



**WINTER-16 EXAMINATION**  
**Model Answer**

Subject code : 17312

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**Important Instructions to examiners:**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.



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| Q No. | Answer  | marks          |
|-------|---|----------------|
| 1     | Any 10  | 20             |
| 1-a   | <b>organic chemistry:</b> it is the study of substances obtained from living organisms and chemical compounds that contain carbon-hydrogen bonds.<br><b>inorganic chemistry:</b> Inorganic chemistry is the study of the synthesis, reactions, structures and properties of compounds of the elements and chemical compounds that do not contain carbon-hydrogen bonds                              | 1<br>1         |
| 1-b   | <b>structural formula of</b><br>i) ethanoic acid- $\text{CH}_3\text{-C-OH}$<br>$\begin{array}{c} \parallel \\ \text{O} \end{array}$<br>ii) formaldehyde- $\text{H-C-H}$<br>$\begin{array}{c} \parallel \\ \text{O} \end{array}$   | 1<br>1         |
| 1-c   | <b>Physical properties of Alkane:</b><br>1) First four members(C1 to C4) of alkane are gases,next thirteen members (C5 to C17) are colourless liquids and higher alkanes are solids.<br>2) Liquid alkanes are lighter than water.<br>3) Alkanes are insoluble in water but freely soluble in organic solvent.<br>4) Boiling point and specific gravity increases with increase in molecular weight. | ½ mark<br>each |



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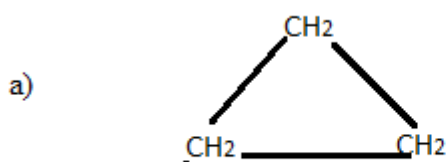
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1-d

**1. Alicyclic compounds:**

These are cyclic compounds composed of ring of carbon atoms with properties similar to aliphatic compounds.

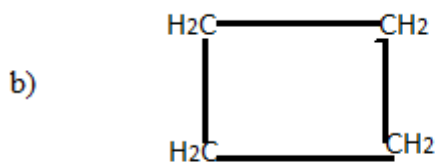
Example : (Any 1)



OR



cyclopropane



OR



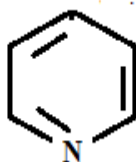
Cyclobutane

**2. Heterocyclic compounds:**

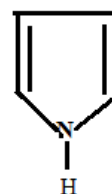
These are cyclic compounds in which ring consist of atoms atoms and some other element such as oxygen, nitrogen, sulphur.

Example : (Any 1)

a) pyridine



b) pyrrole



1

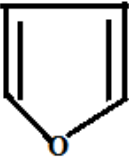
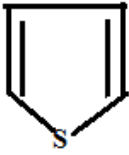
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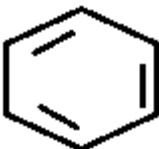
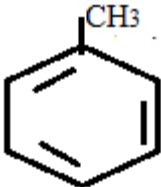
|            |  |                        |
|------------|--|------------------------|
|            | <p>c) furan  d) Thiophene </p>   |                        |
| <p>1-e</p> | <p><b>Saturated hydrocarbons</b> - Compounds of carbon and hydrogen whose adjacent carbon atoms contain only one carbon-carbon bond are known as saturated hydrocarbons. saturated hydrocarbons are called alkanes. The general formula for an alkane is <math>C_nH_{2n+2}</math>.</p> <p><b>Unsaturated hydrocarbons</b> - Compounds of carbon and hydrogen that contain one double bond between carbon atoms (carbon=carbon) or a triple bond between carbon atoms (carbon≡carbon) are called unsaturated hydrocarbons. Unsaturated hydrocarbons can be divided into 'alkenes' and 'alkynes' depending on the presence of double or triple bonds respectively. The general formulae are <math>C_nH_{2n}</math> for alkenes and <math>C_nH_{2n-2}</math> for alkynes.</p> | <p>1<br/>1</p>         |
| <p>1-f</p> | <p><b>Properties of alcohol:</b></p> <ol style="list-style-type: none"> <li>1) Higher members are colorless waxy solids.</li> <li>2) Lower members are soluble in water &amp; organic solvents.</li> <li>3) These are lighter than water.</li> <li>4) Lower members have pleasant smell while higher member are odorless &amp; tasteless.</li> </ol>   | <p>½ mark<br/>each</p> |
| <p>1-g</p> | <p><b>Aromatic compounds are ring OR closed chain compounds,</b></p> <p>These are cyclic compounds having six membered ring of carbon atoms with alternate single and double bonds</p> <p>Example :</p>  | <p>2</p>               |



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|     |  |        |
|-----|--|--------|
|     | <p>a) Benzene</p>  <p>b) Toluene</p>  <p>These are cyclic compounds having six membered ring of carbon atoms with alternate single and double bonds</p>  |        |
| 1-h | <p><b>Functional group</b> – It is a group of atoms bonded together in a unique fashion which is present in the molecule &amp; it is responsible for its characteristics chemical properties.<br/>e.g. –OH, –COOH are the functional groups of alcohol &amp; acid respectively.</p>  | 1<br>1 |
| 1-i | <p><b>Raoult's law:</b> It states that the partial vapor pressure of each component of an ideal mixture of liquids is equal to the vapor pressure of the pure component multiplied by its mole fraction in the mixture.</p>  | 2      |
| 1-j | <p><b>Indicator</b> : A chemical indicator is a substance that undergoes a distinct observable change when conditions in its solution change. This could be a color change, precipitate formation, bubble formation, temperature change, or other.<br/>or<br/>An indicator is an organic substance used in very small amount to determine the end point in a titration by a visual change of color.<br/>ex: phenolphthalein, Methyl orange, starch etc.(any 2)</p> | 1<br>1 |
| 1-k | IUPAC NAME OF  |        |



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|  |   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
|--|---|--------|---------|---|-----------------|--------------------|-------------------------|--|---|--|-----------------------------------|--|------------------------|-----------------------------------|------------------------|----------|-----------|-----------------------------|
|  | i) n- propyl alcohol ----Ethanol<br>ii) sec-butyl alcohol----2butanol   | 1<br>1 |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| 1-1  | <b>Alcohol and phenol</b> <table border="1"><tbody><tr><td>PHENOL</td><td>ALCOHOL</td></tr><tr><td>phenol reacts with <math>\text{FeCl}_3</math> whereas normal</td><td>alcohol can not</td></tr><tr><td>Phenols are acidic</td><td>Alcohols are not acidic</td></tr><tr><td>Phenols are acidic and dissolve in a basic solution.</td><td>Alcohols are not acidic and will not dissolve in a basic solution</td></tr><tr><td>When phenol react with <math>\text{FeCl}_3</math> it changes its colour from green to purple.</td><td>Alcohols produce no color change.</td></tr><tr><td>Phenols produce a brown tarry mass when combined with chromic acid</td><td>Not observe in alcohol</td></tr><tr><td>phenols dissolve in aqueous NaOH,</td><td>Not observe in alcohol</td></tr><tr><td>Aromatic</td><td>Aliphatic</td></tr></tbody></table> | PHENOL | ALCOHOL | phenol reacts with $\text{FeCl}_3$ whereas normal | alcohol can not | Phenols are acidic | Alcohols are not acidic | Phenols are acidic and dissolve in a basic solution. | Alcohols are not acidic and will not dissolve in a basic solution | When phenol react with $\text{FeCl}_3$ it changes its colour from green to purple. | Alcohols produce no color change. | Phenols produce a brown tarry mass when combined with chromic acid | Not observe in alcohol | phenols dissolve in aqueous NaOH, | Not observe in alcohol | Aromatic | Aliphatic | 1 mark<br>each for<br>any 2 |
| PHENOL   | ALCOHOL   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| phenol reacts with $\text{FeCl}_3$ whereas normal                                  | alcohol can not   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| Phenols are acidic   | Alcohols are not acidic   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| Phenols are acidic and dissolve in a basic solution.                               | Alcohols are not acidic and will not dissolve in a basic solution   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| When phenol react with $\text{FeCl}_3$ it changes its colour from green to purple. | Alcohols produce no color change.   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| Phenols produce a brown tarry mass when combined with chromic acid                 | Not observe in alcohol  |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| phenols dissolve in aqueous NaOH,  | Not observe in alcohol  |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| Aromatic   | Aliphatic   |        |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| 2  | <b>Any 4</b>  | 16     |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |
| 2-a  | <b>Organic compounds</b> are classified into four categories on the basis of structure.<br><b>Aliphatic compounds :</b><br>Which consist of open chain of carbon atoms are called aliphatic compounds.<br>Example : (Any 1)<br>a) Propane $\text{CH}_3\text{-CH}_2\text{-CH}_3$<br>b) Acetic acid $\text{CH}_3\text{-COOH}$<br><b>Alicyclic compounds:</b><br>These are cyclic compounds composed of ring of carbon atoms with properties   | 1<br>1 |         |   |                 |                    |                         |  |   |  |                                   |  |                        |                                   |                        |          |           |                             |



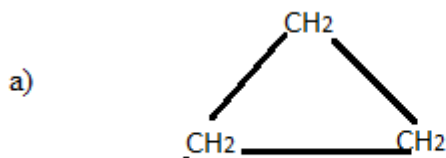
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similar to aliphatic compounds.

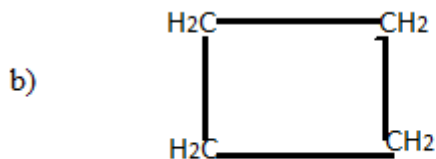
Example : (Any 1)



OR



cyclopropane



OR



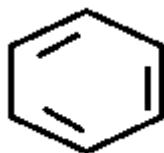
Cyclobutane

**Aromatic compounds:**

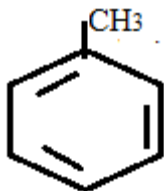
These are cyclic compounds having six membered ring of carbon atoms with alternate single and double bonds

Example :

Benzene



Toluene



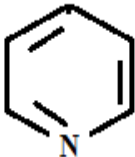
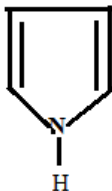
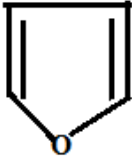

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|     |  |   |
|-----|--|---|
|     | <p><b>Heterocyclic compounds:</b></p> <p>These are cyclic compounds in which ring consist of atoms atoms and some other element such as oxygen, nitrogen, sulphur.</p> <p>Example : (Any 1)</p> <p>a) pyridine </p> <p>b) pyrrole </p> <p>c) furan </p> <p>d) Thiopheno </p> | 1 |
| 2-b | <p><b>Aliphatic compounds :</b> Compounds which consist of open chain of carbon atoms are called aliphatic compounds. There is no limit to the number of carbon atoms involved.</p> <p>they are</p> <p>further classified on the bases of C-H bonds, as single bond compounds as alkanes, double bond between C=H called as alkenes, and triple bond between C≡H called as Alkynes.</p> <p>1) Alkanes: of C-H bondsh as single bond compounds. With general formula of <math>C_nH_{2n+2}</math></p> <p>ex: methane, structural formula-<math>CH_4</math></p>   | 4 |





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|     |   |   |
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|     | <p>ethane, structural formula-<math>C_2H_6</math>, etc</p> <p>2) alkenes: double bond between C=C called as alkenes. general formula of <math>C_nH_{2n}</math></p> <p>ex: ethene, structural formula-<math>C_2H_4</math>.</p> <p>propene, structural formula-<math>C_3H_6</math>, <math>H_3C-CH=CH_2</math> etc.</p> <p>3) alkynes: triple bond between <math>C\equiv C</math> called as Alkynes. general formula of <math>C_nH_{2n-2}</math>.</p> <p>ex: ethyne, structural formula-<math>HC\equiv CH</math>.</p> <p>Propyne, structural formula-<math>H_3C-C\equiv CH</math>.</p> <p>etc.</p>   |   |
| 2-c | <p><b>Rules for nomenclature (any 4)</b></p> <p>1. Select the longest continuous chain of carbon atoms, it is known as main or parent chain &amp; other chains attached to it are known as side chains. The no. of carbon atoms present in main chain determines the parent name of hydrocarbon.</p> <p style="text-align: center;">C<br/> <br/>C-C-C-C-C-C-C</p> <p>2. Number the C atoms of parent chain from the end which gives smallest possible no. to the carbon carrying the branches.</p> <p style="text-align: center;">C<br/> <br/>C-C-C-C-C-C-C<br/>1 2 3 4 5 6 7</p> <p>3. Prefix the name of substituent to the name of parent hydrocarbon &amp; indicate its position on parent chain.</p> | 4 |



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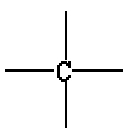





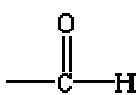
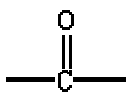
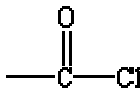
|     |  |  |
|-----|--|--|
|     | <p style="text-align: center;"><math>\text{CH}_3</math><br/>1</p> <p><math>\text{CH}_3\text{-CH}_2\text{-CH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3</math><br/>3-methyl heptane</p> <p>4. When more than one substituent's are present on the main chain their names are given as per alphabetical order, inserting hyphen (-) in between the names of substituents.</p> <p style="text-align: center;"><math>\text{CH}_3</math> <math>\text{C}_2\text{H}_5</math><br/>1 1</p> <p><math>\text{H}_3\text{C-CH-CH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3</math><br/>3-ethyl-2-methyl heptane</p> <p>5. When the same substituent is present two or more times in the molecule then it is indicated by di, tri, tetra etc to the substituent name.</p> <p style="text-align: center;"><math>\text{CH}_3\text{CH}_3</math><br/>1 1</p> <p><math>\text{H}_3\text{C-CH-CH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3</math><br/>2,3-dimethyl heptane</p> <p>6. The position of double bond or triple bond is indicated by prefixing the no. of carbon preceding such bonds.</p> <p><math>\text{H}_3\text{C-CH}_2\text{-CH=CH-CH}_2\text{-CH}_2\text{-CH}_3</math>      3-heptene</p> |  |
| 2-d | <p>IUPAC NAMES ARE:</p> <p>i) 1chloro 2,2di methyl propane      1</p> <p>ii) propanone      1</p> <p>iii) 2amino 2methyl propanoic acid      1</p> <p>iv) 3chloro propene      1</p>   |  |



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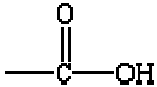
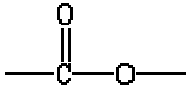
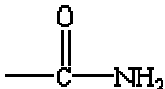
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| 2-e | <p>An <b>organic compound</b> is any member of a large class of gaseous, liquid, or solid chemical compounds whose molecules contain carbon.</p> <p><i>Functional Group Name</i>                      <i>Example</i></p> <p> Alkane                      CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub> (propane)</p> <p> Alkene                      CH<sub>3</sub>CH=CH<sub>2</sub> (propene)</p> <p> Alkyne                      CH<sub>3</sub>C≡CH (propyne)</p> <p>F, Cl, Br, or I                      Alkyl halide                      CH<sub>3</sub>Br (methyl bromide)</p> <p> Alcohol                      CH<sub>3</sub>CH<sub>2</sub>OH (ethanol)</p> <p> Ether                      CH<sub>3</sub>OCH<sub>3</sub> (dimethyl ether)</p> <p> Amine                      CH<sub>3</sub>NH<sub>2</sub> (methyl amine)</p> <p> Aldehyde                      CH<sub>3</sub>CHO (acetaldehyde)</p> <p> Ketone                      CH<sub>3</sub>COCH<sub>3</sub> (acetone)</p> <p> Acyl chloride                      CH<sub>3</sub>COCl (acetyl chloride)</p> | 4 |
|-----|--|---|



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|     | <p> Carboxylic acid <math>\text{CH}_3\text{CO}_2\text{H}</math> (acetic acid)</p> <p> Ester <math>\text{CH}_3\text{CO}_2\text{CH}_3</math> (methyl acetate)</p> <p> Amide <math>\text{CH}_3\text{NH}_2</math> (acetamide)</p>  |                             |
| 2-f | <p><b>Any two reactions of Alkanes:</b></p> <p><b>1. Combustion</b></p> <p>The combustion of carbon compounds, especially hydrocarbons, has been the most important source of heat energy for human civilizations throughout recorded history. The practical importance of this reaction cannot be denied, but the massive and uncontrolled chemical changes that take place in combustion make it difficult to deduce mechanistic paths. Using the combustion of propane as an example, we see from the following equation that every covalent bond in the reactants has been broken and an entirely new set of covalent bonds have formed in the products. No other common reaction involves such a profound and pervasive change, and the mechanism of combustion is so complex that chemists are just beginning to explore and understand some of its elementary features.</p> $\text{CH}_3\text{-CH}_2\text{-CH}_3 + 5 \text{O}_2 \longrightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O} + \text{heat}$ <p><b>2. Halogenation</b></p> <p>Halogenation is the replacement of one or more hydrogen atoms in an organic</p> | 2 mark<br>each for<br>any 2 |



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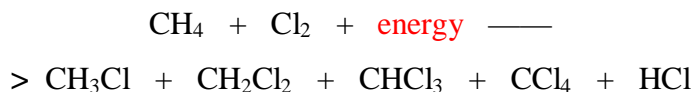
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compound by a halogen (fluorine, chlorine, bromine or iodine). Unlike the complex transformations of combustion, the halogenation of an alkane appears to be a simple **substitution reaction** in which a C-H bond is broken and a new C-X bond is formed. The chlorination of methane, shown below, provides a simple example of this reaction.



Since only two covalent bonds are broken (C-H & Cl-Cl) and two covalent bonds are formed (C-Cl & H-Cl), this reaction seems to be an ideal case for mechanistic investigation and speculation. However, one complication is that all the hydrogen atoms of an alkane may undergo substitution, resulting in a mixture of products, as shown in the following unbalanced equation. The relative amounts of the various products depend on the proportion of the two reactants used. In the case of methane, a large excess of the hydrocarbon favors formation of methyl chloride as the chief product; whereas, an excess of chlorine favors formation of chloroform and carbon tetrachloride.



The following facts must be accommodated by any reasonable mechanism for the halogenation reaction.

1. The reactivity of the halogens decreases in the following order:  $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ .
2. We shall confine our attention to chlorine and bromine, since fluorine is so explosively reactive it is difficult to control, and iodine is generally



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|     | <p>unreactive.</p> <p><b>3. Thermal Cracking</b></p> <p>The complex alkanes with high molecular weights that are found in crude oil are frequently broken into smaller, more useful alkanes by thermal cracking; alkenes and hydrogen gas are also produced by using this method. Thermal cracking is typically performed at high temperatures, and often in the presence of a catalyst. A mixture of products results, and these alkanes and alkenes can be separated by fractional distillation.</p>   |           |
| 3   | <b>Any 4</b>   | <b>16</b> |
| 3-a | <p><b>Method of preparation of alkene ( any two)</b></p> <p><b>By Wurtz Reaction:</b></p> <p>When alkyl halides are heated with sodium metal in the presence of dry ether, alkanes are obtained (generally having double number of C-atoms than in alkyl halides). This reaction is known as Wurtz reaction and used for the preparation of symmetrical alkanes.</p> $\begin{array}{c} \text{R-X} + 2\text{Na} + \text{X-R} \xrightarrow{\text{Dry ether}} \text{R-R} + 2\text{NaX} \\ \text{Eg:-} \\ \text{CH}_3\text{-Br} + \text{Na} + \text{Br-CH}_3 \xrightarrow{\text{Dry ether}} \text{CH}_3\text{-CH}_3 + 2\text{NaBr} \\ \text{methyl bromide} \qquad \qquad \qquad \text{ethane} \end{array}$ <p>2) <b>From unsaturated Hydrocarbons</b></p> <p>Alkanes can be prepared by the catalytic hydrogenation of unsaturated hydrocarbons in the presence of catalyst 'Ni' or 'pt' at 200°C to 300°C.</p> | 4         |



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|     |   |   |
|-----|---|---|
|     | <p>General Equation:<br/> <math display="block">R-CH=CH_2 + H_2 \xrightarrow[\Delta]{Ni} R-CH_2-CH_3</math>           Where R is H or Alkyl group<br/>           Eg. <math display="block">\underset{\text{ethene}}{CH_2=CH_2} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{ethane}}{CH_3-CH_3}</math></p> <p><math display="block">\underset{\text{propyne}}{CH_3-C \equiv CH} + H_2 \xrightarrow[\Delta]{Ni} \underset{\text{propene}}{CH_3-CH=CH_2} \xrightarrow[\Delta]{Ni} \underset{\text{propane}}{CH_3-CH_2-CH_3}</math></p> <p>Or(<br/>           3) by dehalogenation of vicinal dihalides,<br/>           4) by cracking of alkanes,<br/>           5) by dehydrohalogenation of alkyl halides<br/> <i>Any 2 of above methods should be given marks)</i></p>   |   |
| 3-b | <p>i) <b>Isomerism:</b><br/>           An <b>isomer</b> is a <u>molecule</u> with the same <u>molecular formula</u> as another molecule, but with a different <u>chemical structure</u>.<br/>           That is, isomers contain the same number of atoms of each element, but have different arrangements of their atoms. Isomers do not necessarily share similar properties, unless they also have the same <u>functional groups</u>. There are two main forms of <b>isomerism</b> : <u>structural isomerism</u> (or constitutional isomerism) and <u>stereoisomerism</u> (or spatial isomerism).</p> <p>ii) <b>Polymerisation:</b><br/>           A chemical process that combines several monomers to form a polymer or polymeric compound. polymerization. chemical action, chemical change, chemical process - (chemistry) any process determined by the atomic and molecular composition and structure of the substances involved</p> | 2 |
| 3-c | <b>Baeyer's Angle Strain Theory :</b>   | 4 |



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- Van't Hoff and Lebel proposed tetrahedral geometry of carbon.
- The bond angle is of  $109^{\circ} 28'$  (or  $109.5^{\circ}$ ) for carbon atom in tetrahedral geometry (methane molecule).
- Baeyer observed different bond angles for different cycloalkanes and also observed some different properties and stability.  $\rightarrow$
- On this basis, he proposed angle strain theory.
- The theory explains reactivity and stability of cycloalkanes.
- Baeyer proposed that the optimum overlap of atomic orbitals is achieved for bond angle of  $109.5^{\circ}$ . In short, it is ideal bond angle for alkane compounds.
- Effective and optimum overlap of atomic orbitals produces maximum bond strength and stable molecule.
- If bond angles deviate from the ideal then ring produce strain.
- Higher the strain higher the instability.
- Higher strain produce increased reactivity and increases heat of combustion.
- Baeyer proposed "any deviation of bond angle from ideal bond angle value ( $109.5^{\circ}$ ) will produce a strain in molecule. Higher the deviation lesser the instability".
- Baeyer's theory is based upon some assumptions as following. 1. All ring systems are planar. Deviation from normal tetrahedral angles results in to instable cycloalkanes. 2. The large ring systems involve negative strain hence do not exist. 3. The bond angles in cyclohexane and higher cycloalkanes (cycloheptane, cyclooctane, cyclononane.....) are not larger than  $109.5^{\circ}$  because the carbon rings of those compounds are not planar (flat) but they are puckered (Wrinkled).
- The ring of cyclopropane is triangle. All the three angles are of  $60^{\circ}$  in place





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of  $109.5^\circ$  (normal bond angle for carbon atom) to adjust them into triangle ring system.

- In same manner, cyclobutane is square and the bond angles are of  $90^\circ$  in place of  $109.5^\circ$  (normal bond angle for carbon atom) to adjust them into square ring system.
- The deviation for cyclopropane and cyclobutane ring systems then normal tetrahedral angle will produce strain in ring. The ring strain will make them unstable as compare to molecules having tetrahedral bond angle.
- So, cyclopropane and cyclobutane will easily undergo ring opening reactions to form more stable open chain compounds.
- Now compare the stability of cyclopropane and cyclobutane
- The bond angle in cyclopropane is  $60^\circ$ . The normal tetrahedral bond angle value is  $109.5^\circ$ . That is why, deviation = (normal tetrahedral bond angle) – (actual bond angle) Deviation =  $109.5^\circ - 60 = 49.5^\circ$  The bond angle in cyclobutane is  $90^\circ$ . The normal tetrahedral bond angle value is  $109.5^\circ$ . That is why, deviation = (normal tetrahedral bond angle) – (actual bond angle) 3 | Page Deviation =  $109^\circ 5' - 90 = 19.5^\circ$ . Deviation for cyclopropane is  $49.5^\circ$  Deviation for cyclobutane is  $19.5^\circ$  The deviation is higher for cyclopropane than cyclobutane therefore cyclopropane is more prone to undergo ring opening reactions. As a result of this, the strain is more in cyclopropane as compare to cyclobutane. It will make cyclopropane less stable than cyclobutane. So, cyclopropane easily undergoes ring opening reaction as compare to cyclobutane. According to Baeyer, the relative order of stability for some common cycloalkanes is as under. Cyclopentane > Cyclohexane > Cyclobutane > Cyclopropane Actual observed order of stability for these cycloalkanes is as under. Cyclohexane > Cyclopentane > Cyclobutane > Cyclopropane According to Baeyer, the bond angle in cyclopentane is  $108^\circ$



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|     |   |                |
|-----|---|----------------|
|     | <p>(the geometry is pentagonal) that is very close to tetrahedral angle (<math>109.5^\circ</math>), so it is almost free from ring strain. Baeyer also proposed some facts for cyclohexanes that stood incorrect later on.</p> <ul style="list-style-type: none"><li>➤ Cyclohexane is unstable ring due to higher ring strain.</li><li>➤ It is difficult to synthesize for cyclohexane and higher ring systems as deviation from the normal tetrahedral value (<math>109.5^\circ</math>) would be larger.</li></ul> <p>The larger deviation will result into more strain and the ring system will be unstable. In conclusion, Baeyer proposed that ring systems smaller or larger than cyclopentane or cyclohexane are unstable due to higher ring strain. Therefore, he assumed that cyclopropane and cyclobutane easily undergo ring opening reaction whereas larger ring systems are difficult to synthesize</p> |                |
| 3-d | <p><b>Uses of acetylene</b></p> <ol style="list-style-type: none"><li>1. Ethyne is useful for artificial ripening and preservation of fruits.</li><li>2. It is useful in acetylene lamps to generate light.</li><li>3. Ethyne is used to prepare various organic compounds.</li><li>4. It is also useful to manufacture important organic compounds like acetic acid, acetaldehyde, ethyl alcohol and polymers like PVC...etc.</li><li>5. It is useful to produce an oxyacetylene flame.</li><li>6. is widely used as a fuel and a chemical building block.</li><li>7. Acetylene is used to volatilize carbon in <u>radiocarbon dating</u>.</li><li>8. Acetylene is sometimes used for <u>carburization</u> (that is, hardening) of steel when the object is too large to fit into a furnace</li></ol>  | ½ mark<br>each |
| 3-e | <p><b><i>Wurtz-Fittig Reaction</i></b></p>  | 2              |



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|     |   |    |
|-----|---|----|
|     | $\text{C}_6\text{H}_5\text{Br} + \text{CH}_3\text{I} + 2 \text{Na} \longrightarrow \text{C}_6\text{H}_5\text{CH}_3 + 2 \text{NaX}$  |    |
|     | <p>This reaction allows the alkylation of aryl halides. The more reactive alkyl halide forms an organosodium first, and this reacts as a nucleophile with an aryl halide as the electrophile. Excess alkyl halide and sodium may be used if the symmetric coupled alkanes formed as a side product may be separated readily.</p>  | 2  |
| 3-f | <p><b>i) Nitration:</b></p> <p>Benzenes <math>\xrightarrow[\text{60}^\circ\text{C}]{\text{c. H}_2\text{SO}_4 / \text{c HNO}_3}</math> Nitrobenzene</p> <p>Nitrobenzene <math>\xrightarrow[\text{at } 100^\circ\text{C}]{\text{c. HNO}_3 + \text{fuming H}_2\text{SO}_4}</math> 2,4-dinitrobenzene <math>\xrightarrow[\text{at } 100^\circ\text{C}]{\text{fuming HNO}_3 + \text{fuming H}_2\text{SO}_4}</math> 2,4,6-trinitrobenzene</p> <p><b>ii) Combustion:</b></p> $\begin{array}{c} \text{H} & & \text{H} \\ & \diagdown & / \\ & \text{C} = \text{C} & \\ & / & \diagdown \\ \text{H} - \text{C} & & \text{C} - \text{H} \\ & \diagup & \backslash \\ & \text{C} & - \text{C} \\ & \backslash & / \\ & \text{H} & & \text{H} \end{array} + \frac{15}{2} \text{O}_2 \longrightarrow 6\text{CO}_2 + 3\text{H}_2\text{O}$ | 2  |
| 4   | Any 4   | 16 |
| 4-a | Isomerism of alcohols<br>Alcohols exhibit following types of isomerism:   |    |



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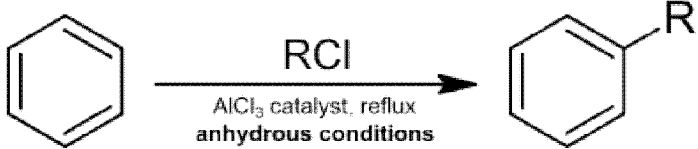
|     |   |   |
|-----|---|---|
|     | <p><b>1. Chain isomerism</b></p> <p>Alcohols with four or more carbon atoms exhibit this type of isomerism in which the carbon skeleton is different.</p> <p><math>\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{OH}</math><br/>Butan -1- ol</p> <p><math>\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3\text{—CH—CH}_2\text{OH} \end{array}</math><br/>2 - Methylbutan -1-ol</p> <p><b>2. Position isomerism</b></p> <p>Alcohols with three or more carbon atoms can exhibit position isomerism. In this type of isomerism the position of the functional group i.e., the -OH group varies. In other words the carbon atoms to which the -OH group is attached is different.</p> <p><math>\text{CH}_3\text{—CH}_2\text{—CH}_2\text{OH}</math><br/>Propan -1- ol</p> <p><math>\begin{array}{c} \text{CH}_3\text{—CH—CH}_3 \\   \\ \text{OH} \end{array}</math><br/>Propan -2- ol</p> | 2 |
| 4-b | <p><b>i) Reduction of Ketone:</b></p> <p>By Clemmensen reduction of ketone with zinc amalgam and HCl</p> <p><math>\text{C}_6\text{H}_5\text{COCH}_3 + 4[\text{H}] \rightarrow \text{C}_6\text{H}_5\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}</math></p> <p><b>ii) Action of alkyl Halide:</b></p> <p>The <b>Friedel–Crafts reactions</b> are a set of reactions developed by Charles Friedel and James Crafts in 1877 to attach substituents to an aromatic ring.<sup>1</sup> There are two main types of Friedel–Crafts reactions: alkylation reactions</p>   | 2 |



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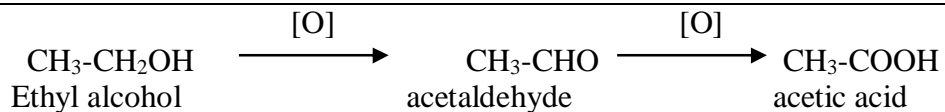
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|     | <p>and acylation reactions. Both proceed by electrophilic aromatic substitution. The general reaction scheme is shown below.</p>  <p><chem>c1ccccc1</chem> <math>\xrightarrow[\text{anhydrous conditions}]{\text{AlCl}_3 \text{ catalyst, reflux}}</math> <chem>c1ccc(R)cc1</chem></p>   |   |
| 4-c | <p><b>Preparation of phenols (any 2)</b></p> <p>i) By fusing sodium benzene sulphonate with caustic soda</p> $\text{C}_6\text{H}_5\text{SO}_3\text{Na} \xrightarrow{\text{NaOH}} \text{C}_6\text{H}_5\text{ONa} \xrightarrow{\text{NaOH}} \text{C}_6\text{H}_5\text{OH}$ <p>ii) By heating chlorobenzene under pressure with 10% solution of sodium carbonate or sodium hydroxide at about 300°C in the presence of copper salts as a catalyst</p> $\text{C}_6\text{H}_5\text{Cl} + \text{NaOH} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{NaCl}$ <p>iii) By Rasching method</p> <p>iv) By passing benzene and air in the presence of vanadium oxide.</p> <p>v) By oxidation of Cumene</p> | 4 |
| 4-d | <p><b>Differentiate between primary, secondary and tertiary alcohols.</b></p> <p>To differentiate between primary, secondary and tertiary alcohols, four methods are used (any 2 methods)</p> <p>(1) Oxidation method (2) Action of hot reduced cu. (3) victor mayer's method (4) Lucas test.</p> <p>1) <b>Oxidation method</b> :- i) primary alcohols easily oxidized to aldehydes and then to acids, containing same number of carbon atoms, as the original alcohol.</p>   | 4 |



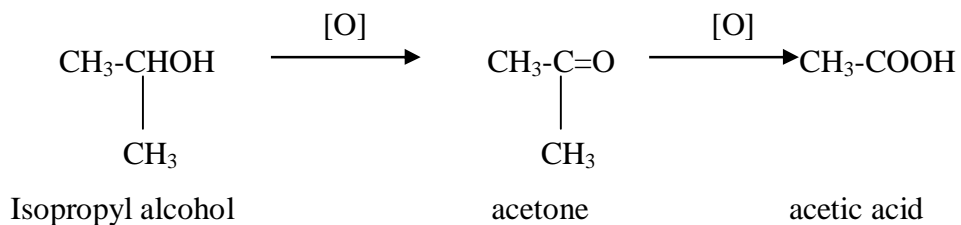
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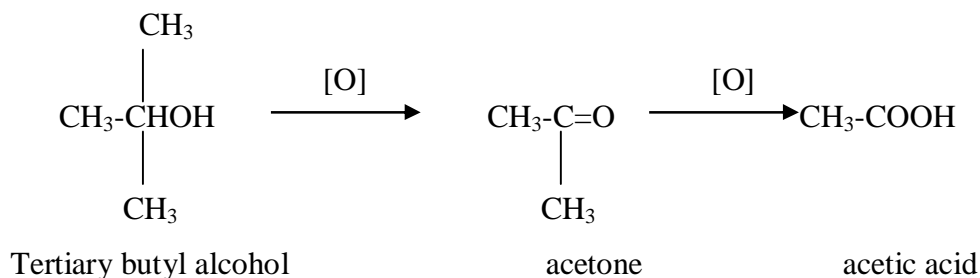
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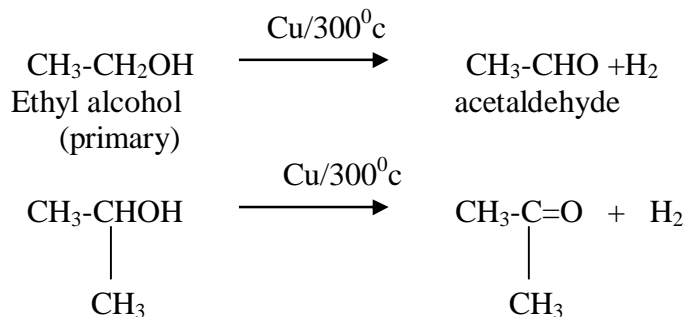
ii) Secondary alcohol, gives ketone, which on prolonged oxidation, by action of oxidizing agent gives acids.



iii) Tertiary alcohol are oxidized by acid oxidizing agents to give mixture of ketone and acid



(2) By action of hot reduced Cu : with hot reduced Cu at 300°C, primary alcohol gives aldehydes secondary gives ketone and tertiary alcohols gives olefins.





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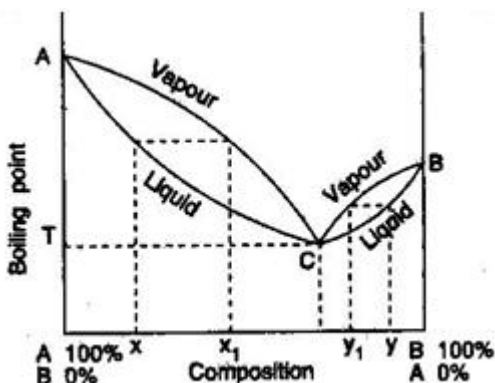
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|     | <p>Isopropyl alcohol<br/>(secondary)</p> $\begin{array}{ccc} & \text{CH}_3 & \\ &   & \\ \text{CH}_3 & -\text{CHOH} & \\ &   & \\ & \text{CH}_3 & \end{array} \xrightarrow{\text{Cu}/300^\circ\text{C}} \begin{array}{ccc} & & \\ & & \\ \text{CH}_3 & -\text{C}=\text{CH}_2 & + \text{H}_2\text{O} \\ &   & \\ & \text{CH}_3 & \end{array}$ <p>Tertiary butyl alcohol<br/>isobutylene</p>  |   |
| 4-e | <p><b><i>Azeotropic Mixture</i></b></p> <p>Azeotropes are defined as the mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of components in liquid as well as in vapour phase. Azeotropes are also called constant boiling mixtures because whole of the azeotropes changes into vapour state at constant temperature and their components can not be separated by fractional distillation. Azeotropes are of two types as described below,</p> <p>(1) <b>Minimum boiling azeotrope</b> : For the solutions with positive deviation there is an intermediate composition for which the vapour pressure of the solution is maximum and hence, boiling point is minimum. At this composition the solution distills at constant temperature without change in composition. This type of solutions are called minimum boiling azeotrope. e.g.,</p> | 2 |



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2

4-f

**Distinguish between ideal and non ideal solutions:**

4

| Ideal solutions  | Non-ideal solutions   |  |
|--|---|--|
|  | Positive deviation from Raoult's law  | Negative deviation from Raoult's law   |
| 1. Obey Raoult's law at every range of concentration.  | 1. Do not obey Raoult's law.  | 1. Do not obey Raoult's law.   |
| 2. $\Delta H_{mix} = 0$ ; neither heat is evolved nor absorbed during dissolution.               | 2. $\Delta H_{mix} > 0$ . Endothermic dissolution; heat is absorbed.                            | 2. $\Delta H_{mix} < 0$ . Exothermic dissolution; heat is evolved.                         |
| 3. $\Delta V_{mix} = 0$ ; total volume of solution is equal to sum of volumes of the components. | 3. $\Delta V_{mix} > 0$ . Volume is increased after dissolution.                                | 3. $\Delta V_{mix} < 0$ . Volume is decreased during dissolution.                          |
| 4. $P = p_A + p_B = p_A^0 X_A + p_B^0 X_B$<br>i.e.,<br>$p_A = p_A^0 X_A$ ; $p_B = p_B^0 X_B$     | 4. $p_A > p_A^0 X_A$ ;<br>$p_B > p_B^0 X_B$ $\therefore$<br>$p_A + p_B > p_A^0 X_A + p_B^0 X_B$ | 4. $p_A < p_A^0 X_A$ ; $p_B < p_B^0 X_B$<br>$\therefore p_A + p_B < p_A^0 X_A + p_B^0 X_B$ |
| 5. A-A, A-B, B-B Interacti   | 5. A-B Attractive   | 5. A-B Attractive for  |





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|     |  |   |  |  |            |
|-----|--|---|--|--|------------|
|     | <p>ons should be same, i.e., 'A' and 'B' are identical in shape, size and character.</p>   | <p>force should be weaker than <math>A-A</math> and <math>B-B</math> attractive forces. 'A' and 'B' have different shape, size and character.</p> | <p>should be greater than <math>A-A</math> and <math>B-B</math> attractive forces. 'A' and 'B' have different shape, size and character.</p> |  |            |
|     | <p>6. Escaping tendency of 'A' and 'B' should be same in pure liquids and in the solution.</p>   | <p>6. 'A' and 'B' escape easily showing higher vapour pressure than the expected value.</p>   | <p>6. Escaping tendency of both components 'A' and 'B' is lowered showing lower vapour pressure than expected ideally.</p>                   |  |            |
|     | <p>7.Examples:<br/>benzene + toluene;<br/>n-hexane + n-heptane;</p>  | <p>7. Examples:<br/>Acetone + ethanol</p>   | <p>7. Examples:<br/>Acetone + aniline;</p>   |  |            |
| 5   | <b>Any 4</b>   |   |  |  | <b>16</b>  |
| 5-a | <p>A solution is a mixture in which substances are inter mixed so intimately that they can not be observed as a separate component.</p> <p><b>Types of solutions :</b></p> <p>1) solid in liquid solutions<br/> Example :Mercury in zinc , Mercury in Gold, b) <math>CuSO_4 \cdot 5H_2O</math></p> <p>2) Liquid in liquid<br/> Example : Alcohol in water</p> <p>3) Gas in liquid<br/> <br/> Example : water vapours in air, mist.</p> <p>4) liquid in gas<br/> example: <math>CO_2</math> dissolved in water</p> <p>5) liquid in solid<br/> example: salt in water</p> <p>6) gas in gas</p> |   |  |  | 1<br><br>3 |



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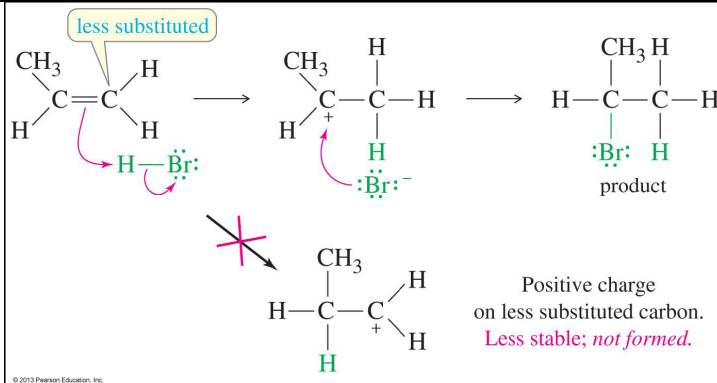
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|     |   |  |
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|     | <p>examples: mixtures of gases.</p> <p>7) solid in solid</p> <p>examples: copper in gold, zinc in copper</p>  |  |
| 5-b | <p><b>paraffin</b> hydrocarbon chemical <b>compound</b> also called alkane any of the saturated hydrocarbons having the general formula <math>C_nH_{2n+2}</math>, C being a carbon atom, H a hydrogen atom, and n an integer.</p> <p>The word "paraffin" is used to refer to the paraffin wax found in candles and electrical insulation, as well as the fuel kerosene in some countries. Paraffin is made of long-chain alkanes, which are made up of only carbon and hydrogen atoms. In addition, all the chemical bonds in alkanes are single bonds. The two main industrial sources of alkanes are crude oil and natural gas.</p> <p>The general chemical formula for paraffin wax is <math>C_nH_{2n+2}</math>, where "n" has an average value between 20 and 30. Paraffin wax is a type of hydrocarbon known as an "alkane."</p> | 2<br><br><br><br><br><br><br><br><br><br><br><br>2 |
| 5-c | <p><b>ANY TWO REACTIONS OF ALKENES:</b></p> <p>1. Markovnikov's Rule: The addition of a proton acid to the double bond of an alkene results in a product with the acid hydrogen bound to the carbon atom that already has the greater number of hydrogens attached.</p>   | 2 marks<br>each for<br>any 2                       |

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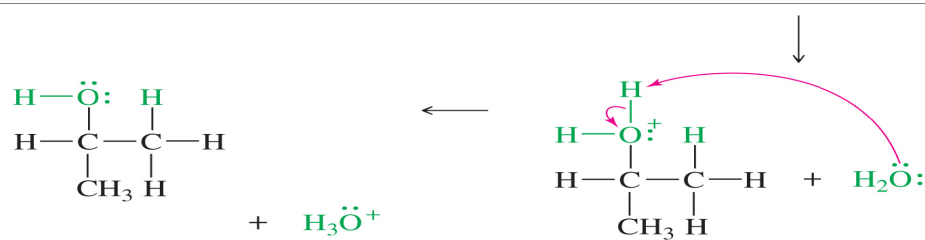


### 2. Addition of Water :

Alkenes can be converted to alcohols.

It is the *reverse* reaction of the dehydration of alcohols to give alkenes.

The principle of microscopic reversibility states that a forward reaction and a reverse reaction taking place under the same conditions must follow the **same** reaction pathway in microscopic detail.



### 3. Addition of Sulfuric Acid followed by Hydrolysis

The alkene reacts with conc. sulfuric acid to give an alkyl hydrogen sulfate, which then in turn is hydrolyzed to give the alcohol.

The formation of the alkyl hydrogen sulfate arises from initial protonation on the double bond, and the intermediate carbocation is trapped by the bisulfate anion. (Markovnikov addition).



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#### 4. Catalytic Hydrogenation

This is the addition of a hydrogen molecule to a compound using a (usually Pt, Pd, Ni) catalyst.

When the catalyst is in a different physical state to the other reactants it is called Heterogeneous catalysis (E.g. a solid catalyst with a liquid and a gas).

In contrast a liquid catalyst in a reaction solution is an example of homogeneous catalysis (acid catalyzed alcohol dehydration).

During catalytic hydrogenation, the hydrogen adsorbs onto the surface of the metal catalyst, and they add syn to the



#### 5. Hydrogenation

In the presence of a catalyst—typically platinum, palladium, nickel, or rhodium—hydrogen can be added across a triple or a double bond to take an alkyne to an alkene or an alkene to an alkane. In practice, it is difficult to isolate the alkene product of this reaction, though a poisoned catalyst—a catalyst with fewer available reactive sites—can be used to do so. As the hydrogen is immobilized on the surface of the catalyst, the triple or double bonds are hydrogenated in a *syn* fashion; that is to say, the hydrogen atoms add to the same side of the molecule.

#### 6. Hydrohalogenation

Alkenes and alkynes can react with hydrogen halides like HCl and HBr.



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|     |  |            |
|-----|--|------------|
|     | <p>Hydrohalogenation gives the corresponding vinyl halides or alkyl dihalides, depending on the number of HX equivalents added. The addition of water to alkynes is a related reaction, except the initial enol intermediate converts to the ketone or aldehyde. If the alkene is asymmetric, the reaction will follow Markovnikov's rule—the halide will be added to the carbon with more alkyl substituent.</p> <p>7. Ozonolysis of alkenes</p> <p>It is a reaction in which the double bond is completely broken and the alkene molecule converted into two smaller molecules.</p> <p><math display="block">\begin{array}{c} R_1 &amp; &amp; R_3 \\ &amp; \backslash &amp; / \\ &amp; C=C \\ &amp; / &amp; \backslash \\ R_2 &amp; &amp; R_4 \end{array} \xrightarrow{O_3} \begin{array}{c} R_1 \\   \\ C=O \\   \\ R_2 \end{array} + \begin{array}{c} R_3 \\   \\ O=C \\   \\ R_4 \end{array}</math></p> |            |
| 5-d | <p>alkyl halides reacts with aqueous sodium hydroxide to form alcohols.</p> <p>1) <math>C_2H_5I + KOH \rightarrow C_2H_5OH + KI</math><br/>Ethyl iodide (aqueous) ethanol</p> <p>2) <math>CH_3Br + AgOH \rightarrow CH_3OH + AgBr</math><br/>methyl bromide moist silver oxide methyl alcohol</p>  | 2<br><br>2 |
| 5-e | <p><b>Uses of alcohols: (any 4)</b></p> <p><b>1. Industrial methylated spirits</b></p>   | 4          |



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Ethanol is usually sold as industrial methylated spirits, which is ethanol with a small quantity of methanol and possibly some color added. Because methanol is poisonous, industrial methylated spirits are unfit to drink, allowing purchasers to avoid the high taxes levied on alcoholic drinks.

**2. Use of ethanol as a fuel**

Ethanol burns to produce carbon dioxide and water, as shown in the equation below, and can be used as a fuel in its own right or in mixtures with petrol (gasoline). "Gasohol" is a petrol/ethanol mixture containing approximately 10–20% ethanol. Because ethanol can be produced by fermentation, this is a useful method for countries without an oil industry to reduce the amount of petrol imports.

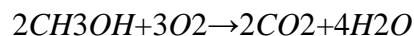


**3. Ethanol as a solvent**

Ethanol is widely used as a solvent. It is relatively safe and can be used to dissolve many organic compounds that are insoluble in water. It is used, for example, in many perfumes and cosmetics.

**4. Methanol as a fuel**

Methanol also burns to form carbon dioxide and water:



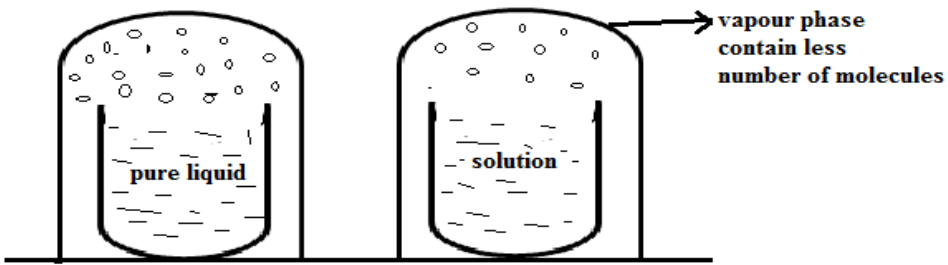
It can be used as a petrol additive to improve combustion, and its use as a fuel in



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|     |  |    |
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|     | <p>its own right is under investigation.</p> <p><b>5.Methanol as an industrial feedstock</b></p> <p>Most methanol is used to make other compounds, for example, methanal (formaldehyde), ethanoic acid, and methyl esters of various acids. In most cases, these are then converted into further products.</p>   |    |
| 5-f | <p><b>Vapour pressure of solvent is lowered by addition of non-volatile solute :</b></p> <p>If a non-volatile solute is added to a volatile liquid, the vapour pressure of the solution is lower than the vapour pressure of pure solvent.</p>  <p>In pure liquid, the whole, surface of the liquid is occupied by the molecules of the liquid. In case of solution , a part of surface of the solution is occupied by the solute particles. This decreases number of molecules of liquid at the surface of the solution. This reduces escaping tendency of solvent molecules, thereby lowering vapour pressure of the liquid (solvent).</p> | 4  |
| 6   | <b>Any 4</b>   | 16 |
| 6-a | <p><b>Ostwald's theory</b> considers indicator to be a weak acid or base whose unionised forms differently coloured. In presence of acid or base, ie pH change, there is ionization of indicator and hence the colour change appears.</p>  | 4  |



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|     |   |        |
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|     | <p>For example<br/>phenolphthalein<br/>phenolphthalein is a weak acid (PhH)</p> $\text{PhH} \rightleftharpoons \text{Ph}^- + \text{H}^+ \dots\dots\dots(1)$ <p>(colourless (Pink in base)<br/>in acid)</p> $\text{H}^+ + \text{OH}^- \rightleftharpoons \text{H}_2\text{O}$ <p>In presence of an acid (H<sup>+</sup>) equilibrium (1) is displaced towards the left hand side (a case of LeChatelier's principle); when strong base like NaOH is added, this equilibrium is displaced towards right hand side and there is colour change from colourless to pink when pH changes. This indicator is not suitable for titrating weak base since weak base can't furnish enough OH<sup>-</sup> that can react with H<sup>+</sup> of the phenolphthalein and can impart pink colour only after excess of weak base is added.</p> |        |
| 6-b | <p><b>Alkene</b> - C<sub>n</sub>H<sub>2n</sub> example: ethane C<sub>2</sub>H<sub>4</sub>, PROPENE C<sub>3</sub>H<sub>6</sub>, BUTENE C<sub>4</sub>H<sub>8</sub> etc.</p> <p><b>Alkyne</b> - C<sub>n</sub>H<sub>2n-2</sub> example : ethyne(acetylene) C<sub>2</sub>H<sub>2</sub>, PROPYNE C<sub>3</sub>H<sub>4</sub> etc.</p>  | 2<br>2 |
| 6-c | <p><b>PHYSICAL PROPERTIES OF ALKYL HALIDES(any 4)</b></p> <ol style="list-style-type: none"><li>1. Alkyl halides (RX) have higher boiling points (BP) than alkanes with the same number of carbons.</li><li>2. As the molecular weight (MW) increases the boiling point (BP) increases.</li><li>3. As branching increases, BP decreases.</li></ol>  | 4      |

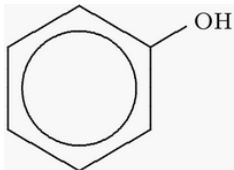




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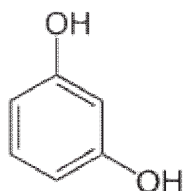
|     |  |                   |
|-----|--|-------------------|
|     | <p>4. Alkyl halides are insoluble in water.</p> <p>5. Alkyl halides are soluble in low polarity solvents.</p>  |                   |
| 6-d | <p>: these are obtained by prefixing the name of alkane by halogen. the paraffins react with halogens which replace one or more of their hydrogen atoms by halogen atoms. the products obtained are called halogen derivatives of paraffins.</p> <p><b>CLASSIFICATION</b></p> <p>Alkyl halides are classified the same as hydrogens. The class of carbon the halide is attached to determines the classification of the halide.</p> $\begin{array}{ccc} \text{R}-\text{C}-\text{X} & \text{R}-\text{C}-\text{X} & \text{R}-\text{C}-\text{X} \\   &   &   \\ \text{H} & \text{R} & \text{R} \\   &   &   \\ \text{H} & \text{H} & \text{R} \\ 1^\circ & 2^\circ & 3^\circ \end{array}$ | <p>2</p> <p>2</p> |
| 6-e | <p>1. Mono Hydric Phenol</p> <p>Those aromatic phenols which contain only one OH group are called Mono Hydric Phenol.</p> <p>ex: C<sub>6</sub>H<sub>5</sub>OH</p>  <p>2. Di Hydric Phenol</p> <p>Those aromatic phenols which contain two OH groups are called Di Hydric Phenol.</p>  | <p>2</p>          |



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**Uses of phenol :** (any two)

- 1) The main use of phenol is as a feedstock for phenolic resins, bisphenol A and caprolactam (an intermediate in the production of nylon-6).
- 2) It is used in the manufacture of many products including insulation materials, adhesives, lacquers, paint, rubber, ink, dyes, illuminating gases, perfumes, soaps.
- 3) Also used in embalming and research laboratories. It is a product of the decomposition of organic materials, liquid manure, and the atmospheric degradation of benzene.
- 4) It is found in some commercial disinfectants, antiseptics, lotions and ointments.
- 5) Phenol is active against a wide range of microorganisms, and there are some medical and pharmaceutical applications including topical anaesthetic and ear drops, sclerosing agent.
- 6) It is used in dermatology for chemical face peeling

2

6-f

The **Friedel–Crafts reactions** are a set of reactions developed by Charles Friedel and James Crafts in 1877 to attach substituents to an aromatic ring. There are two main types of Friedel–Crafts reactions: alkylation reactions and acylation reactions. Both proceed by electrophilic aromatic substitution. (ANY ONE )

4



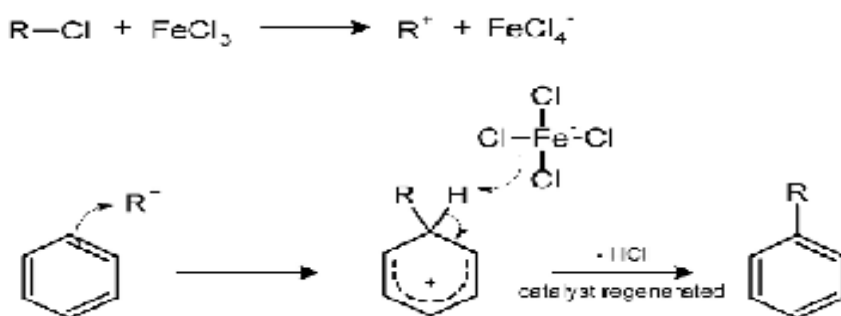
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*Friedel-Crafts alkylation*

Friedel-Crafts alkylation involves the alkylation of an aromatic ring with an alkyl halide using a strong Lewis acid catalyst. With anhydrous ferric chloride as a catalyst, the alkyl group attaches at the former site of the chloride ion. The general mechanism is shown below.



*Friedel-Crafts acylation*

Friedel-Crafts acylation is the acylation of aromatic rings with an acyl chloride using a strong Lewis acid catalyst. Friedel-Crafts acylation is also possible with acid anhydrides. Reaction conditions are similar to the Friedel-Crafts alkylation mentioned above. This reaction has several advantages over the alkylation reaction. Due to the electron-withdrawing effect of the carbonyl group, the ketone product is always less reactive than the original molecule, so multiple acylations do not occur. Also, there are no carbocation rearrangements, as the carbonium ion is stabilized by a resonance structure in which the positive charge is on the oxygen.

The viability of the Friedel-Crafts acylation depends on the stability of the acyl chloride reagent. Formyl chloride, for example, is too unstable to be isolated. Thus,



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synthesis of benzaldehyde via the Friedel–Crafts pathway requires that formyl chloride be synthesized.

