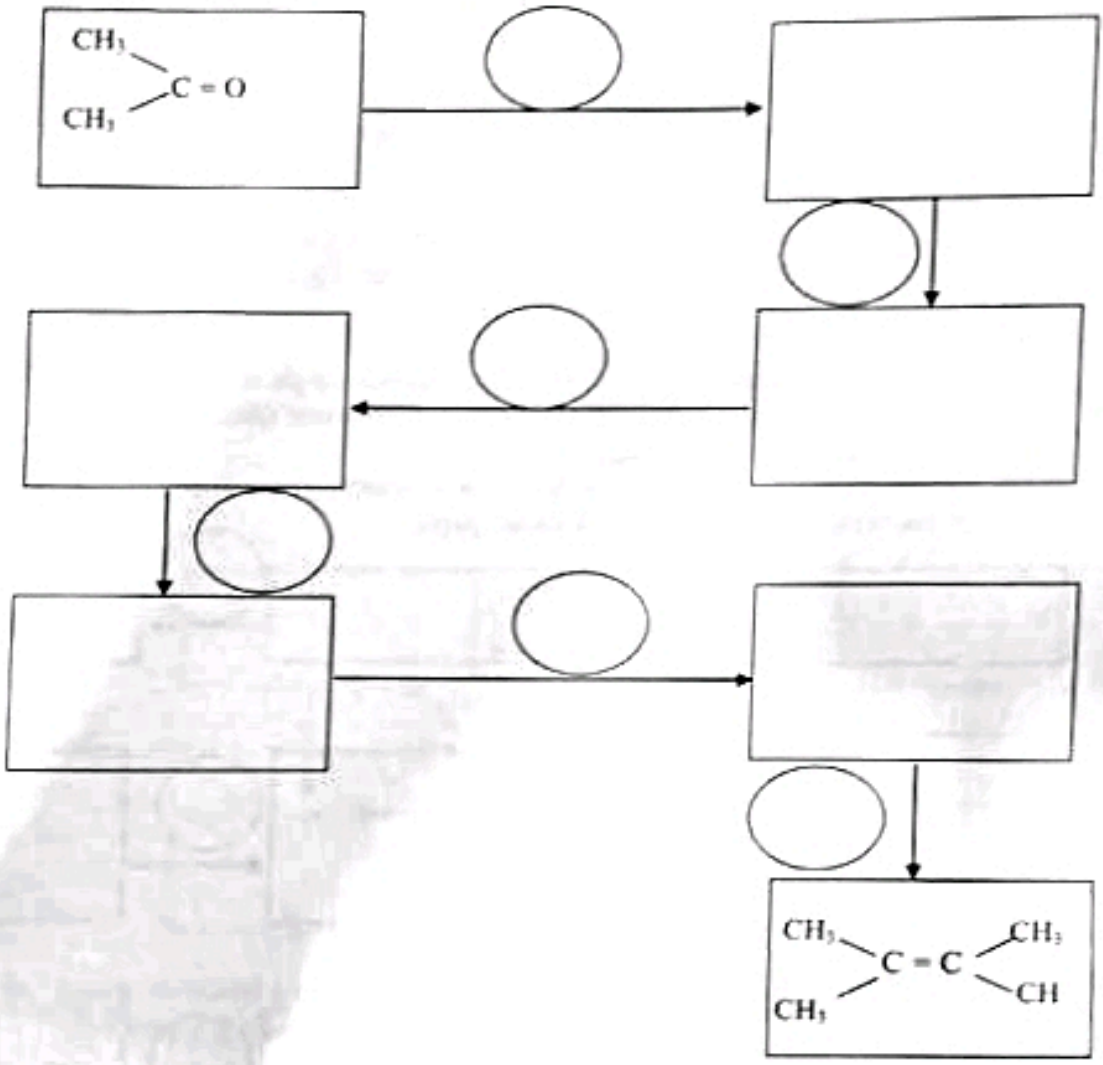
Note:

i) In the following schemes, write in the boxes the structures of the appropriate compounds and in the circles the appropriate reagents / solvents

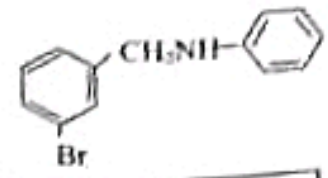
ii) Each arrow indicates a single reaction except in the case of hydride reduction followed by hydrolysis for which the reagents should be given in the same circle as shown below.



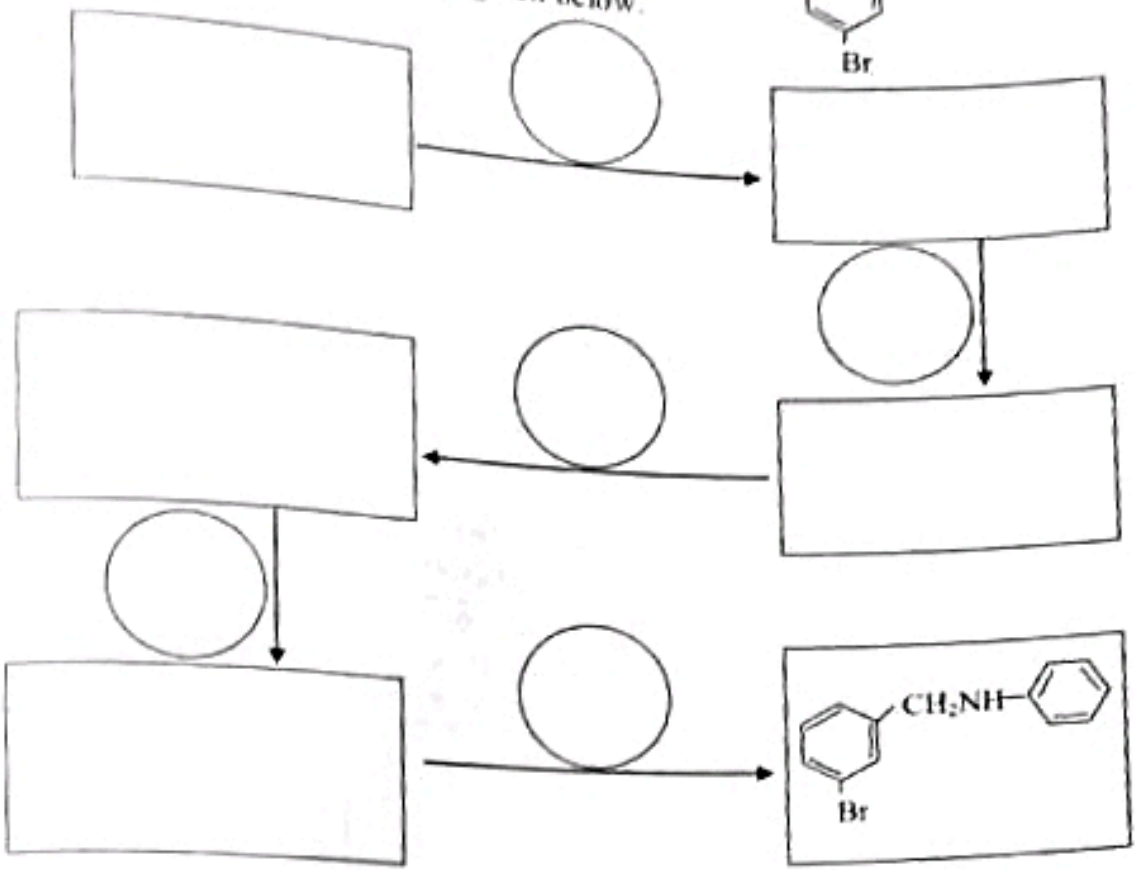
a) Show how you would prepare 1, 1, 2, 2-tetramethylethane from acetone by completing the scheme given below.



b) Show how you would synthesise the compound



By completing the scheme given below.



(29) **2007 A/L**

a) The elements present in an organic compound *A* and their mass percentages are given below.

	C	H	N	Cl
mass %	55.6	6.2	10.8	27.4

i) Deduce the empirical formula of A (C = 12, H = 1.0, N = 14, Cl = 35.5)

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ii) A is soluble in water and the solution is acidic. An aqueous solution containing 1.30 g of A required 25.0 cm^3 of 0.40 mol dm^{-3} NaOH solution when titrated using phenol phenopthalein as the indicator. Determine the relative molar mass of *A*. (1 mol of A reacts with 1 mol of NaOH)

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iii) Write the molecular formula of *A*.

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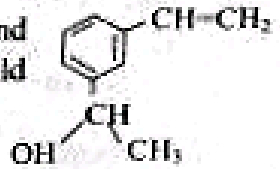
iv) A undergoes the following reaction.

$$A \xrightarrow[0-5\ ^\circ C]{\text{aq. } NaNO_2} B \xrightarrow[0-5\ ^\circ C]{C_6H_5OH,\ \text{aq. NaOH}} C$$

Further, an aqueous solution of A gives a white precipitate with $AgNO_3$ solution. Write the structures of *A*, *B* and *C* in the relevant cages.

A B C

b) Starting from benzene and selecting appropriate reagents and solvents only from those given below, show how you would synthesize the compound.



Reagents and solvents.

$AlCl_3$, PCl_5, Br_2, I_2, $LiAlH_4$, Zn(Hg), Mg, Fe, $K_2Cr_2O_7$, CH_3COCH_3, CH_3COCl, CH_3CHO, dil H_2SO_4, water, aq. NaOH, dry ether, ethanol.

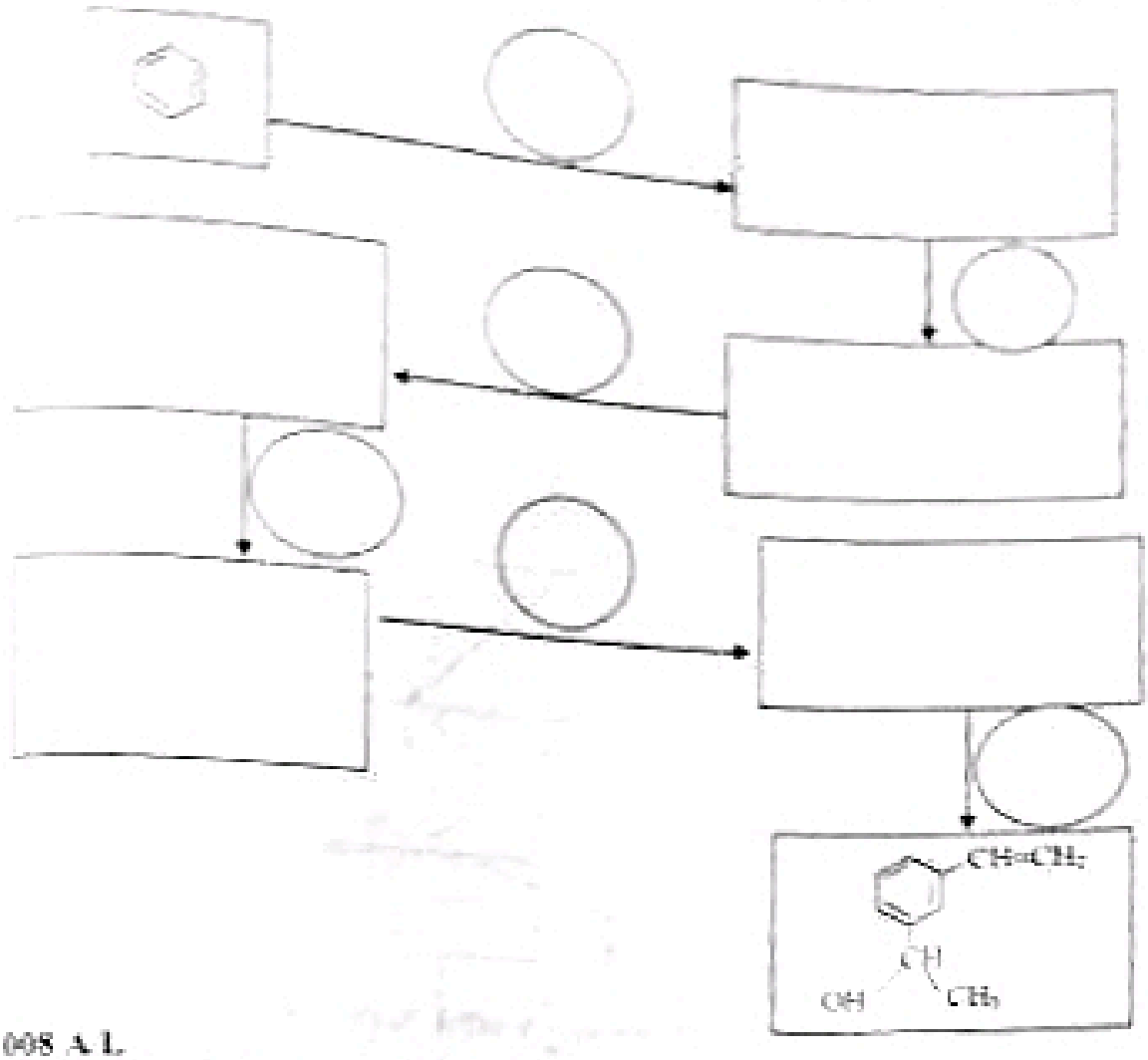
In the following scheme, each arrow indicates a single reaction

However, consider

A) Reaction with $LiAlH_4$ followed by hydrolysis and

B) Reaction with RMgX followed by hydrolysis as a single reaction

a) Write in the boxes the structures of the appropriate compounds and in the circles the reagents / solvents required.



2008 A L

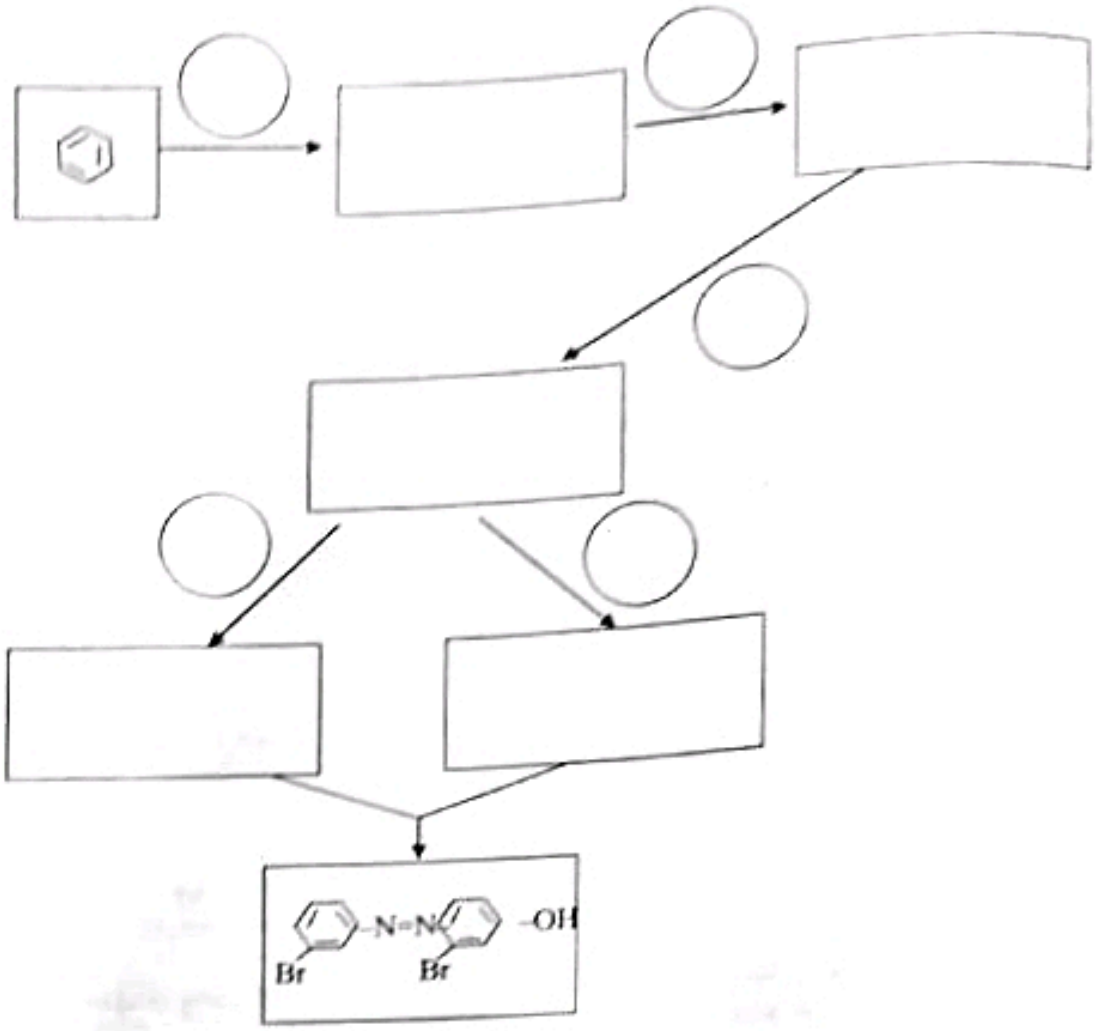
Complete the following synthesis schemes *A* and *B* selecting reagents and solvents only from those given with each scheme.

- Write the structure of appropriate compounds in the boxes and the reagents / solvents in the circles.
- Indicate temperature where important.

i) Scheme A

Reagents and solvents:

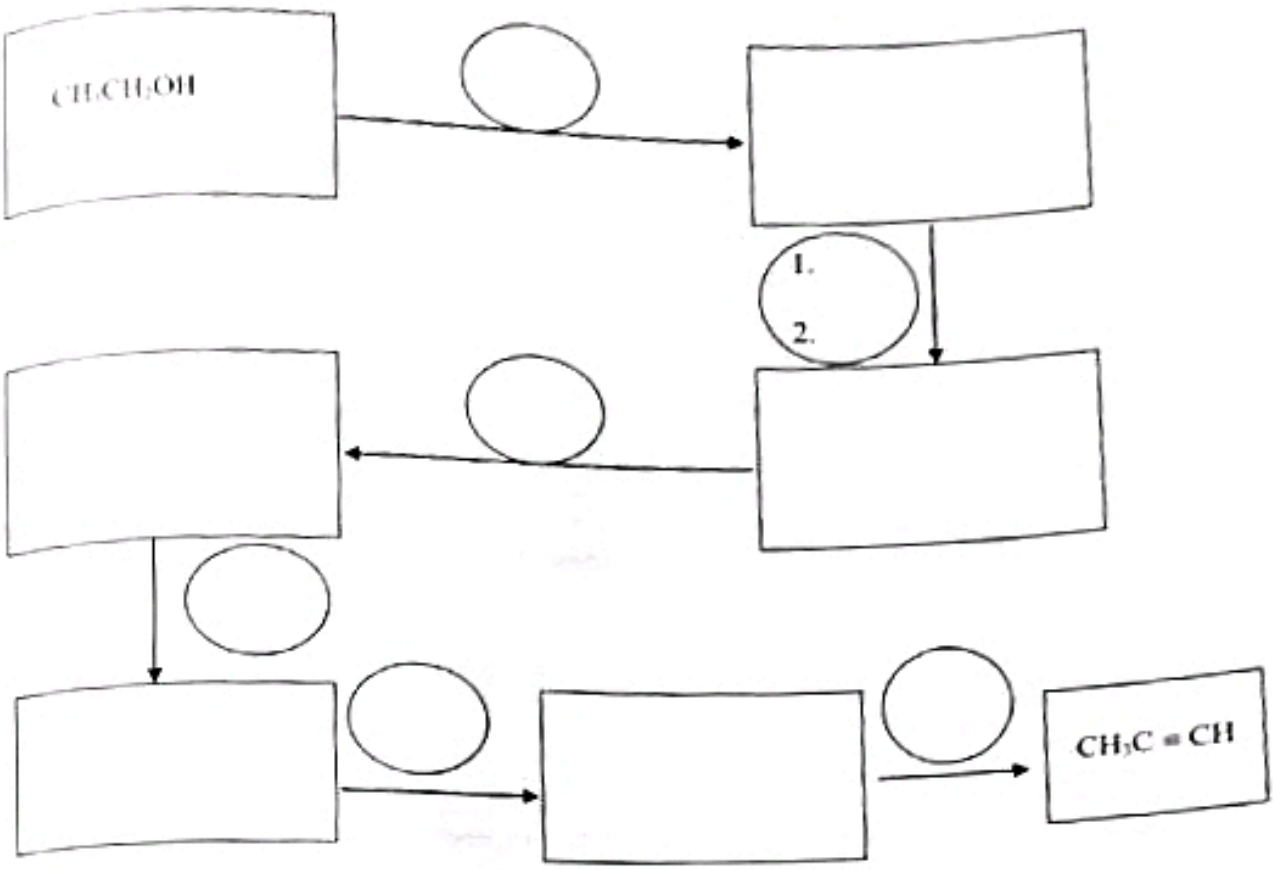
dil. HCl, conc. HCl , conc. H_2SO_4, conc. HNO_3, aq. NaOH, $NaNO_2$, CuBr, Br_2, $FeBr_3$, Fe, PBr_3, $LiAlH_4$, Sn



ii) **Scheme B**

Reagents and solvents

conc. H_2SO_4, Br_2, $FeBr_3$, PBr_3, HCHO, alcoholic KOH, CH_3CHO, Mg, Fe, dry ether, H_2O



(31) **2009 A/L**

a) An industrially important organic compound *X*, contains carbon, hydrogen and oxygen only.

i) Write a balanced chemical equation for the complete combustion of *X* taking its molecular formula as $C_xH_yO_z$.

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ii) The combustion of 62 mg of *X* (relative molecular mass, (M = 62) gives 88 mg of CO_2 and 54 mg of H_2O. Deduce values for *X*, *Y* and *Z* in the molecular formula $C_xH_yO_Z$ (C = 12.0 H = 1.0, O = 16.0)

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iii) The reaction of 62 mg of *X* with sodium gives 2 mg of hydrogen gas. Deduce the structure of *X*.

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d) An optically active compound, $C_6H_{12}O$, gives a yellow precipitate with 2,4 – dinitrophenylhydrazine but does not react with ammonical silver nitrate. What is the structure of the compound?

(32) **2010 A/L**

a) i) Draw the structure of 2 – methylpropene

ii) Draw in the boxes *P* and *Q* respectively, the structures of the major product and the minor product formed when HBr is added to 2 – methylpropene.

P – Major product

Q – Minor product

iii) Propose a mechanism for the addition of HBr to 2 – methylpropene, explaining why the structure drawn in box *P* is the major product. [Hint: In answering this, pair utilizes your knowledge of the mechanism of addition of HBr to propene, and the stability of carbonations.

b) Compound *A* (molecular formula, $C_6H_{14}O$) exhibits optical isomerism. It reacts with acidic $K_2Cr_2O_7$ at room temperature and gives a carboxylic acid.

(i) Draw possible structures for *A* in the boxes given below.

(ii) Compound *A* when heated with conc. H_2SO_4 gives compound *B* (molecular formula, C_4H_{10})
Compound *B* also exhibits optical isomerism. Draw the structures of *A* and *B* in the relevant boxes.

A B

(iii) When *B* is reacted with HBr compound *C* is obtained as the major product. Compound *C* when reacted with alcoholic KOH gives compounds D and E. Compounds *D* and *E* are structural isomers of *B*. Draw the structures of *C*, *D* and *E* in the boxes given below.

C D E

(iv) Both compounds *D* and *E* when reacted separately with dil. H_2SO_4 give the same compound *F*. Compound F is a structural isomer of *A*. Draw the structure of F in the box given below.

F

(3) **2011 A/L**

a) i) State the characteristic type of reaction that benzene undergoes.

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ii) Give the structure of the product and the mechanism, for the reaction between benzene and $(CH_3)_2CHCl$ in the presence of anhydrous $AlCl_3$.

iii) Explain the stability of the intermediate formed from benzene in the above reaction.

iv) Draw the structure of the expected major product when benzaldehyde (C_6H_5CHO) is reacted with $(CH_3)_2CHCl$ in the presence of anhydrous $AlCl_3$.

b) *A*, *B* and *C* are isomeric, optically inactive, monosubstituted aromatic compounds with the molecular formula $C_{10}H_{14}O$.

- A reacts readily with conc. HCl in the presence of anhydrous $ZnCl_2$ to give the corresponding halide, while B and C do not react with the same reagent at an appreciable rate.
- *B* and *C* when reacted with pyridinium chlorochromate give compounds *D* and *E*, respectively. *D* undergoes aldol type condensation in the presence of dil. NaOH while E does not.

i) Draw the structures of *A*, *B*, *C*, *D* and *E* in the relevant boxes given below.

A B C

D E

- *B* when heated with conc. H_2SO_4 gives *F*.
- *F* when reacted with HBr gives *G*.

ii) Draw the structures of *F* and *G* in the relevant boxes given below.

F G

iii) Draw the structures of the three products formed, in the boxes given below, when G is reacted with alcoholic KOH.

iv) State whether G could exist as stereo isomeric forms.

v) Explain your answer in iv) above.

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(5D) 2017 A/L

a) The alcohols *A*, *B*, *C* and *D* are structural isomers of each other having the molecular formula $C_4H_{10}O$. *A*, *B*, and *C* show optical isomerism.

i) Draw possible structures for *A*, *B*, and *C*

When *B*, *C* and *D* are reacted with acidic $K_2Cr_2O_7$, *X*, *Y* and *Z* are formed respectively. The product *X*, *Y*, and *Z* can be converted back to *B*, *C* and *D* respectively by reacting with $NaBH_4$.

ii) What is the structure of *A*?

On heating with conc. H_2SO_4 A and *B* gave *E* and *F*, respectively, while *C* and *D* gave the same product *G*. *G* shows diastereoisomerism. All three compounds *E*, *F* and *G* have the molecular formula C_4H_{10}. When E and F are reacted with HBr the same product *H* was formed.

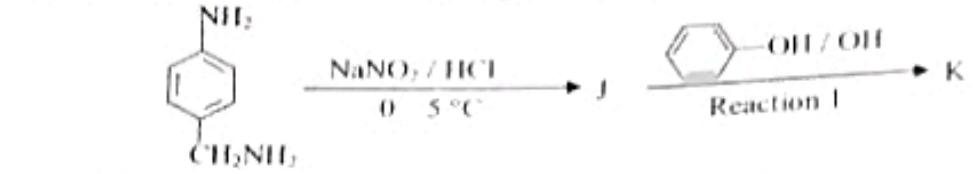
iii) Draw the structures of *B*, *C*, *D*, *E*, *F* and *H*

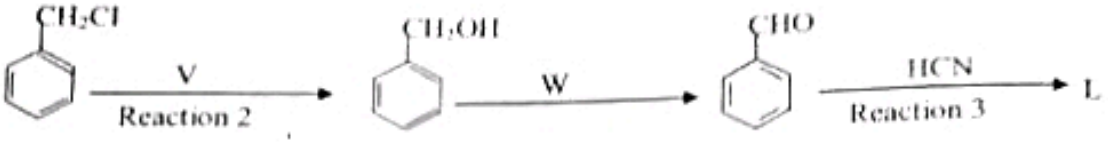
B C D

E F G

iv) Draw the structures of the diastereoisomers of *G*.

b) Consider the two reaction schemes given below.





i) Draw the structures of J, K and L in the boxes given below.

J K L

ii) Write the reagents V and W in the boxes given below.

V = W =

iii) Writing A_E, A_N, S_E, S_N or E in the appropriate box, classify each the reactions 1, 2 and 3 as electrophilic addition (A_E), nucleophilic electrophilic substitution (S_E), nucleophilic substitution (S_N) or elimination (E) reaction.

Reaction 1 Reaction 2 Reaction 3

c) i) What is the structure of the major product of the reaction between $CH_3CH{=}CH_2$ and HBr?

ii) Write the mechanism of the above reaction.

(1) **1980 AL**

a) i) Under which conditions and how does bromine reacts with benzene?

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(2) **1981 AL**

a) A neutral organic compound named $A(C_xH_yO_z)$ contains 54.55% of carbon. It does not decolorize bromine water and also does not produce a precipitate with Brady's reagent. (RAM of A = 88, RAM of C = 12, O = 16; H = 1)

i) What is the most possible molecular formula for *A*?

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ii) What is the empirical formula of *A*

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iii) What are the possible structures for *A*.

iv) Write the IUPAC name for one of the possible structures of *A*.

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b) Give the necessary reagents and conditions to do the following conversions in one step.

A .....

B .....

C .....

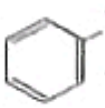
D .....

(3) **1981 AL (optional)**

a) State the products of each of the following reactions giving necessary conditions.

i) $(CH_3CH_2)_2CHOH + H_2SO_4 \rightarrow A$

ii) $C_6H_5\underset{\displaystyle CH_3}{\underset{|}{C}}HCH(OH)CH_3 + Cu \rightarrow B$

iii)  + conc. HNO_3 / conc. H_2SO_4 / 80°C ⟶ C

A -

B -

C -

b) If the products in a) i) and ii) shows isomerism, give your ideas.

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Indicate these isomers using suitable diagrams showing the important features clearly.

(4) **1982 AL**

a) An organic compound named *R* contains carbon, hydrogen, and oxygen only. When *R* is burnt completely CO_2 and H_2O result in equal moles. (RAM of C = 12; O = 16; H = 1)

i) When 5.80 g of *R* is burnt completely, 5.40 g of water was resulted. What is the empirical formula of *R*?

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ii) *R*, which has only one functional group gives an orange, red precipitate with 2, 4-dinitrophenylhydrazine reagent. What is the molecular formula of *R*?

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iii) When R reacts with hydrogen cyanide, a compound named T is formed with a chiral carbon. Draw the possible structures for R and T

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b) Draw the structures of the major products of the following reactions

i) $C_6H_6 \xrightarrow[\text{Anhydrous AlCl}_3]{CH_3COCl}$ product A

ii) RNH_2 (A) $\xrightarrow[\text{heat}]{1 \text{ mol of } CH_3CH_2Br}$ product B (B) $\xrightarrow[C]{HNO_2}$ product C

(5) **1983 AL**

a) State the reagents and the necessary conditions to do the following conversions as one step conversions.

i) $C_6H_5COCH_3 \longrightarrow C_6H_5CH_2CH_3$

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ii) $RCOONa \rightarrow RCOOCOCH_3$

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b) Draw the structures of the major products of the following reactions.

i) $C_2H_5OH + HCHO$

ii) $RMgX + CH_3COOH \rightarrow$

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d) Draw the possible structures of the compound W which possess a molecular formula of $C_8H_8O_2$, which decolorizes bromine water and which dissolves in a dilute sodium carbonate solution.

(6) **1984 AL**

a) Indicate how the following conversions could be effected in one step.
State the necessary reagents and reaction conditions.

i) 

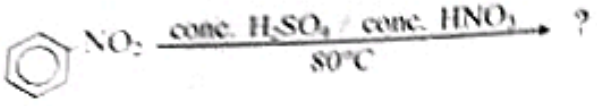
ii) 

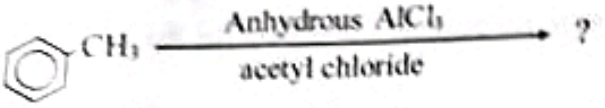
iii) 

b) Write down a mechanism for the following reaction.

$$CH_4 + 4Cl_2 \xrightarrow{\text{Sun light}} CCl_4 + 4HCl$$

c) State the structures of the major products result from the following reactions.





$(CH_3)_3CCl \xrightarrow{Mg\ /\ dry\ ether}$?

(7) **1985 AL**

a) Indicate how the following conversions could be effected? The necessary reagents and reaction conditions should be clearly stated at the appropriate places.

i) 

ii) 

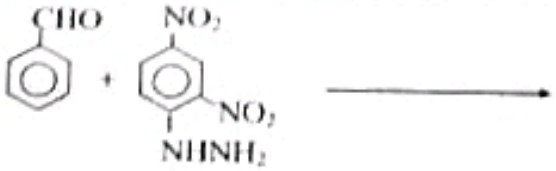
b) When benzene get nitrated by concentrated HNO_3 and concentrated H_2SO_4 under room temperature,

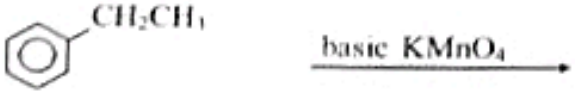
i) What would react with the benzene ring first?

.....

ii) Write down the structure of the intermediate form when it reacts on the benzene ring?

c) Draw the structures of the major products result from the following reactions.

i) 

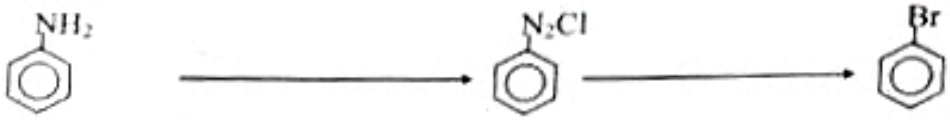
ii) 

iii) $CH_3CH_2CH_2CONH_2 \xrightarrow[\Delta]{P_2O_5}$

(8) **1986 AL**

a) Indicate how the following conversions could be effected in one step? State the necessary reagents and reaction conditions.

i) 

ii) 

b) i) Explain the chlorination mechanism of producing chloro methyl benzene (benzene chloride $C_6H_5CH_2Cl$) from methyl benzene (toluene $C_6H_5CH_3$) in the presence of sun light.

ii) State the structure of the intermediate forms when phenyl ethanone (aceto phenone $C_6H_5COCH_3$) forms from the reaction between benzene and ethanoyl chloride (acetyl chloride CH_3COCl) in the presence of anhydrous $AlCl_3$.

iii) Draw the structure of the main product forms when ethanoyl chloride and phenyl ethanone react in the presene of anhydrous $AlCl_3$

c) Write the structural formulae of the organic compound of the following reactions in the given space.

i) $CH_3\text{-}CHO$ + ... $\xrightarrow[\text{Heat}]{NaOH}$ $C_6H_5 - CH = CH - CHO$

ii) C_2H_5Cl + ... $\longrightarrow$ $C_6H_5 - O - C_2H_5$

(9) **1987 AL**

a) Indicate how the following conversions could be effected. The necessary reagents and reaction conditions should be clearly given at the appropriate places.

N. B. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) 

ii) 

b) Explain how **does 4 – nitro phenol act** as a stronger acid than phenol.

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(10) **1988 AL**

b) i) Show the mechanism of the reaction between $H_2C = CH_2$ and Br_2 under polar conditions.

ii) When $CH_3CH=CH_2$ reacts with IBr under polar conditions, the product obtain in large quantity is, $CH_3\underset{\underset{Br}{|}}{C}H - CH_2I$. How would you explain this?

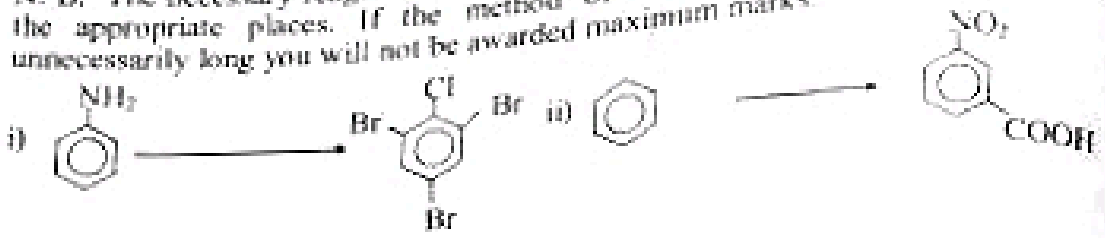
(11) **1989 AL**

a) i) Draw the structure of 5-bromo – 2 – nitrophenol

ii) Draw the structure of the acid 2, 2-dimethyl-4-hydroxypentanoic acid

b) Explain why does bromo group shows ortho-para directing ability when bromo benzene get nitrated.

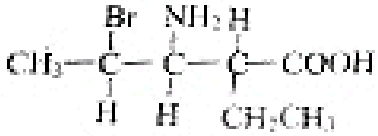
c) Indicate how the following conversions could be effected
N. B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long you will not be awarded maximum marks.



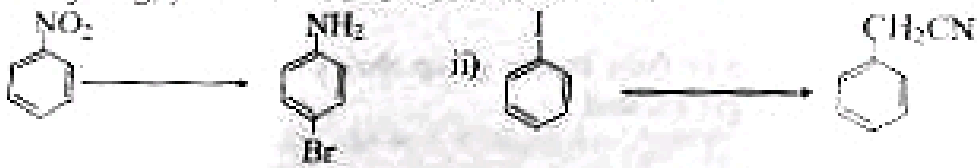
(12) **1990 AL**

a) i) Draw the structure of the compound given by the following name
5-chloro-2-phenyl-3-heptynal

ii) Name the compound with the following structure, in accordance with IUPAC nomenclature

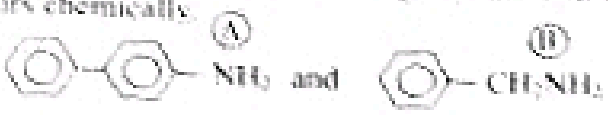


b) Indicate how the following conversions could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.



(13) **1991 AL**

a) Indicate how you would distinguish the two compounds given in the following pairs chemically.

i)  and

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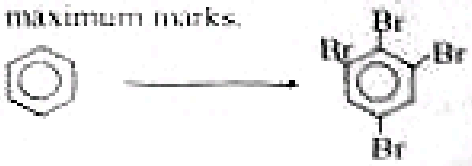
b) i) Indicate the mechanism of the addition reaction takes place in between $CH_3CH = CHCH_3$ and Br_2 under polar conditions.

c) Indicate how the following conversions could be effect.

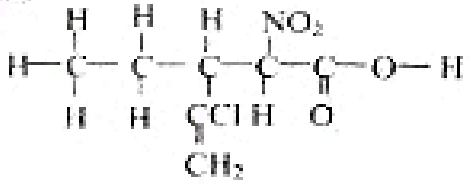
N.B.: The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long you will not be awarded maximum marks.

i) 

ii) 

(14) **1992 AL**

a) Name the compound with the following structure, in accordance with IUPAC nomenclature.



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b) When $C_6H_5COCH_3$ reacts with a mixture of conc. HNO_3 and conc. H_2SO_4, 3-nitro derivative produces. Considering the mechanism of this reaction, explain the above observation.

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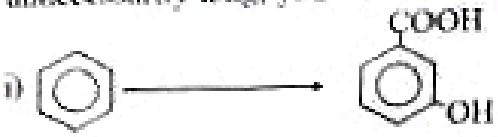
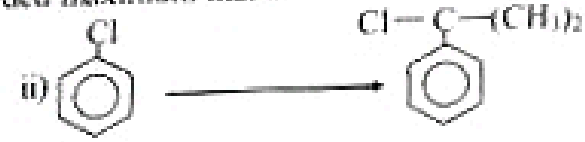
c) Indicate how the following conversion could be effected.
N. B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) 

ii) 

(15) **1993 AL**

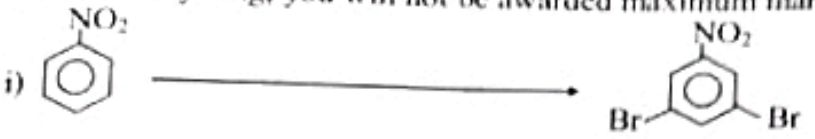
a) i) Present the mechanism for the addition reaction of Br_2 to C_2H_4.

ii) Draw the structure of the product formed when HCl added to $CH_3CH = CH_2$ in accordance with the above mechanism.

b) i) Molecular formula of the primary amine *B* is $C_4H_{11}N$. Draw all the possible structures for *B*.

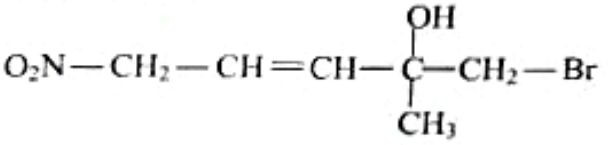
ii) If *B* shows optical activity and have enantiomers, draw the structure of the hydrochloride of *B*.

c) Indicate how the following conversion could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) 

(16) **1994 AL**

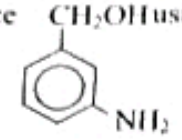
a) Name the compound with the following structure, in accordance with IUPAC nomenclature.



N.B. Neglect the geometrical and optical isomerism.

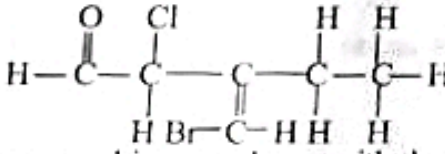
.....

b) Draw all the possible structures for the mono substituted benzene derivatives with the molecular formula C_8H_8O.

c) Indicate how the following conversions, could be effected
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropnate places If the method of conversion proposed by you is unnecessarily long, you with not be awarded maximum marks
i) Synthesize  using benzene as the only starting organic material.

ii) Synthesize $(C_6H_5)_3COH$ using benzene as the only starting organic material

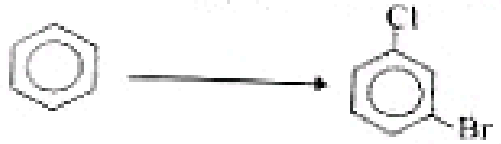
(17) **1995 AL**

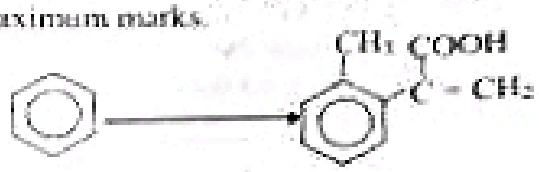
a)  Name IUPAC nomenclature the following compound in accordance with the IUPAC nomenclature.
NB : Disregard optical and geometrical isomerism

.....

b) When benzoic acid is reacted with a mixture of Conc. HNO_3 and conc. H_2SO_4, 3– nitrobenzoic acid is produced. Considering the mechanism of this reaction, briefly explain the above fact.

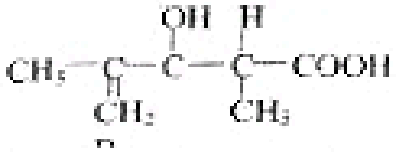
c) Indicate how the following conversions could be effected.
N.B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

i) 

ii) 

(18) **1996 AL**

a) Name the compound with the following structure in accordance with IUPAC nomenclature.
N. B.Disregard stereoisomerism.



.....

b) Give the mechanism relevant to the following addition reaction.

$C_2H_4 + Br_2 \longrightarrow BrCH_2CH_2Br$

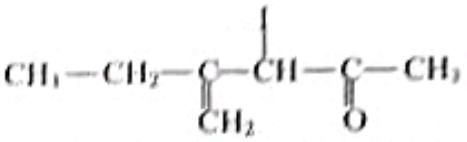
c) Indicate how the following conversions could be effected. The necessary reagents and reaction conditions should be clearly stated at the appropriate places.
N. B. If the method of conversion proposed by you is unnecessarily long, you will not be awarded full marks.

i) 

ii) 

(19) **1997 AL**

a) Name the compound having the structure in accordance with IUPAC nomenclature.



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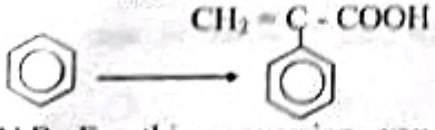
b) Give the mechanism of the substitution reaction that occurs between $CH_2 = CH_2$ and HBr in the presence of polar medium.

c) Indicate how the following conversions could be effected. The necessary reagents and reaction conditions should be clearly given at the appropriate places. N.B. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

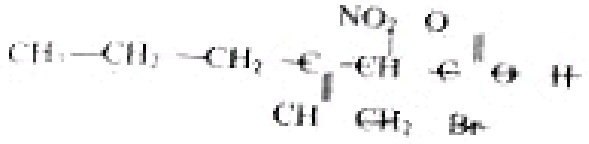
i) 

ii) $(CH_3)_2CHOH \longrightarrow \begin{matrix} CH_3 \\ \diagup \\ C = CHCH_2CH_3 \\ \diagdown \\ CH_3 \end{matrix}$

N.B. For this conversion, you are supplied with only $(CH_3)_2CHOH$ as an organic compound.

(20) 1998 AL

a) Name the compound with the following structure, in accordance with IUPAC nomenclature.



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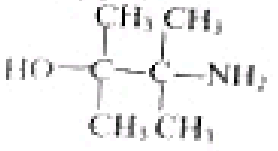
b) Indicate how you would distinguish between the two compounds in each of the following pairs.

i)  and 

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ii) $(CH_3)_2CHCOOCH_2CH_3$ (X) and $CH_3CH_2COOCH(CH_3)_2$ (Y)

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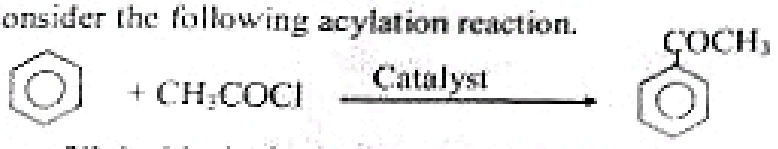
c) Consider the following acylation reaction.



Now, fill the blanks in the following sentences.

i) For this reaction, ... is a suitable catalyst.

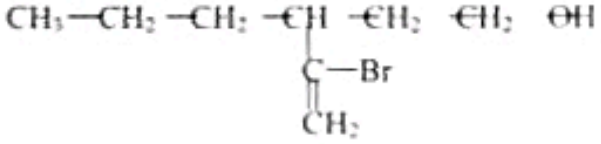
ii) In this reaction, ... is the ionic species that attacks the benzene ring.

iii) This attack is called ..... reaction.

d) Indicate how the following conversion could be effected.
N. B. The necessary reagents and reaction conditions should be shown clearly at the appropriate places. If the method of conversion proposed by you is unnecessarily long, you will not be awarded maximum marks.

(21) **1999 AL**

a) Name the compound with the following structure, in accordance with IUPAC nomenclature.



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c) i) A brief description pertaining to the reaction between aqueous KCN and the bromoalkane, $R_1R_2R_3CBr$ is given below.

"This reaction is called { a free radical/ an electrophillic/ a nucleophillic } { substition / addition } reaction."

Clearly cross out the inappropriate words out of the five words within the brackets.

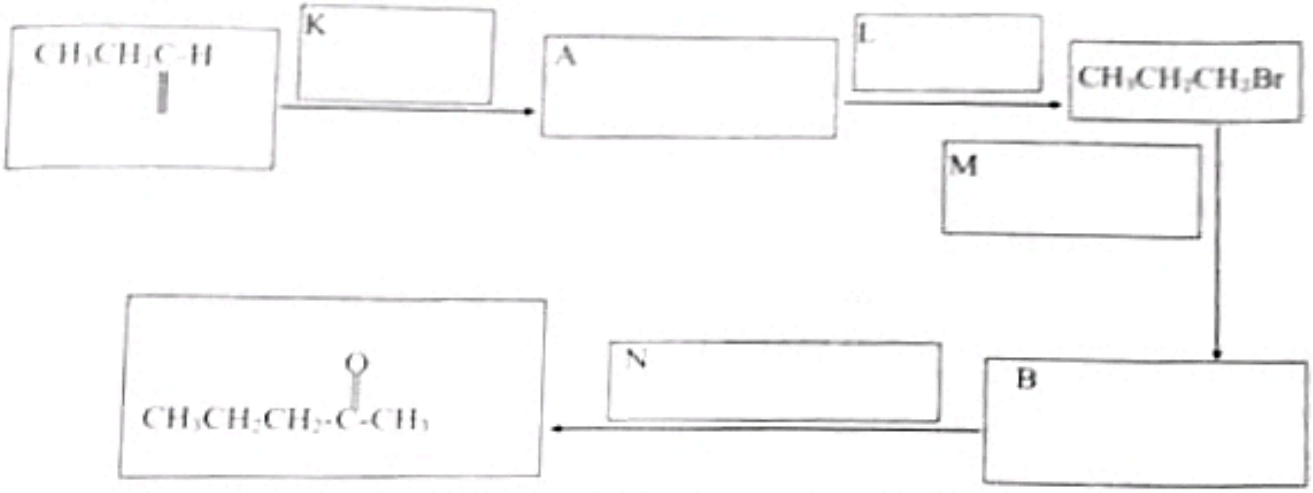
N.B. The appropriate words should be clearly visible. If your responses are not clear, you will not be awarded marks.

ii) Present clearly the mechanism of the reaction given in 4 c) i) above.

d) Propose a method for effecting the following conversion.
N.B. If the method of conversion proposed by you is unnecessarily long, you will not be awarded the maximum marks.

(22) **2000 A/L**

a) Consider the reaction scheme represented through the boxes below for the synthesis of pentan - 2 - one.



i) Write the structural formulae of the compounds *A* and *B* in the relevant boxes.

ii) Write the reagents corresponding to *K*, *L*, *M* and *N* in the relevant boxes.

c) Compounds *P*, *Q* and *R* all have the same molecular formula, C_7H_{14}. All three compounds exhibit optical isomerism. However, none of them is a geometrical isomer or an optical isomer of any of the others.

The three compounds *P*, *Q* and *R*, undergo catalytic hydrogenation to yield the same compound S with molecular formula, C_7H_{16}. *S* exhibits optical isomerism.

i) Write in the relevant box below, the possible structural formula for each of the compounds *P*, *Q*, *R* and *S*.

compound	structural formula
P	
Q	
R	
S	

ii) One out of the three compounds *P*, *Q* and *R* exhibits geometrical isomerism. Draw the structures of the two geometrical isomers of this compound in the cages below.

geometrical isomer I	geometrical isomer II

(23) **2001 AL**

a) i) A saturated non cyclic hydrocarbon C_nH_m has one asymmetric centre. Write the smallest possible numbers for n and m.

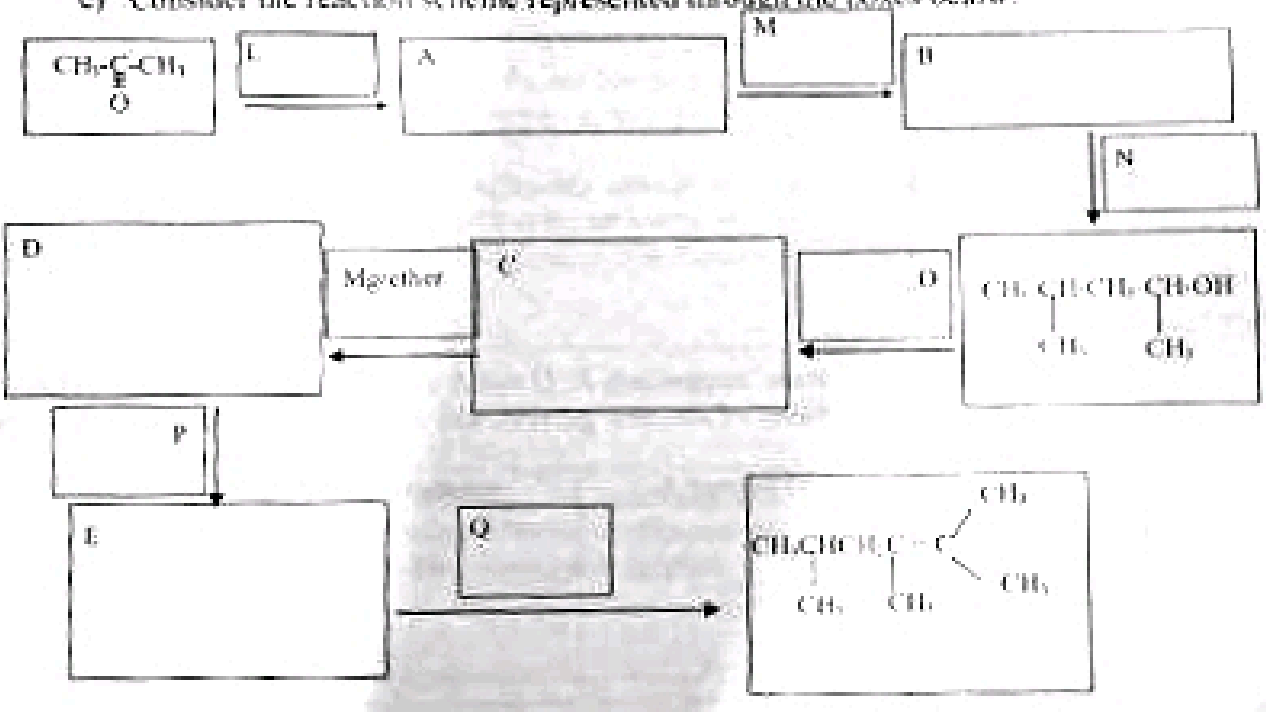
.....

ii) Write the structures (see instruction box on page 1) of the structural isomers of this hydrocarbon.

b) i) Without the use of catalytic hydrogenation, show how you would convert $CH_3CH_2C{\equiv}CH \rightarrow CH_3CH{=}CHCH_2CH_3$ utilizing not more than three steps.

ii) Without the use of CN ion as a reactant, show how you would convert $CH_3CH_2CH_2OH \rightarrow CH_3CH_2CN$ utilising not more than five steps.

c) Consider the reaction scheme represented through the boxes below.



i) Write the structures (see instruction box in page 1) of the compounds corresponding to *A, B, C, D* and *E* in the relevant boxes.

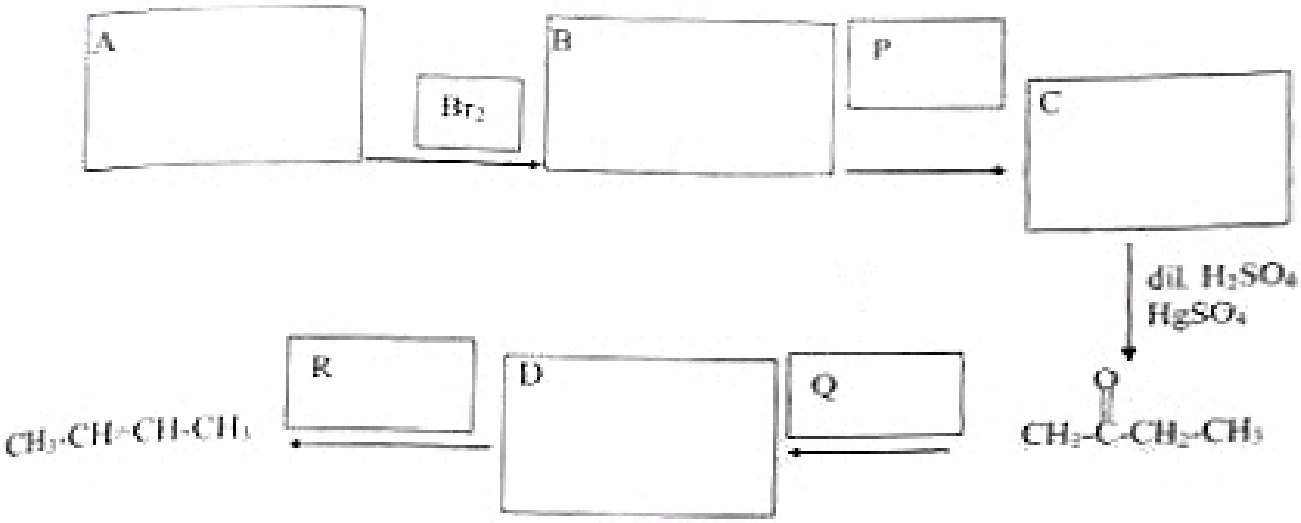
ii) Write the reagents corresponding to *L, M, N, O, P* and *Q*. Amongst these reagent the only organic compound allow as 2 – propanone.

(24) **2002 A1**

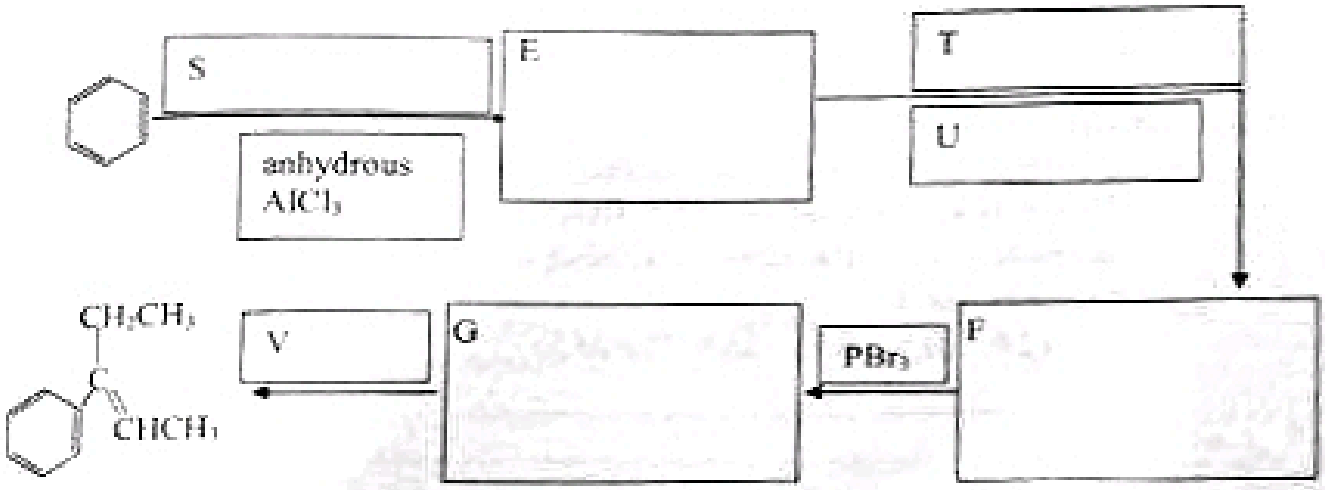
a) Consider the following reaction scheme

Write down in the appropriate boxes the structures corresponding to compounds *A, B, C, D, E, F* and *G*. Also indicate in the appropriate boxes the reagents corresponding to *P, Q, R, S, T, U* and *V*.

i)



ii)



b) Show how you would carry out the following conversion.

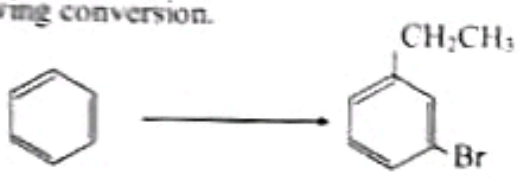
$C_6H_5COOH \longrightarrow C_6H_5CH = N - CH_2C_6H_5$

(The only organic compound which could be used as a reagent is C_6H_5CHO)

N.B: This conversion can be carried out in four steps. Marks will not be awarded to answers containing more than six steps.

c) Show how you would carry out the following conversion.

N.B: This conversion can be carried out in three steps. Marks will not be awarded to answers containing more than five steps.

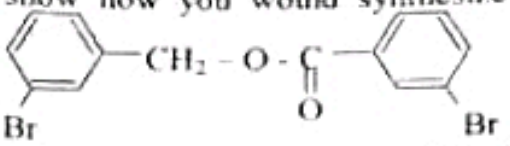


(25) **2003 AL**

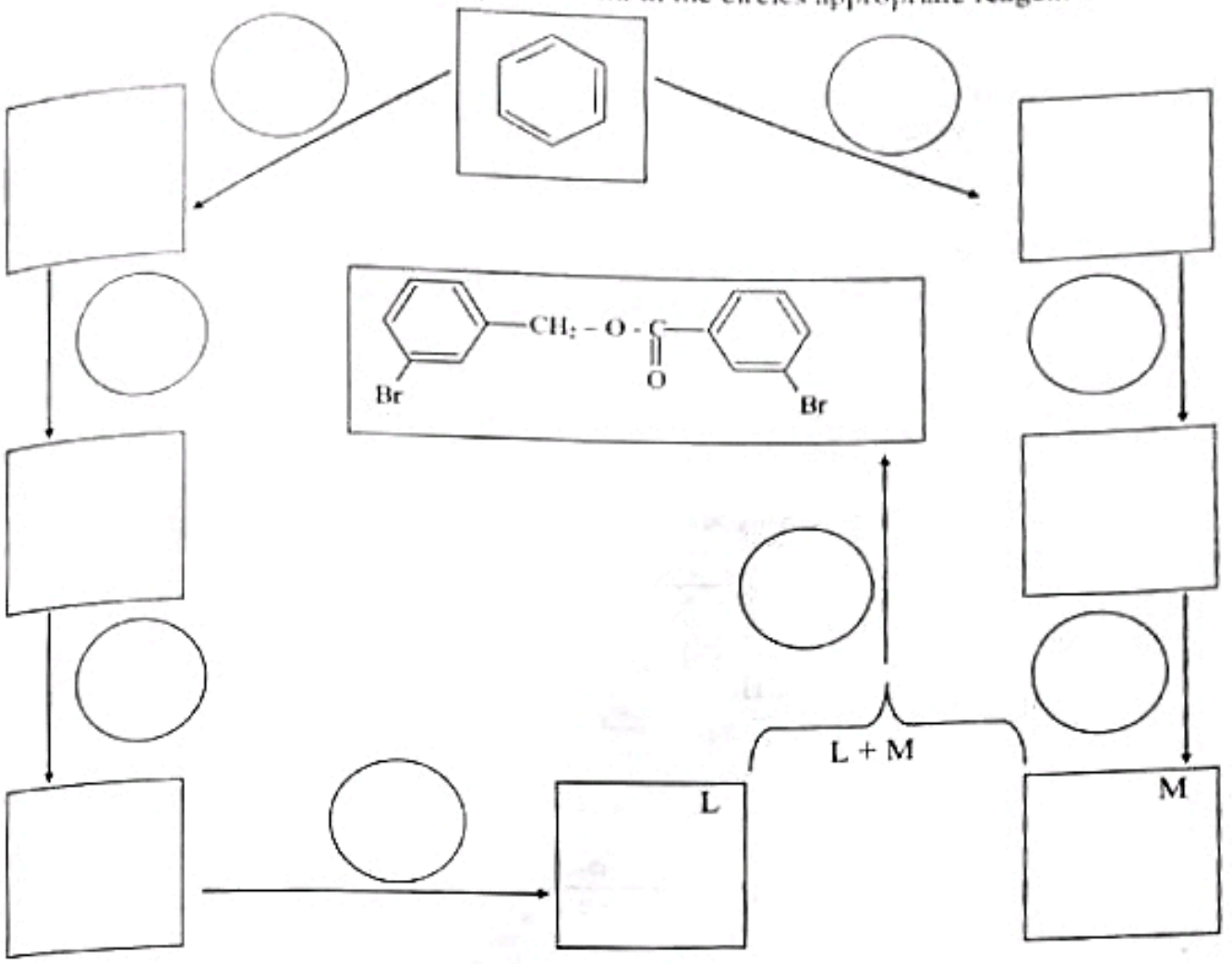
a) A compound $X(C_5H_{10}O_5)$ on reaction with PCl_5 gives a compound Y having a relative molecular mass of 205.5. Reaction of one mole of X with Na_2CO_3 gives one mole of CO_2. Calculate the number of alcoholic hydroxyl groups present in the compound X.

(C = 12.0; H = 1.0; O = 16.0; Cl = 35.5)

b) Using benzene as the starting meterial, show how you would synthesize the following compound.



By completin g the scheme given below. For this purpose, write in the boxes the structures of appropriate compounds and in the circles appropriate reagents.



(26) **2004 AL**

a) i) The relative molecular mass of a hydrocarbon *A* is 58.
Write the molecular formula of *A*. (C = 12.0; H = 1.0)

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ii) Write possible structures for *A*.

iii) When one mole of the acyclic hydrocarbon *B* is subjected to complete catalytic hydrogenation, it reacts with 2 moles of hydrogen and gives one mole of *A*. What is the structure of *A*?

iv) Write four possible structures for *B*

v) *B* reacts with ammoniacal Cu_2Cl_2 to give a red precipitate. What is the structure of *B*?

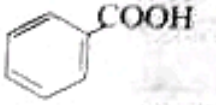
vi) *C* an isomer of *B*, gives *D* in the presence of dilute H_2SO_4 and $HgSO_4$ *D* reacts with an acidified alcoholic solution of 2,4-dinitrophenylhydrazine to give an orange precipitate, *E*. Write down the structures of *C*, *D* and *E*.

c) Consider the following reactions.

I) $CH_3-C(=O)-CH_3 \xrightarrow[\text{ethanol}]{HCN,\ KCN}$ A

II) $CH_3-CH_2-C(CH_3)_2-Br \xrightarrow{\text{aq. NaOH}}$ B

III) $CH_3-CH=CH_2 \xrightarrow[CCl_4]{Br_2}$ C

IV)  $\xrightarrow[\text{conc. } H_2SO_4]{\text{conc. } HNO_3}$ D

ii) Identify the mechanism type of the above reactions I) II) III) and IV) by writing I, II, III or IV in the appropriate cage in the second column of the following table. Also indicate the electrophile/ nucleophile in the appropriate cage.

Mechanism-type	Reaction No	Electrophile	Nucleophile
Electrophilic addition			
Electrophilic substitution			
Nucleophilic addition			
Nucleophilic substitution			

iii) Write the structure of the intermediate in reaction III).

(27) **2005 AL**

b) A compound ***X*** with the molecular formula, $C_9H_{12}O$ reacts,

i) With hot acidic $KMnO_4$ to give benzoic acid

ii) With sodium to give a colourless and odourless gas ***Y***, and

iii) With concentrated hydrochloric acid and zinc chloride to give a cloudy precipitate immediately.

Write the structure of ***X*** in the cage below.

X

Identify the gas ***Y*** in the cage below.

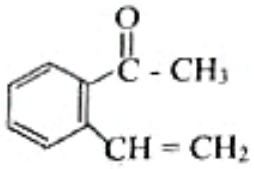
Y

c) Consider the following reactions. (I - V)

I) $CH_3CH_2I \xrightarrow{\text{aq. KCN}}$ P

II) $CH_3CH = CH_2 \xrightarrow[\text{ether}]{\text{HBr}}$ Q

III) $CH_3CHO \xrightarrow[\text{room. temp.}]{\text{dil. aq. NaOH}}$ R

IV)  $\xrightarrow[\text{ethanol}]{H_2, Ni}$ S

V)  $\xrightarrow[\text{conc. } H_2SO_4]{\text{conc. } HNO_3}$ T

i) ***P***, ***Q***, ***R***, ***S*** and ***T*** are the respective major products of the above reactions (I - V) Write their structures in the appropriate cages.

ii) Identify the mechanism type of each of the above reactions as,
Electrophonic addition (A_E).
Electrophonic substitution (S_E).
nucleophilic addition (A_N).
nucleophilic substitution (S_N).
Any other mechanism (M_O)

by writing A_E, S_E, A_N, S_N or M_O in the appropriate cage in the second column of the table below.
also write in the appropriate cages the electrophones in electrophonic reactions and the nucleophiles in nucleophilic reactions.

Reaction number	Mechanism-type (A_E, S_E, A_N, S_N or M_O)	Electrophile (in electrophilic reactions)	Nucleophile (in nucleophilic reaction)
I			
II			
III			
IV			
V			

iii) Write the structure of the intermediate in reaction V)

(28) **2006 AL**

a) ***A*** and ***B*** are isomeric hydrocarbons each having two sp-hybridized carbon atoms and two sp^3 hybridized carbon atoms. Substitution of one of the hydrogen atoms in ***B*** by a chlorine atom gives ***C*** which shows optical isomerism. ***A*** and ***B*** separately react with a mixture of water, mineral acid and catalyst ***Y*** to give compound ***D***. ***D*** has three sp^3 hybridized carbon atoms. **One** sp^2 hybridized carbon atom and one oxygen atom.

i) Write the structures of ***A***, ***B***, ***C*** and ***D***.

A

B

C

ii) What is catalyst *Y* Y = ...

iii) How would you distinguish between ***A*** and ***B*** using a chemical test?

.....

.....

.....

b) Consider the reactions given in column *P* of the table below

i) Write the structure of the major organic product of each of the reactions in the respective cage in column Q of the table

ii) Identify the mechanism-type of each of the reactions as

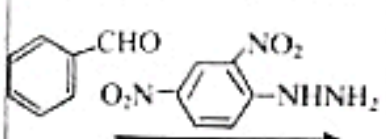
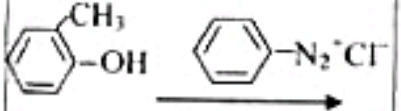
electrophilic addition (A_E) — electrophilic substitution (S_E)
nucleophilic addition (A_N) — nucleophilic substitution (S_N)
Elimination (E) — any other mechanism (M_O)

By writing A_E, S_E, A_N, S_N, E or M_O in the appropriate cages in column *R* of the table.

iii) In electrophilic reactions write the electrophiles in the appropriate cages in column S of the table.

iv) In nucleophilic reactions write the nucleophiles in the appropriate cages in column T of the table.

v) In each of the reactions write the colour of the main organic product in the appropriate cage in column *U* of the table.

P	Q	R	S	T	U
Reaction	Major organic product	Mechanism type	Electrophile	Nucleophile	Colour
$CH_3CH_2CH_2I \xrightarrow{\text{aq. NaOH}}$					
$\begin{matrix}CH_3\\ \diagdown\\ \quad C = CH_2\\ \diagup\\ CH_3\end{matrix} \xrightarrow{\text{dil. } H_2SO_4}$					
$CH_3CH_2\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}HI \xrightarrow[\text{KOH}]{\text{alcoholic}}$					
 $\xrightarrow[AlCl_3]{CH_3COCl}$					
					
					

(29) **2007 AL**

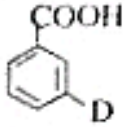
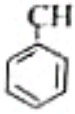
a) *A*, *B* and *C* are three isomeric hydrocarbons each having two sp^1 hybridized carbon atoms and two sp^2 hybridized carbon atoms only. A shows stereoisomerism. On bromination followed by dehydrobromination *A*, *B* and *C* form *D*, *E* and *F* respectively. *D* and *E* are isomers but F is not an isomer of either *D* or *E*.

Give the structures of *A*, *B*, *C*, *D*, *E* and *F* in the appropriate cages.

A B C

D E F

b) i) Reactants and reagents for reactions I – V are given in the table below. Write active species relevant to each reaction in column *R* of the table. Write the major organic product/products in column S of the table, for each of the reactions.

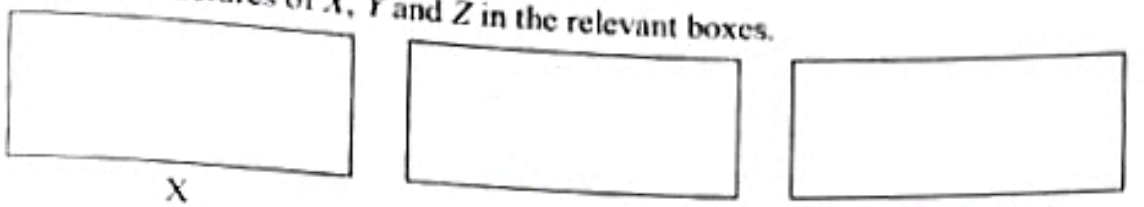
	P Reactant	Q Reagents	R Active species	S Major product/s
I.	 D (Deuterium)	conc. HNO_3 conc. H_2SO_4		
II.		CH_3Cl, $AlCl_3$		
III.		Br_2, $FeBr_3$		
IV.	$CH_3COCH_2CH_2COOH$	$NaBH_4$		
V	CH_4 (excess)	Cl_2, sunlight		

ii) Consider the scheme of reactions given below.

$$C_3H_4 \xrightarrow[Hg\ SO_4]{dil.\ H_2SO_4} C_3H_6O \xrightarrow{aq.\ NaOH} C_6H_{12}O_2$$

X Y Z

Give the structures of X, Y and Z in the relevant boxes.



X Y Z

Write the IUPAC name of Z.

.....

(30) **2008 AL**

a) Cinnamaldehyde is the main constituent of cinnamon oil. It has the following structure.

$$C_6H_5 - CH = CH - CHO$$

i) Suggest a test, to show that cinnamaldehyde contains a double bond. Give the expected observation/s.

Test observations

.....

ii) Cinnamaldehyde is reacted with $LiAlH_4$ and reaction mixture is treated with dil. acid.

I. Draw the structure of the final organic product obtained.

II. Name the type of reaction occuring between Cinnamaldehyde and $LiAlH_4$.

.....

iii) Cinnamaldehyde reacts with isopropyl magnesium bromide $(CH_3)_2$ CHMgBr.

I) Give the name of a solvent used on this reaction.

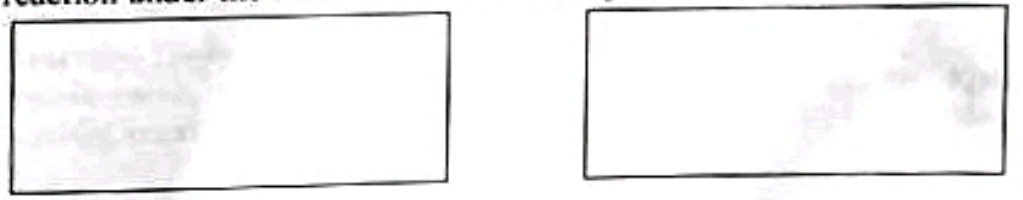
.....

II) Why is it important to keep the solvent dry?

.....

III) Write the structural formula of the product obtained when cinnamaldehyde is reacted with $(CH_3)_2CHMgBr$ and the intermediate hydrolysed.

IV. Recall the condensation reaction that occurs between two molecules of CH_3CHO in the presence of aqueous NaOH.
Write the structures of the two molecules that would undergo a similar reaction under the same conditions forming cinnamaldehyde.



b) The two compounds *A* and *B* have the same molecular formula C_3H_6O. Both *A* and *B* react with Brady's reagent giving orange coloured precipitates.
A reacts with HCN forming a single product *C*
B reacts with HCN forming a mixture of two stereo-isomers *D* and *E*.

i) Write the structures of *A*, *B*, *C*, *D* and *E* in the appropriate cages.

A B

C D E

ii) State the specific type of isomerism shown by *D* and *E*.

.....

iii) State a physical property that can be used to distinguish between D and E.

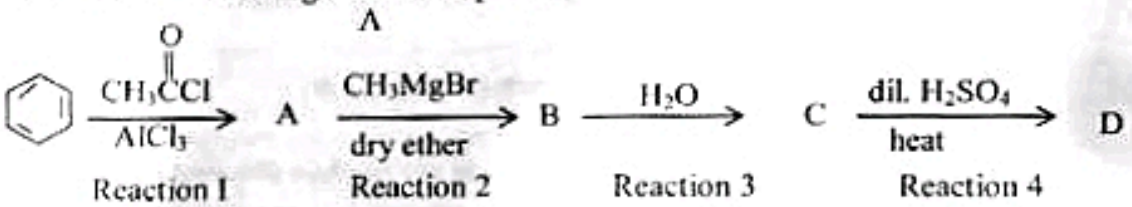
.....

iv) What difference is shown by D and E in respect of the physical property given by you in iii) above.

.....

(31) 2009 AL

a) Consider the following reaction sequence.



i) Write the structures of *A*, *B*, *C* and *D* in the boxes given below.

A B C D

ii) Classify each of the reactions in the above sequence as addition (*Ad*), elimination (*E*), rearrangement (*R*) or substitution (*S*) by writing *Ad*, *E*, *R* or S in the appropriate cage.

Reaction	1	2	3	4
Reaction type				

iii) Write the active species and whether it is an electrophile or a nucleophile, in each of the reactions 1 and 2 in the appropriate cages.

reaction	Active species	Electrophile / nucleophile
1		
2		

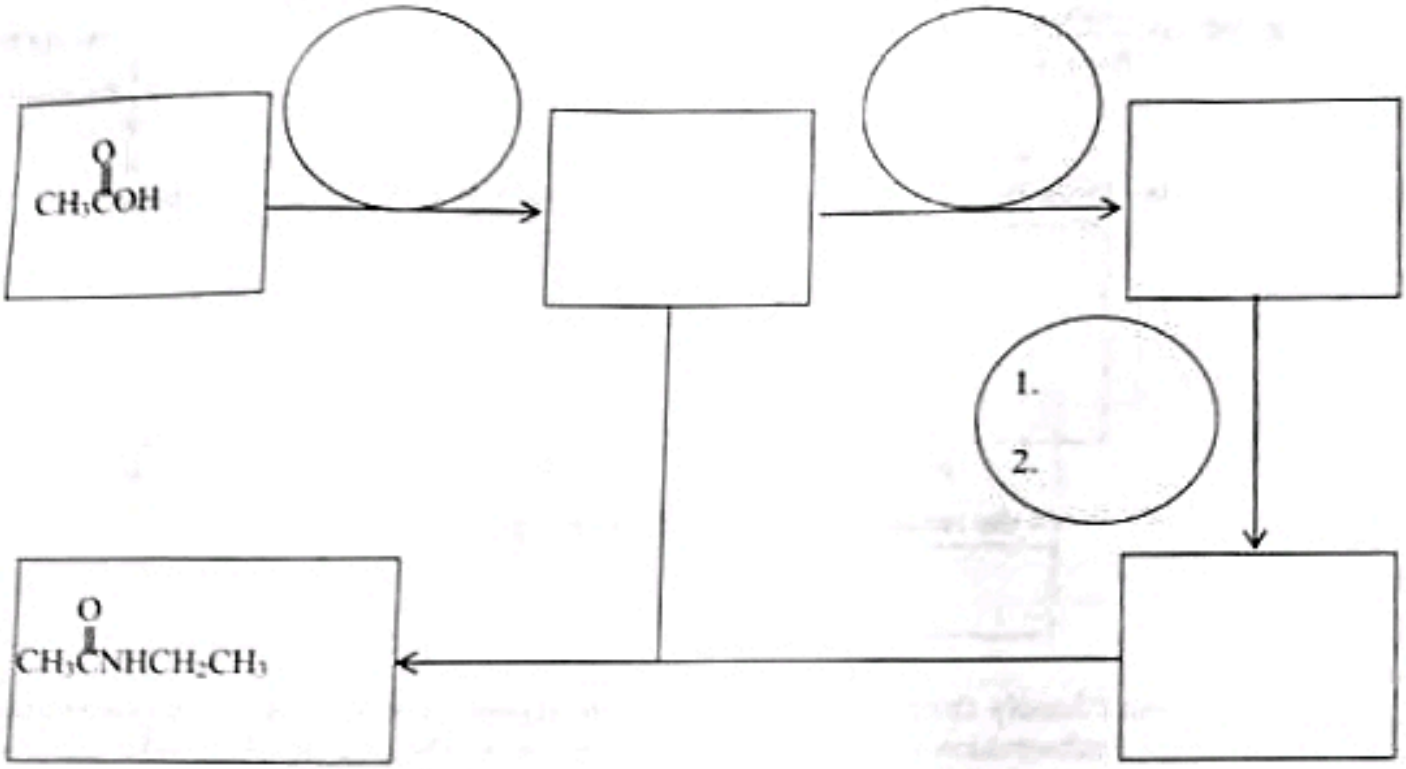
b) Complete the syntheses in schemes *A* and *B* selecting appropriate reactants / reagents / solvents only from those given with each scheme.

- Write the structures of appropriate compounds in the boxes and the reagents / solvents in the circles.
- Indicate temperature where it is important.

i) **Scheme *A***

Reagents / solvents

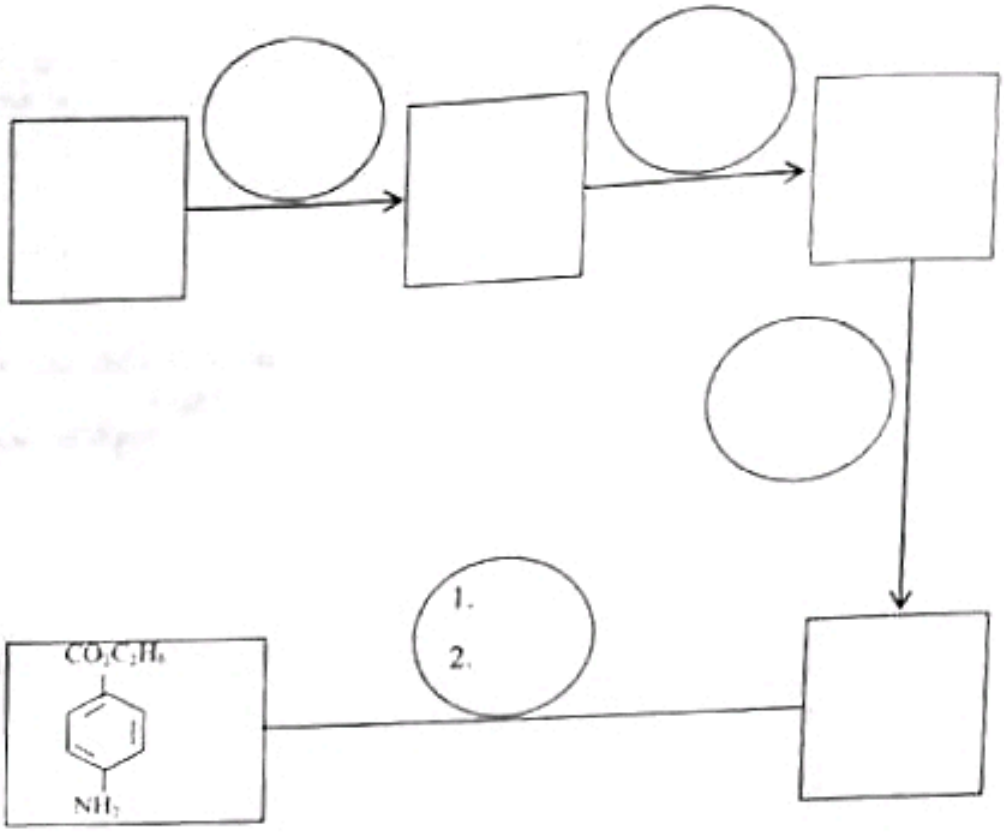
Mg, P_2O_5, PCl_5, $LiAlH_4$, $NaBH_4$, CH_3CHO, conc. NH_3, dil. H_2SO_4, water, dry ether.



ii) **Scheme *B***

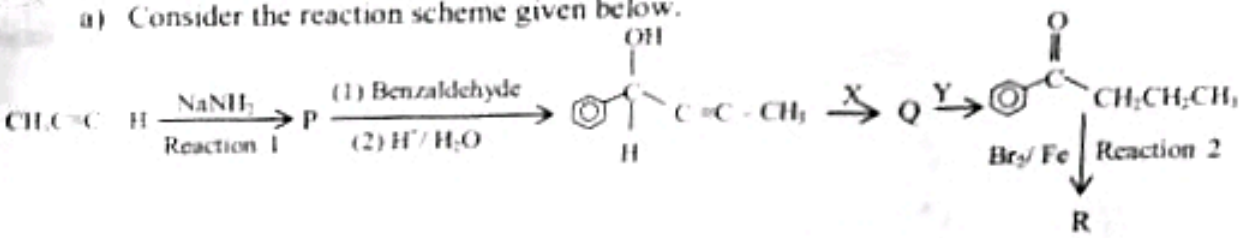
Reactants / reagents / solvents

nitrobenzene, toluene ($C_6H_5CH_3$), CH_3Cl, $AlCl_3$, Zn(Hg), Sn, $KMnO_4$, $NaNO_2$, conc. HNO_3, conc. H_2SO_4, conc. HCl, aq. NaOH, water, ethanol



(32) 2010 AL

a) Consider the reaction scheme given below.



i) Draw the structures of compounds *P*, *Q* and *R* in the boxes given below.

P Q R

ii) Write the reagents *X* and *Y* in the boxes given below.

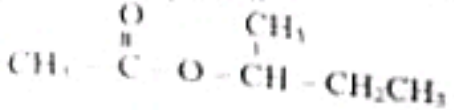
X Y

iii) Classify the reactions labelled as Reaction 1 and Reaction 2, as nucleophilic substitution (S_N), electrophilic substitution (S_E), nucleophilic addition (A_N), electrophilic addition (A_E) or acid - base reaction (AB).

Reaction 1		Reaction 2	

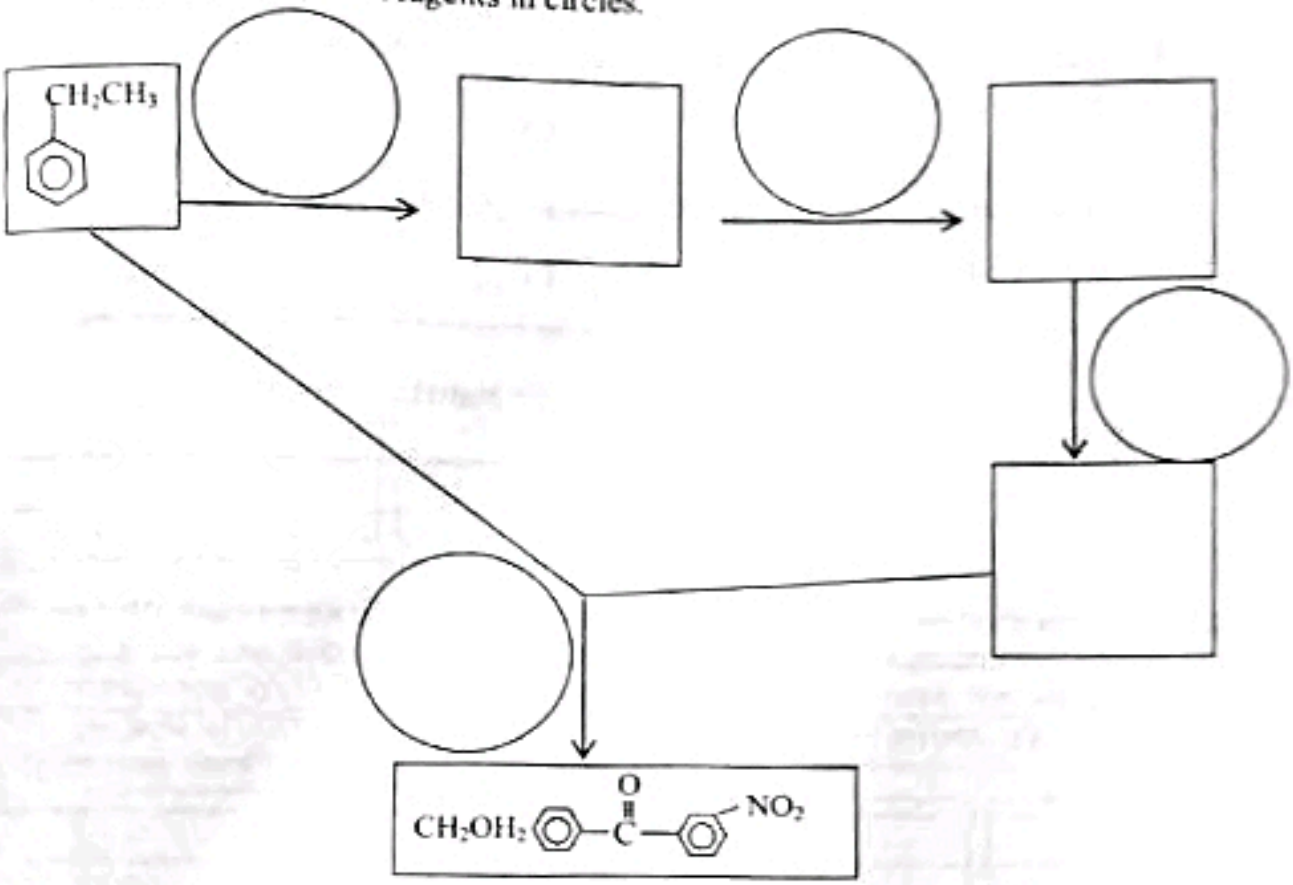
(v) Recalling the reaction of alkylhalides with KCN, write the structure of the product obtained when compound *P* reacts with CH_3Br

b) Using only the chemicals and ragents given in the list propose a synthesis of the following compound.



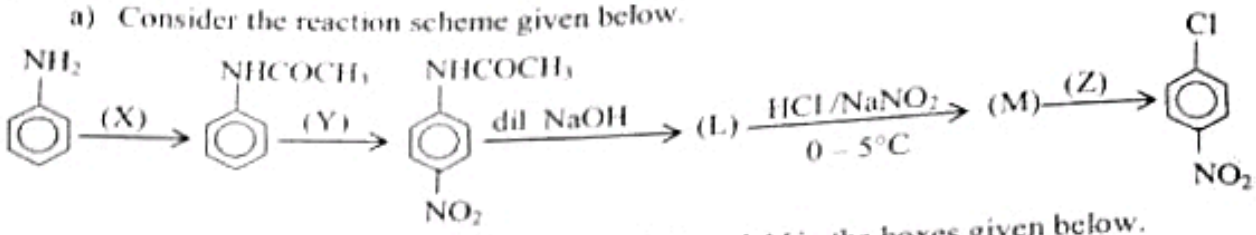
List of chemicals and reagents
CH_3CHO, PBr_3, Mg, ether, dil. H_2SO_4, $NaBH_4$, $K_2Cr_2O_7$, conc H_2SO_4

c) Complete the following reaction scheme, by writing the structures of compounds in the boxes and the reagents in circles.



(33) **2011 AL**

a) Consider the reaction scheme given below.



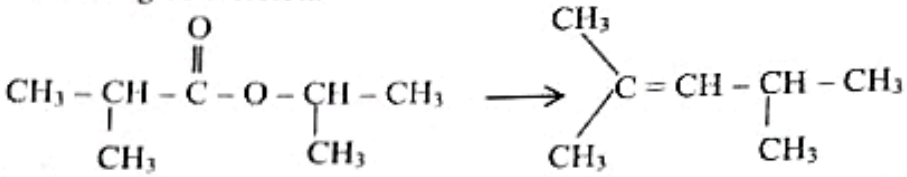
i) Draw the structures of the compounds *L* and *M* in the boxes given below.

L M

ii) Write the reagents *X*, *Y* and *Z* in the boxes given below.

X Y Z

b) Using only the chemicals and reagents given in the list propose a synthesis of the following conversion.



List of the chemicals and reagents
dil. NaOH, dilute H_2SO_4, conc.H_2SO_4, $NaBH_4$, $LiAlH_4$, Mg, PBr_3, $K_2Cr_2O_7$, ether

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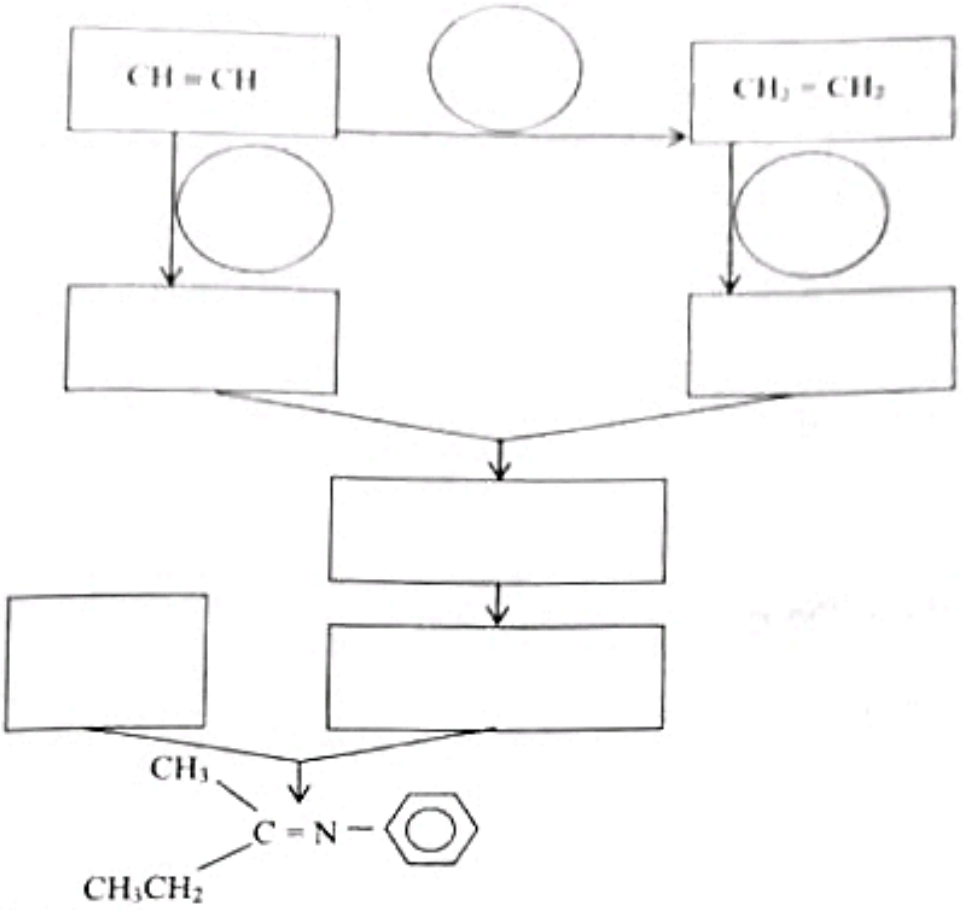
c) Complete the following reaction scheme, by writing the structures of compounds in the boxes and the reagents in circles



(34) **2012 AL**

a) *A*, *B* and *C* are three isomeric hydrocarbonis with the molecular formula C_7H_{14}. Compound A shows geometrical isomerism while compounds *B* and *C* do not. All three compounds exhibit optical isomerism. On catalytic hydrogenation all three compounds yield compound *D* (C_7H_{16}). Compound *D* also shows optical isomerism. Give the structures of *A*, *B*, *C* and *D*. (It is not necessary to draw the stereoisomeric forms)

(A) (B) (C) (D)

On treatment with bromine followed by dehydrobromination with alcoholic KOH. A forms two compounds *E* and *F*, while *B* forms compound *G*, and *C* forms compound *H*. All four compounds *E*, *F*, *G* and H have the same molecular formula of C_7H_{12} Compound E shows geometrical isomerism, while *F*, *G* and *H* do not. Give the structures of *E*, *F*, *G* and *H*.

(E) (F) (G) (H)

Give one chemical test to distinguish between *I* and *G*

.....

.....

b) The reactant and reagent in each of the reactions 1 – 5 are given in the table below.
For each reaction, write the reaction type [Nucleophilic addition (A_N), Electrophilic addition (A_E), Nucleophilic substitution (S_N), Electrophilic substitution (S_E), Elimination (E)] and the major product in the relevant boxes

	reactant	reagent	reaction type	major product
1.		conc. HNO_3/ conc. H_2SO_4		
2.	$CH_3CH = CH_2$	HBr		
3.	CH_3CHO	H^+/KCN		
4.	$CH_3CH_2CHBrCH_3$	alcoholic KOH		
5.	CH_3CH_2I	aq. KCN		

(35) **2013 AL**

a) i) Compound *A* exhibits optical isomerism and has the molecular formula C_7H_{16}.

I) Draw two possible structures for *A* which are not enantiomers of each other, in the boxes given below.

II) State the isomeric relationship between the two structures you have drawn.

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ii) ***B*** and ***C*** are optically inactive compounds with the molecular formula C_7H_{14}. Both ***B*** and ***C*** exhibit geometric isomerism. ***B*** and ***C*** are **not** geometric isomers of each other. Catalytic hydrogenation of either ***B*** or ***C*** yields the same compound *A*.

I) Draw the structures of ***A***, ***B*** and ***C*** in the boxes given below. (It is not necessary to draw the stereo isomeric forms)

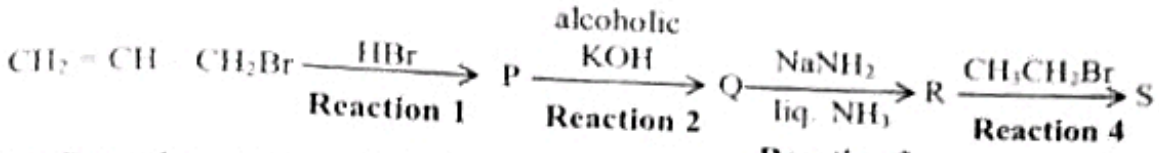
A B C

II) Write the IUPAC names of ***B*** and ***C***.

B : - .....

C : - .....

b) Consider the following reaction sequence:



i) Draw the structures of *P*, *Q*, *R* and *S* in the boxes given below.

P

Q

R

S

ii) Classify each of the reactions in the above sequence as nucleophilic addition (A_N), Electrophilic addition (A_E), Nucleophilic substitution (S_N), Electrophilic substitution (S_E), Elimination (E) or acid-base (AB), by writing A_E, S_N, S_E, E, AB in the appropriate cages.

Reaction	1	2	3	4
Reaction type				

ii) Write the mechanism for Reaction I.

iii) Draw the structure of the product *T* obtained when Reaction 1 is carried out in the presence of peroxide.

T

iv) It has been found that *T* is also formed in Reaction I, as a minor product. By considering the mechanism of the reaction, explain why the major product in Reaction I is *P* and not *T*.

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(36) **2014 AL**

a) *A* and *B* are structural isomers of methylpentene with the molecular formula C_6H_{12}. *A* exhibits geo metric isomerism while *B* exhibits optical isomerism. On hydrogenation, *A* and *B* yield the same compound *C* with the molecular formula C_6H_{14}. *C* does not exhibit optical isomerism. Draw the structure of *A*, *B* and *C* in the boxes given below. (It is not necessary to draw the stereoisomeric forms)

A B C

b) i) Consider the following two reaction sequences (I and II) and draw the structures of the products *D*, *E*, *F*, *G*, *H* and *I* in the boxes given below.

I. $A \xrightarrow[H_2O_2]{HBr} D \xrightarrow{\text{aq. KOH}} E \xrightarrow{PCC} F$

II. $B \xrightarrow[H_2O_2]{HBr} G \xrightarrow{\text{aq. KOH}} H \xrightarrow{PCC} I$

D E F

G H I

ii) Give a chemical test with the relevant observations to distinguish between *F* and *I*.

.....

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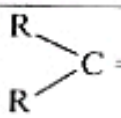
iii) Compound *E* is a structural isomer of *H*. Name the type of structural isomerism that is found between these two compounds.

.....

c) Draw the structures of the major products of the reactions given in the table below. Classify each of the reactions as nucleophilic addition (A_N), Electrophilic addition (A_E), Nucleophilic substitution (S_N), Electrophilic substitution (S_E) or Elimination (E) by writing A_N, A_E, S_N, S_E, E in the appropriate cages.

Reaction number	Reactant	Reagent	Major product	Reaction type
1	$C_2H_5CH = CHC_2H_5$	Br_2/CCl_4		
2		CH_3COCl / anhydrous $AlCl_3$		
3	ROH	PCl_3		
4	RCH_2CH_2OH	anhydrous Al_2O_3 / Δ		
5		RMgBr		

c) Write the mechanism for Reaction No 2. Explain why the intermediate formed from benzaldehyde is stable in this reaction.

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(37) **2015 AL**

a) ***A***, ***B*** and ***C*** are structural isomers with the molecular formula $C_5H_{11}Br$. All three isomers exhibit optical isomerism. When reacted with alcoholic KOH, ***A***, ***B*** and ***C*** give ***D***, ***E*** and ***F*** respectively. ***D*** exhibits geometric isomerism, while ***E*** and ***F*** do not exhibit geometric isomerism. When reacted with HBr, ***E*** and ***F*** both give the same compound ***G***. ***G*** is a structural isomer of ***A***, ***B*** and ***C***. ***G*** does not exhibit optical isomerism. Draw the structures of ***A***, ***B***, ***C***, ***D***, ***E***, ***F*** and ***G*** in the boxes given below. (It is **not necessary** to draw stereo isomeric forms)

A B C

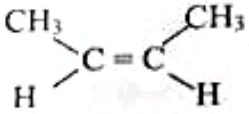
D E F

G

b) Write the reagent(s) / catalyst(s) ***H***, ***I***, ***J***, ***K***, ***L***, ***M***, ***N***, ***O***, ***P*** and ***Q*** (with suitable conditions, if any) of the following reactions in the boxes given below.

i) $CH_2 = CH_2 \xrightarrow{H} HOCH_2CH_2OH$

ii) $C_6H_5N_2Cl \xrightarrow{I} C_6H_5I$

iii) $CH_3C \equiv C - CH_3 \xrightarrow{J}$ 

iv) $C_6H_5COCH_2CO_2H \xrightarrow{K} C_6H_5\underset{OH}{C}HCH_2CO_2H$

v) $C_2H_5CH_2OH \xrightarrow{L} C_2H_5CO_2H$

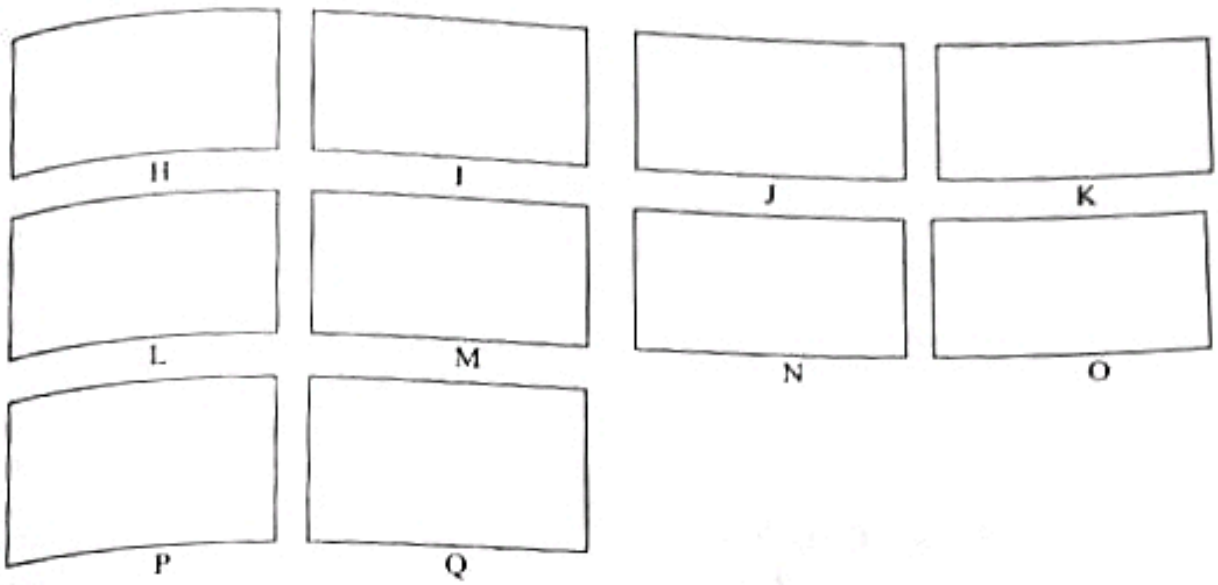
vi) $CH_3\underset{OH}{C}H - CH_3 \xrightarrow{M} CH_3CH = CH_2$

vii) $CH_3C \equiv CH \xrightarrow{N} CH_3C \equiv CCu$

viii) $C_2H_5CO_2H \xrightarrow{O} C_6H_5COCl$

ix) $C_6H_5CONH_2 \xrightarrow{P} C_6H_5CH_2NH_2$

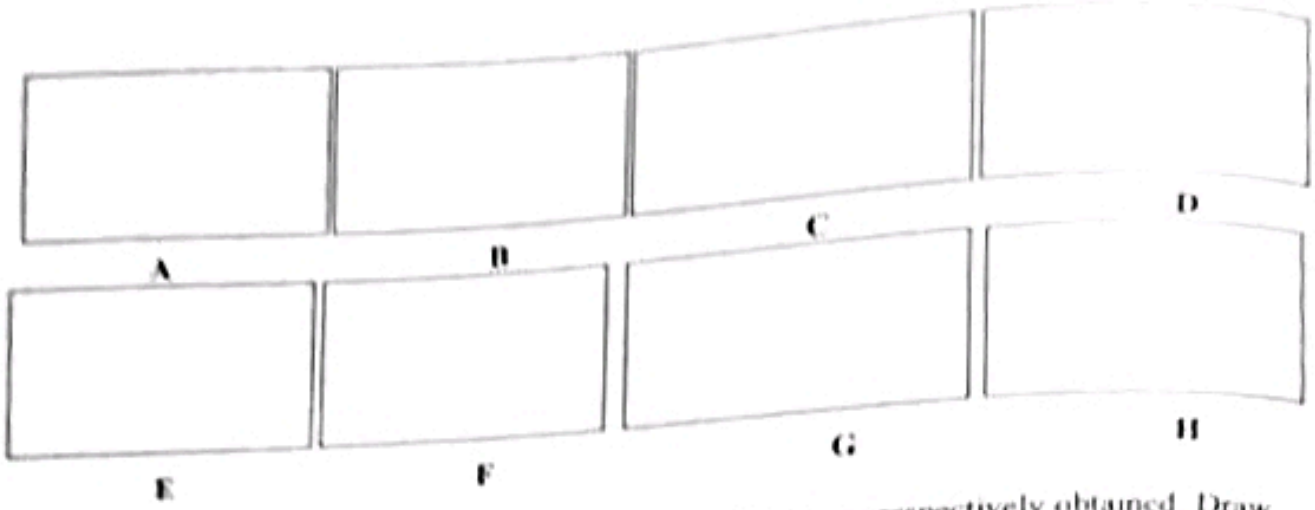
x) $C_6H_6 \xrightarrow{Q} C_6H_5COCH_3$



c) Write the mechanism for the reaction of CH_3COCl with aqueous sodium hydroxide.

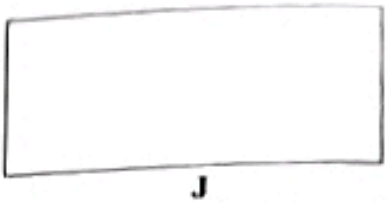
(38) **2016 AL**

a) i) ***A***, ***B***, ***C*** and ***D*** are structural isomers with the molecular formula $C_4H_{10}O$. All four isomers reacted with metallic sodium to evolve H_2 gas. Of the four isomers, only ***A*** exhibited optical isomerism. When ***B***, ***C*** and ***D*** were added separately to conc. HCl, containg $ZnCl_2$, the mixture containg **B** become turbid very rapidly. The development of turbidity with **C** and ***D*** was very slow. When ***C*** and ***D*** were heated with conc. H_2SO_4, ***E*** and ***F*** were respectively obtained. ***E*** and ***F*** are structural isomers with the molecular formula C_4H_8. Neither E nor F exhibited geometric isomerism. When E and F were treated with HBr, ***G*** and **H** were respectively obtained. Only ***G*** exhibited optical isomerism. Draw the structures of ***A***, ***B***, ***C***, ***D***, ***E***, ***F***, ***G*** and ***H*** in the boxes given below. (It is not necessary to draw stereo isomeric forms)



ii) When *A* and *C* were reacted with PCC, *I* and *J* were respectively obtained. Draw the structures of *I* and *J* in the boxes given below. (PCC – Pyridinium chlorochromate)

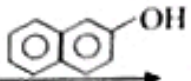

I


J

b) Draw the structure of the major organic products ***K, L, M, N, O, P, Q, R, S*** and ***T*** of the following reactions in the relevant boxes.

i) $CH_3CH=CH_2 \xrightarrow[\text{Peroxide}]{HBr}$ **K**

ii) $C_6H_5CHO \xrightarrow[\text{② dehydration}]{\text{① 2 , 4 - DNP}}$ **L**

iii) $C_6H_5N_2^+Cl^- \xrightarrow[0-5°C]{\text{NaOH}}$  **M**

iv) $C_6H_5COCl \xrightarrow{NH_3}$ **N**

v) $C_6H_5CO_2H \xrightarrow[\text{conc. } H_2SO_4]{\text{conc. } HNO_3}$ **O**

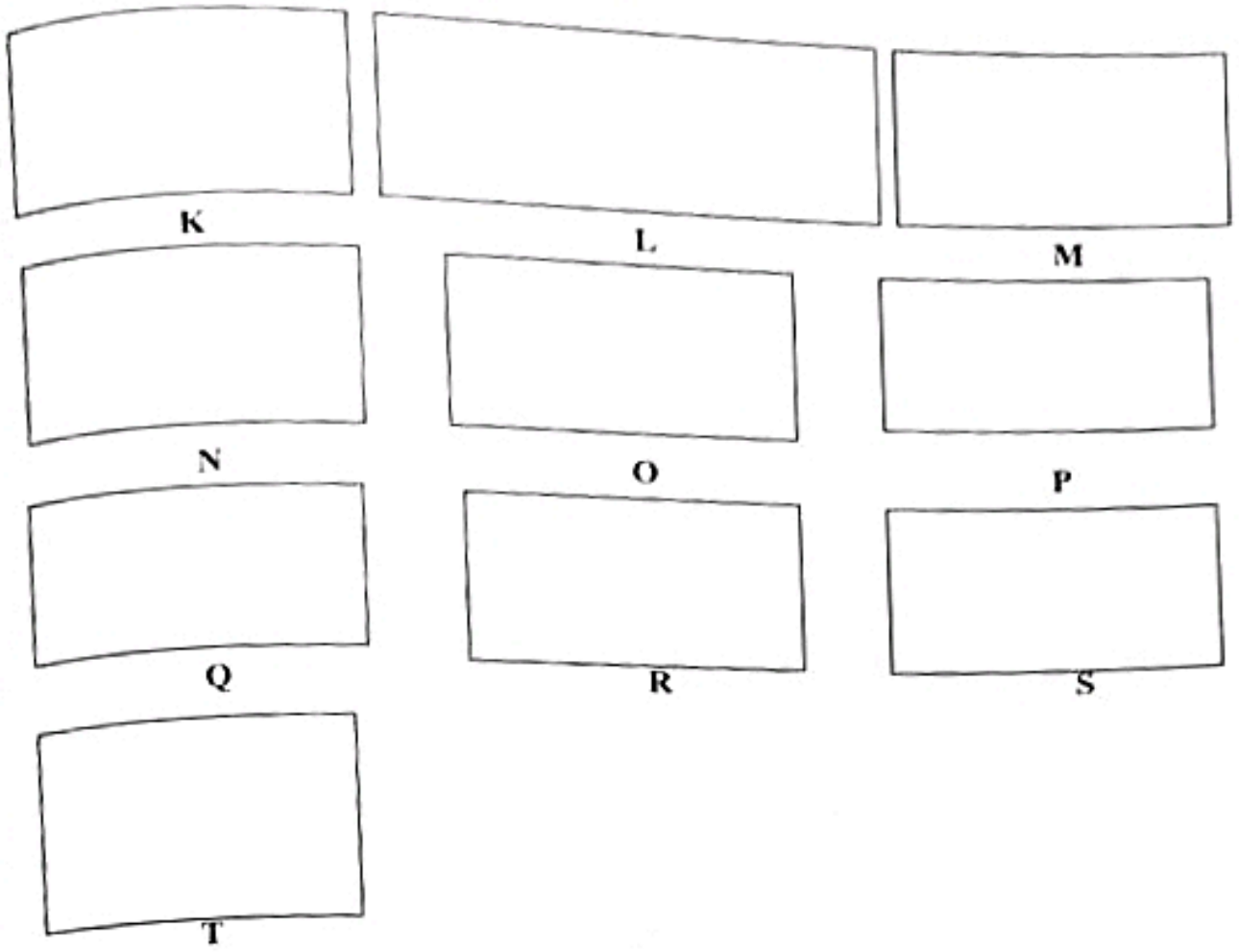
vi) $CH_3COC_2H_5 \xrightarrow[\text{conc. HCl}]{Zn\,|\,Hg}$ **P**

vii) $CH_3CHO \xrightarrow{Ag(NH_3)_2^+\ OH^-}$ **Q**

viii) $CH_3C\equiv CH \xrightarrow{NaNH_2}$ **R**

ix) $CH_3C\equiv CCH_3 \xrightarrow{H_2\,|\,Pd}$ **S**

x) $C_6H_5OH \xrightarrow{Br_2}$ **T**



c) Write the mechanism for the reaction between $C_2H_5CH = CHC_2H_5$ iy $Br_2(CCl_4)$