Oxides of Nitrogen

Introduction to oxides of nitrogen

Nirogen has a position in second period of group V in the modern periodic table. It has molecular formula N_2. It has atomic number 7 and atomic weight 14.08 and its electronic configuration of 2,5.

Besides combining with hydrogen and forming NH_3 , nitrogen combines with oxygen in different ratios and forms five different oxides.

The **oxides of nitrogen** and the details of the oxygen states of nitrogen and the N:O ratio can be presented in a tabular form as:

Name	**Formula**	**Oxidation state of N**	**Ratio of N:O**
1) Nitrogen Oxide or nitrous oxide	NO	+2	1:1
2) Nitrogen dioxide	NO_2	+4	1:2
3) Nitrous oxide (also called laughing gas)	N_2O	+1	2:1

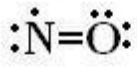
All of these oxides of nitrogen are gases, excepting NO and N_2O the other oxides are brownish gases. Except the oxides of NO and N_2O all the other oxides are acidic. NO and N_2O are neutral.

The other oxides are prepared in the laboratory using different methods characteristic to each oxide.

Example of Oxides of Nitrogen (nitric Oxide - NO)

Structure:

NO



Laboratory Preparation: The oxide is prepared in the laboratory by treating the metallic copper with a moderately concentarted nitric acid (1:1) at room temperature.

The reaction is given as :

$2Cu + 8\,HNO_3 \text{ ------> } Cu(NO_3)_2 + 2NO + 4H_2O$

The gas is collected by downward displacement of water.The apparatus used is Wolfe's apparatus. The purification is done by absorbing the NO gas in frashly prepared ferrous sulphate solution. Ferrous sulphate absorbs all the NO gas and forms

$Fe(H_2O)_5$ NO and the solution becomes brown. On heating this solution pure Nitric Oxide is obatined.

Physical Properties: NO is not a combustible gas. At high temperature around 1000°C it decomposes into N_2 and O_2 .

$$2NO = N_2 + O_2 \qquad \text{at high temperature}$$

From the equation above we can see that once the decomposition starts 50% O_2 gets evolved and this O_2 supports combustion thus making the reaction more violent.

Chemical properties:

1) NO acts as an **oxidising agent**, oxidising SO_2 in presence of water to give H_2SO_4:

$$SO_2 + 2NO + H_2O \rightarrow H_2SO_4 + N_2O$$

2) NO acts as a **reducing agent,**

i) reducing an acidified solution of potassium permanganate (pink) to colorless manganous salt.

$$3KMnO_4 + 6H_2SO_4 + 5NO_2 \rightarrow 3KHSO_4 + 3MnSO_4 + 2H_2O + 5NO_3$$

ii) It can also reduce aqueous solution of I_2 to HI

$3I_2 + 2NO + 4H_2O \rightarrow 2HNO_3 + 6HI$

3) **With halogens** NO can form addition compounds as

$2NO + Cl_2 \rightarrow 2NOCl$ (NOCl is nitrosyl chloride)

It reacts in the same way with flourine and bromine.

4) With ferrous sulphate NO forms an addition compound as

$FeSO_4 + 5H_2O + NO = [Fe(H_2O)_5NO]SO_4$

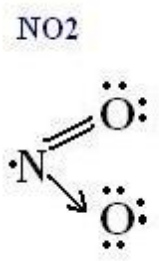
penta aqua nitrosyl iron (II) sulphate

This is the famous **brown ring test** used to identify the nitrate radical or the NO radical.

Uses: NO is used to prepare nitric acid.

Nitrogen Dioxide - NO2

Structure:



Laboratory Preparation: In the laboratory NO_2 is prepared by thermal decomposition of $Pb(NO_3)_2$. Thus

$2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$

Care is taken to ensure the use of dried $Pb(NO_3)_2$ as hydrated nitrate salts on heating react violently and explode.

Physical Properties: NO_2 is a poisonous gas, main source being the exhaust of automobiles.

1) At room temperature it is a deep brown gas.

2) It does not support combustion.

3) It is not combustible.

Chemical Properties:

1) With cold water NO_2 reacts to give a mixture of HNO_2 and HNO_3 acid.

$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$$

2) With hot water the reaction is

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

3) Being acidic it reacts with bases as

$$2NO_2 + KOH \rightarrow KNO_3 + H_2O + KNO_2$$

4) It is also a strong oxidising agent.

$$H_2S + NO_2 \rightarrow NO + H_2S + S$$

5) With excess oxygen and water NO_2 gives HNO_3.

$$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

6) It reacts with concentrated H_2SO_4 to give nitrosyl hydrogen sulphate

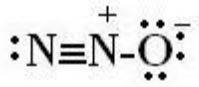
$$2NO_2 + H_2SO_4 \rightarrow SO_2(OH)ONO + HNO_3$$

Uses: NO_2 is used as a fuel in rockets besides being used to prepare HNO_3 .

Nitrous Oxide - N2O (laughing Gas)

Structure:

N2O



Laboratory Preparation: N_2O can be prepared in the laboratory by heating NH_4NO_3 below 200°C to avoid explosion. Sometimes as a safety measure instead of directly using NH_4NO_3, a mixture of $(NH_4)_2SO_4$ and $NaNO_3$ are heated to give NH_4NO_3 which decomposes further to give N_2O.

$NH_4NO_3 \rightarrow N_2O + H_2O$ (endothermic reaction)

Physical Properties:

1) N_2O has a faint sweet smell and produces a tickling sensation on the neck when inhaled and makes people laugh hysterically. Excess of inhalation leads to unconsiousness.

2) Unlike other oxides of nitrogen, N_2O supports combustion though it does not burn itself.

Chemical Properties:

1) At very high temperature N_2O decomposes to N_2 and O_2

$2N_2O \rightarrow 2N_2 + O_2$

If a glowing piece of Mg, Cu, or P is introduced in such an environment, these pieces burn brightly due to the O_2 produced from decomposition of N_2O.

2) With Sodium and potassium N_2O reacts to give the corresponding peroxides liberating N_2 in the process.

$2N_2O + 2Na \rightarrow Na_2O + 2N_2$.

Na_2O is sodium peroxide

Uses:

1) It is used as propellent gas.

2)Used in combination with oxygen in the ratio $N_2O : O_2 = 1:10$ as a mild anaesthetic.