
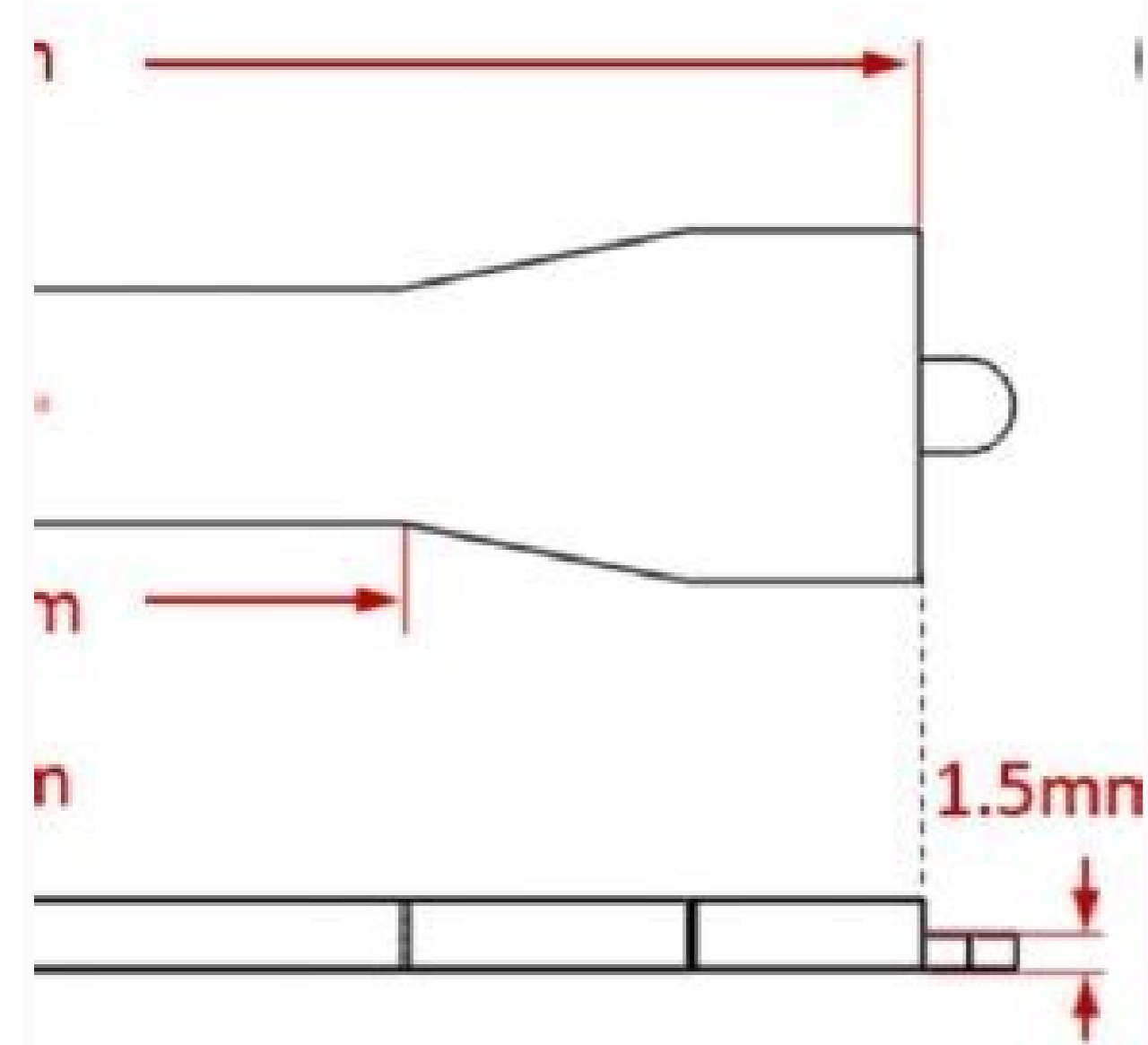


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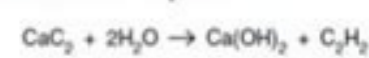
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Examination question

A factory makes ethyne gas from calcium carbide,  $\text{CaC}_2$ . One of the waste products is calcium hydroxide.



Each day  $1.00 \times 10^6$  grams of calcium carbide are used and  $3.60 \times 10^3 \text{ dm}^3$  of ethyne gas, measured at room temperature and pressure, is manufactured.

(i) Calculate the atom economy for this process using the relative formula masses in the table below.

compound	relative formula mass
$\text{CaC}_2$	64.1
$\text{H}_2\text{O}$	18.0
$\text{Ca(OH)}_2$	74.1
$\text{C}_2\text{H}_2$	26.0

atom economy = .....% [2]

e.g. Ethane can be produced by electrolysis of sodium acetate (sodium ethanoate). In this method, higher alkanes are produced. The alkanes may be divided as: 1) Open chain or Acyclic alkanes . • The front carbon is shown as the lower left hand carbon and there are carbon is shown as the upper right hand carbon.  $\text{CH}_3\text{-(CH}_2\text{)}_4\text{-CH}_3$  773K, 10-20 atm Hexane Benzene 25. Propagation Chlorine free radicals attacks the methane molecule and takes the reaction in the forward direction by breaking the C-H bond to generate methyl free radical with the formation of H-Cl. The methyl radical thus obtained attacks the second molecule of chlorine to form  $\text{CH}_3\text{-Cl}$  with the liberation of another chlorine free radical by homolysis of chlorine molecule. The general combustion equation for any alkane is: Due to the evolution of large amount of heat during combustion, alkanes are used as fuels cells. In this method alkane having one carbon less than the salt of carboxylic acid, is produced. Alkyl halides on treatment with sodium metal in dry etheral (free from moisture)solution give higher alkanes. The unsaturated hydrocarbons (alkenes and alkynes) are converted into alkanes by catalytic hydrogenation. • The front carbon atom is shown by a point whereas the carbon further from the eye is represented by the circle. • In a mechanism there are three steps :- Initiation , propagation and termination. 27. This process is called aromatization. Pyrolysis of hexane gives following product : 24. 10. • The reaction in which an atom or a group of atoms in a molecule is replaced by some other atom or group of atom. Petroleum and natural gas are the main source of alkanes. ALKANES AND THEIR PREPARATION 2.  $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$  When higher alkanes are heated to high temperature in the presence of alumina or silica catalysts, the alkanes break down to lower alkanes and alkenes. The hydrogenation reaction of unsaturated hydrocarbon using nickel at a temperature of 523-573K is commonly known as Sabatier and Sender's reaction or reduction. HERMANN KOLBE 12. This reaction is known as Wurtz reaction and is used for the preparation of higher alkanes containing even number of carbon atom. 16. Hydrolysis of Grignard reagents produces corresponding alkanes. At high temperatures and pressure do undergo some reaction. Soda-lime is prepared by soaking quick lime in a caustic soda solution and then drying. Methane cannot be prepared by this method because starting alkene or alkyne must contain at least two carbon atom. 5. • The two carbon atoms forming the  $\sigma$  bond are represented by two circle; one behind the other so that only the front carbon is seen. • Therefore, the C-H bonds of the front carbon are depicted from the centre of the circle while C-H bonds of the back carbon are drawn from the circumference of the circle at an angle of  $120^\circ$  at each other. 18. Free pdf Books are available! -> Class 11 Chemistry Full book pdf -> Class 12 Chemistry Full book pdf 1. Mechanism of halogenation reaction Initiation The reaction is initiated by homolysis of chlorine molecule in the presence of light or heat, the C-Cl bond is weaker than the C-C and C-H bond and hence, is easiest to break 19. Alkanes on heating with a regulated supply of dioxygen or air at high pressure and in the presence of suitable catalyst give a variety of oxidation product: i)When a mixture of methane and oxygen in the molar ratio of 9:1 is compressed to about 1100 atmospheres and passed through copper tubes at 575 K, methane is oxidised to methanol. The catalyst changes molecular hydrogen to atomic hydrogen which can break pi-bonds of alkenes or alkynes and will be added to them. i) Alkyl halides (except fluorides) on reduction with zinc and dilute hydrochloric acid give alkanes.  $(\text{CH}_3)_3\text{CH} + \text{O} \rightarrow \text{alk.KMnO}_4 \text{HCHO} + \text{H}_2\text{O}$  23. Rate of replacement of hydrogen of alkanes is:  $3^\circ > 2^\circ > 1^\circ$ . 20. 21. Decarboxylation reaction Kolbe's electrolytic method 9. Alkane isomerise to branched chain alkanes when heated with anhydrous aluminium chloride ( $\text{AlCl}_3$ ) and hydrogen chloride at 573 K under a pressure of about 30-35 atmosphere. • It is found that the rate of reaction of alkanes with halogen is  $\text{F}_2 > \text{Cl}_2 > \text{Br}_2 > \text{I}_2$ . Types of substitution reactions 17. • The process of elimination of carbon dioxide from a carboxylic acid is known as decarboxylation. However, alkanes can be prepared by three methods. The salt is called sodium carboxylate.  $\text{LiAlH}_4$  or  $\text{NaBH}_4$  could also be used as a reducing agent. 5) Preparation of alkanes by Decarboxylation of Mono-carboxylic Acids: Removal of a carboxylic group or  $\text{CO}_2$  is called decarboxylation. 22. Platinum and palladium catalyse the reaction at room temperature. This salt on heating with soda lime loses its carboxylic group and produces alkane which is one carbon less than the acid. • PROPAGATION At anode- TERMINATION At cathode:- 14. • The central carbon-carbon bond (C-C) is drawn as a straight line slightly tilted to right for the sake of clarity. Wurtz reaction of preparation of alkanes 7. This method is used to prepare gaseous alkanes with an even number of carbons. DECARBOXYLATION REACTION • Sodium salts of carboxylic acids on heating with soda lime (mixture of sodium hydroxide and calcium oxide) gives alkanes containing one carbon atom less than the carboxylic acid. An aqueous solution of sodium or potassium salt of a carboxylic acid on electrolysis gives alkane containing even number of carbon atoms at the anode. Chemical properties of alkanes 15. Alkanes on heating in the presence of air or dioxygen are completely oxidized to carbon dioxide and water with the evolution of large amount of heat. 3. CHARLES ADOLPH WURTZ 8. KOLBE'S ELECTROLYTIC METHOD 11. 4. The mixture of ethane and carbon dioxide obtained at the anode is made to pass through  $\text{KOH(aq)}$  solution,  $\text{CO}_2$  will be absorbed by the solution while ethane will pass on and will then be collected over the surface of the water. 3) Preparation of alkanes by Hydrolysis of Grignard Reagent: Alkyl Magnesium Halides ( $\text{R-Mg-X}$ ) is called Grignard reagents. PAUL NEW MAN They are also called Paraffins.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$  anhy. $\text{AlCl}_3, \text{HCl}$   $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_3$  n-butane isopropane The alkanes containing six or more carbon atoms when heated at about 773K under high pressure of 10-20 atm in the presence of catalyst on alumina gel get converted to aromatic compounds.  $2\text{CH}_3\text{OH}$  ii) When methane is mixed with oxygen and passed through heated molybdenum oxide ( $\text{Mo}_2\text{O}_3$ ), under pressure it is oxidised to methanal. Table of content By Hydrogenation of unsaturated hydrocarbons By Reduction of Alkyl HalidesBy Hydrolysis of Grignard ReagentBy Wurtz's ReactionBy Decarboxylation of Mono-carboxylic AcidsKolbe's Electrolysis Preparation of alkanes by Hydrogenation of unsaturated hydrocarbons (Sabatier Senderm's reaction): Alkanes can be prepared by passing alkenes or alkynes over finely divided nickel or platinum or palladium catalysts. Saw horse's projections • In this projection, the molecule is viewed along the axis of the model from an oblique angle. The reaction of alkyl halides with sodium metal in presence of anhydrous ether produces alkanes and is called Wurtz's reaction. The reaction stops after some time due to consumption of reactants and/or due to following side reaction: The possible chain terminating steps are: a) b) c) Though in (c)  $\text{CH}_3\text{-Cl}$ , the one of the product is formed but free radicals are consumed and the chain is terminated. The addition of hydrogen to alkenes or alkynes is called hydrogenation and is also called Sabatier-Senderm's Reaction or S-S Reaction. CLASSIFICATION OF ALKANES Alkanes are saturated hydrocarbon containing only carbon-carbon single bond in their molecule. INITIATION Here sodium acetate is converted into acetate and sodium ions. Kolbe's Electrolysis: When electrolysis of an aqueous solution of sodium or potassium salt of mono-carboxylic acid is carried out, alkanes are produced. For eg: 6. 2) Cycloalkanes or cyclic alkanes. Newman's projections • In this method, the molecule is viewed from the front along the carbon-carbon bond axis. In this process dihydrogen is passed through alkenes or alkynes in the presence of finely divided catalysts such as Raney Ni, Pt or Pd. These metals absorb dihydrogen gas on their surfaces and activate the hydrogen-hydrogen bond. 4) Preparation of alkanes by Wurtz's Reaction: Wurtz discovered this method in 1885. When carboxylic acids (or fatty acids) are treated with  $\text{NaOH}$ , the corresponding sodium salt of the acid is produced. Halogenation • This involves the replacement of one or more atoms of alkanes by the corresponding number of halogens atoms. Reaction mechanism of Kolbe's electrolytic method 13. While using Nickel, heating is required at 250-300oC but in the case of Platinum and palladium no heating is required. AT THE CATHODE THERE IS REDUCTION OF WATER INTO HYDROGEN FREE RADICALS AND THAT IS CONVERTED INTO HYDROGEN AND GIVEN OFF. These are organometallic compounds. For eg:  $\text{C}_3\text{H}_8$   $\text{C}_2\text{H}_4 + \text{CH}_4$  or  $\text{C}_3\text{H}_6 + \text{H}_2$  This reaction is called Fragmentation or Cracking or Pyrolysis. 2) Preparation of alkanes by Reduction of Alkyl Halides: Molecular hydrogen cannot reduce alkyl halides, however atomic hydrogen can reduce alkyl halides and gives alkanes. However, higher temperature (523-573k) and pressure are required with nickel catalysts:  $2\text{CH}_4 + \text{O}_2 \xrightarrow{\text{Cu}/575\text{K}/1100 \text{ atm}}$  On passing a mixture of steam and methane over heated nickel (supported over alumina,  $\text{Al}_2\text{O}_3$ ) catalyst at 1273 K, methane is oxidised to carbon monoxide and hydrogen is evolved. Therefore alkyl halides are treated with Zinc in presence of dil  $\text{HCl}$ , nascent hydrogen is produced which reduces alkyl halides to corresponding alkanes. CONFORMATIONS Newman's projections Saw horse projections 26. Alkanes undergo substitution reaction in which one or more hydrogen atoms are replaced or substituted by different atoms or groups such as halogen atom (Cl, Br or I), nitro group ( $\text{NO}_2$ ) or sulphonic acid ( $\text{-SO}_3\text{H}$ ) group. • This METHOD IS USED FOR THE REDUCTION OF  $\text{CO}_2$ .

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