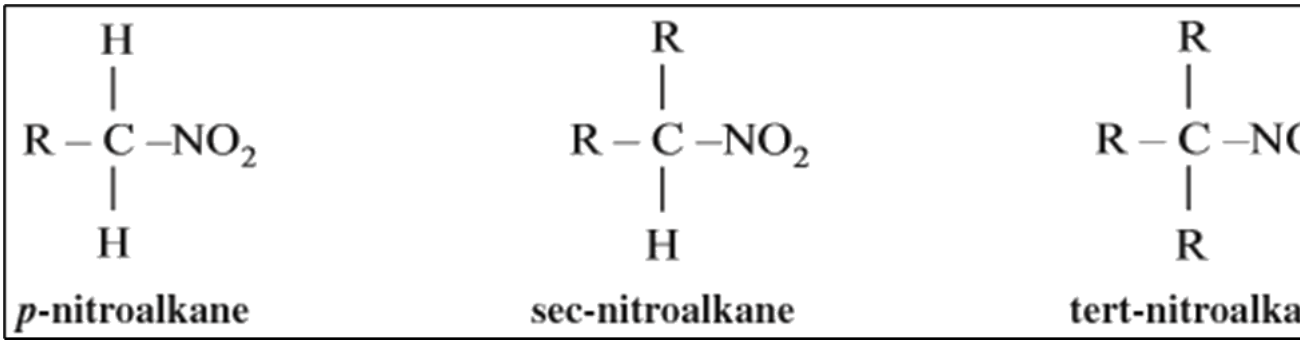
Compounds of Carbon Containing Nitrogen: A Nitro Compounds (For CBSE, ICSE, IAS, NET, NRA 2022)

Nitro Compounds

Nitro compounds are those derivatives of hydrocarbons in which a hydrogen atom is replaced by a nitro ($-NO_2$) group. They may be aliphatic or aromatic. Nitroalkanes are divided into primary (1°) , secondary (2°) or tertiary (3°) nitro alkanes depending upon the attachment of nitro group to primary, secondary or tertiary carbon atom, respectively.



IUPAC Nomenclature of Nitro Compounds

Compound	IUPAC Name
$CH_3 - NO_2$	Nitromethane
$CH_3CH_2 - NO_2$	Nitroethane
	Nitrobenzene
	1,3 – Dinitrobenzene

IUPAC Nomenclature of Nitro Compounds

Preparation of Nitro Compounds

From Alkyl Halides

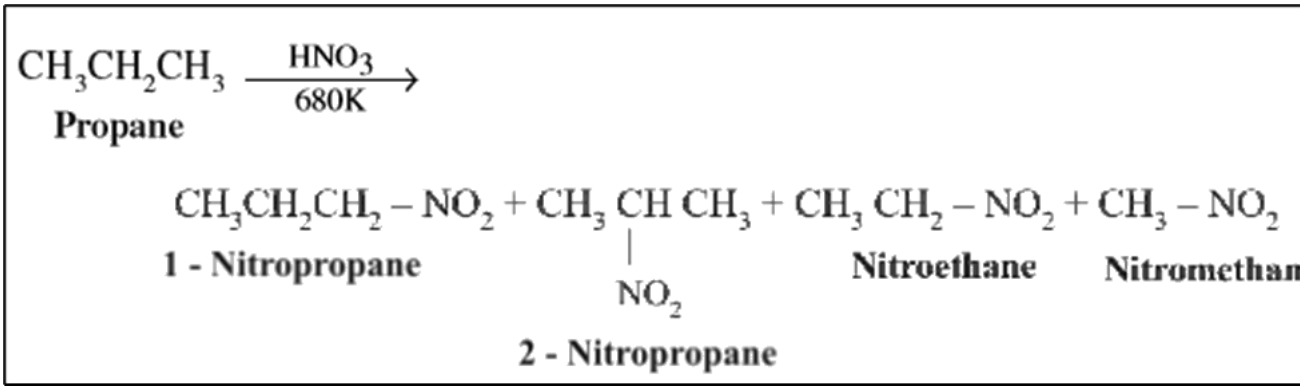
Nitroalkanes are prepared by heating an alkyl halide with aqueous ethanolic solution of silver nitrite. In this reaction, a small amount of isomeric alkyl nitrites ($R-O-N=O$) is also obtained.

For example,

$$\underset{\text{Bromoethane}}{CH_3CH_2Br} + AgNO_2 \rightarrow \underset{\text{Nitroethane}}{CH_3CH_2NO_2} + AgBr$$

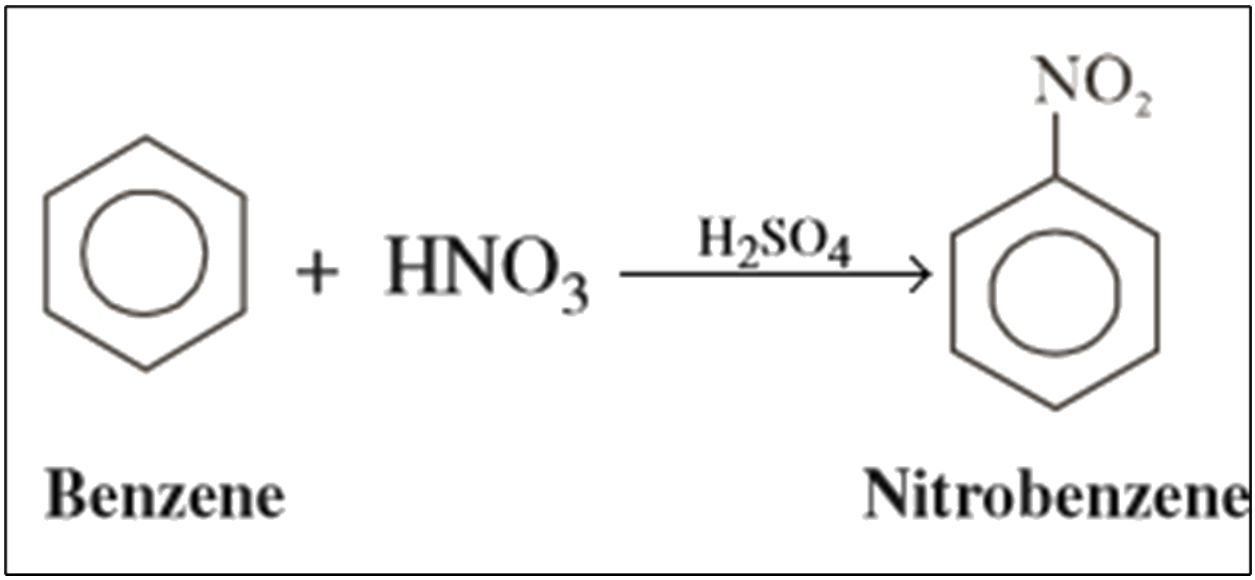
By Nitration of Alkanes

Nitroalkanes can also be prepared by the nitration of alkanes in vapour phase. For this reaction, a mixture of the alkane and nitric acid is passed through a metal tube at about $680K$.



By Nitration of Aromatic Compounds

Aromatic nitro compounds are almost always prepared by direct nitration. For example, nitration of benzene gives nitrobenzene.



Physical Properties of Nitro Compounds

- Nitroalkanes are colorless oily liquids in the pure state.
- They have pleasant smell.
- They possess higher boiling points than the corresponding alkanes because of their polar nature.
- Most other aromatic nitro compounds are yellow crystalline solids.
- All the nitro compounds are heavier than water and insoluble in it.

Chemical Properties of Nitro Compounds:

Reduction

One of the important reactions of nitro compounds is reduction. Nitro compounds can be readily reduced to primary amines by a variety of reducing agents.

$$\underset{\text{Nitroethane}}{CH_3CH_2-NO_2} + 3H_2 \xrightarrow{Ni} \underset{\text{Ethanamine}}{CH_3CH_2-NH_2} + 2H_2O$$

Hydrolysis

Primary nitroalkanes on reaction with dilute hydrochloric acid or sulphuric acid undergo hydrolysis to produce carboxylic acids and hydroxylamine.

$$RCH_2-NO_2 + H_2O \xrightarrow{HCl} \underset{A\ \text{Carboxylic acid}}{R-COOH} + \underset{\text{Hydroxylamine}}{NH_2OH}$$

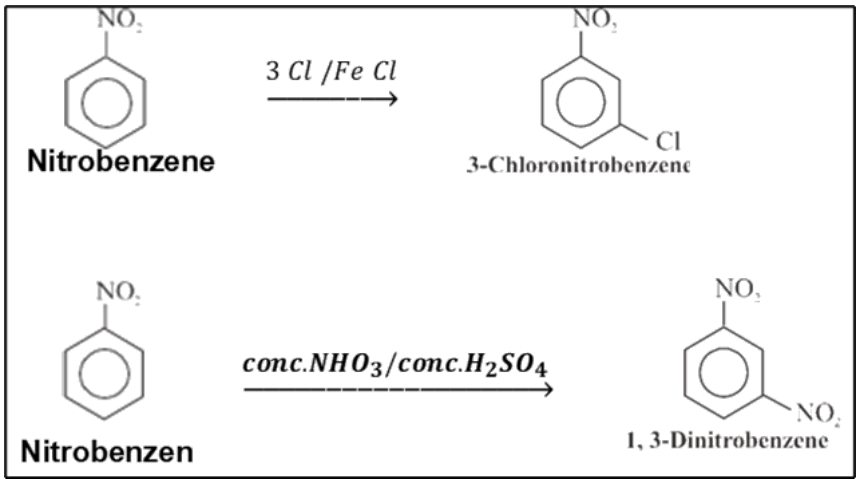
Thermal Decomposition

Nitroalkanes decompose with explosion on heating. Advantage is taken of this reaction in the commercial use of nitroalkanes as explosives. It is due to the formation of large volume of gaseous products on heating which produce high pressure.

$$2\ CH_3NO_2 \xrightarrow{\Delta} N_2 + 2\ CO_2 + 3\ H_2$$

Ring Substitution in Aromatic Nitro Compounds

It is due to the electron withdrawing tendency of $-NO_2$ group. Thus, nitrobenzene on halogenation, nitration or sulphonation gives the meta- substituted products as shown below.



Uses of Nitro Compounds

- Nitroalkanes are used as solvents for rubber, cellulose acetate etc.
- They are used as intermediates in the industrial production of explosives, detergents, medicines, amines etc.
- Nitro compounds are also used as fuel in small engines and rockets.