Formation of ozone is an..?

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For Feedback...
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16th GROUP ELEMENTS

- Industrially dioxygen is obtained from purified air by fractional distillation

Physical properties: It is a colourless and odourless gas.

- Its solubility in water is to the extent of $3.08\,cm^3$ in $100\,cm^3$ water at 293K
- It liquefies at 90K and freezes at 55K
- Oxygen atom has three stable isotopes O^{16}, O^{17}, O^{18}
- Molecular oxygen is paramagnetic even though it contains even number of electrons.

Chemical properties: Oxygen directly reacts with nearly all metals and non-metals except some metals like Au, Pt and noble gases.

With metals :- $2Ca + O_2 \rightarrow 2CaO$

$4Al + 3O_2 \rightarrow 2Al_2O_3$

With non metals:- $P_4 + 5O_2 \rightarrow P_4O_{10}$

$C + O_2 \rightarrow CO_2$

With other compounds

$ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Some compounds are catalytically oxidised.

$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$

$4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$

Uses: In welding and cutting – oxy-hydrogen or oxy-acetylene torch is used.

- In the manufacture of many metals, particularly steel
- Oxygen cylinder are widely used in hospitals, high altitude flying and in mountaineering
- As a fuel in rockets (Hydrazine in liquid oxygen produces tremendous thrust in rockets)

Oxides: A binary compound of oxygen with another element is called oxide.

- Oxides are two types:

1. Simple Oxide (Na_2O , Al_2O_3 etc..)
2. Mixed Oxides

Mixed oxides:- Formed by the combination of two simple oxides eg: Red lead, Pb_3O_4 $(PbO_2.2PbO), Fe_3O_4 (FeO + Fe_2O_3)$

- Simple oxides classified as

(i) **Acidic oxides** (Non-metal Oxides)oxides of non metals which give acids when dissolved in water are called acidic oxides.

eg. $CO_2, NO_2, P_2O_5, SO_2, SO_3, Cl_2O_7$ etc..

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

$SO_2 + H_2O \rightarrow H_2SO_3$ (Sulphurous acid)

- Some metals in high oxidation state also have acidic character $(eg\ Mn_2O_7, CrO_3, V_2O_5)$

ii) **Basic oxides:-** The oxides which give a base with water are known as basic oxides $(eg\ Na_2O, CaO, BaO)$

(iii) **Amphoteric oxides:-** The oxides which can react with both acids and alkalies are known as amphoteric oxides

eg $ZnO, PbO, Al_2O_3, SnO_2, BeO, Sb_2O_3$

$Al_2O_{3(s)} + 6NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 2Na_3\left[Al(OH)_6\right]_{(aq)}$

$Al_2O_{3(s)} + 6HCl_{(aq)} + 9H_2O_{(l)} \rightarrow 2\left[Al(H_2O)_6\right]^{3+}_{(aq)} + 6Cl^-_{(aq)}$

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

(iv) Neutral oxides - such oxides do not combine with an acid or a base eg: NO, N_2O, CO, H_2O etc

Ozone: Ozone is present in upper atmosphere and absorbs the harmful U.V. rays of sun.

- Ozone is prepared by subjecting silent electric discharge of cold and dry oxygen gas
- Formation of ozone is an endothermic, reversible reaction.

$3O_2 \underset{discharge}{\overset{electric}{\rightleftharpoons}} 2O_3$; $\Delta H = +284.5kJ$

- Ozone is prepared in the laboratory by using Siemen's and Brodie's ozonisers.In this process around 10% conversion of O_2 to O_3 is possible.
- The obtained gas is a mixture of O_2+O_3 it is called Ozonised oxygen
- Ozonised oxygen is cooled, when O_3 first liquifies and so can be separated from gaseous O_2
- Electrolysis of acidulated water with platinum electrodes gives O_3 at anode. The gases liberated at the anode contain about 95% O_2 and 5% O_3.
- Ozone can also be prepared by heating oxygen to 2773K and cooling it.(thermal method).

Physical Properties: O_3 is a pale blue,pungent smelling poisonous gas,dark blue in liquid state, violet black in solid state.

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- O_3 harmless in small concentration, however if concentration exceeds 100ppm, breathing becomes uncomfortable resulting in headache and nausea.
- Ozone is thermodynamically unstable. Decomposition is associated with increase in volume.
- In the decomposition heat liberates(ΔH is negative) and the entropy increases(Δ S is positive) for the decomposition of ozone into oxygen ΔG value is negative.
- It is highly soluble in turpentine oil, glacial acetic acid, or carbon tetrachloride.
- It decolourises organic colouring matter by oxidation.
- O_3 bleaches by oxidation.

Chemical properties: Oxidising reactions

OZONE OXIDISES:		
REACTION	ELEMENT WHOSE O.N. CHANGES	CHANGE IN OXIDATION STATE
a) Black PbS to white $PbSO_4$	S	-2 to +6
b) HCl to Cl_2	Cl	-1 to 0
c) KI to I_2	I	-1 to 0
d) Moist I_2 to HIO_3 (iodic acid)	I	0 to +5
e) Ag to Ag_2O (blackening of silver)	Ag	0 to +1
f) Hg to Hg_2O (Tailing of mercury)	Hg	0 to +1
g) $K_4[Fe(CN)_6]$ to $K_3[Fe(CN)_6]$	Fe	+2 to +3
h) SO_2 to SO_3	S	+4 to +6
I) $SnCl_2$ to $SnCl_4$	Sn	+2 to +4

- Oxidising power of O_3 is weaker than F_2 but stronger than H_2O_2 or $KMnO_4$.
- Ozone decomposes to give nascent oxygen. $O_3 \rightarrow O_2 + (O)$.

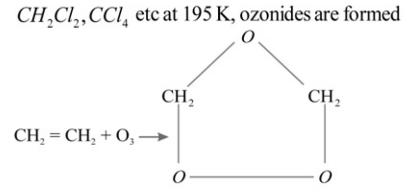
Thus in all oxidation reactions if one mole of ozone is consumed, one mole of oxygen is formed. (in presence of HCl)

- Ozone reduces : a) BaO_2 to BaO b) H_2O_2 to H_2O c) Ag_2O to Ag
- When O_3 reacts with an excess eg : KI solution buffered with a borate buffer ($P^H = 9.2$), Iodine is liberated which can be titrated against a standard solution of sodium thiosulphate. This is thequantitative method for estimating O_3 gas.

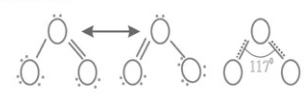
$2KI + H_2O + O_3 \rightarrow I_2 + 2KOH + O_2$

$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$

- When ozone is bubbled through the solution of an alkene or alkyne in an inert sovlent like CH_2Cl_2, CCl_4 etc at 195 K, ozonides are formed



Structure:



- Ozone is an angular molecule and diamagnetic
- The two oxygen - oxygen bond lengths in the ozone molecule are identical (128 pm)

Uses of Ozone: It is used as germicide and disinfectant.

- It is used for sterilizing water.
- it is used in improving the quality of atmosphere at crowded places (tube railways, mines, cinema halls etc.,).
- It is used for bleaching oils, oil paintings, ivory articles , flour,starch etc.
- It is used in the manufacture of artificial silk and synthetic camphor.
- It is used to locate mulitiple bonds in carbon compounds.
- It acts as an oxidising agent in the manufacture of potassium permanganate
- A mixture of O_3 and C_2N_2 is known as cyanogen and is used as Rocket fuel.

Sulphur - Allotropic forms :

- All VI A group elements exhibit allotropism except Te
- Oxygen occurs in two non metallic forms (a) Oxygen (O_2) (b)Ozone (O_3)
- Oxygen is paramagnetic as it contains two unpaired electrons in anti bonding M.O(as per Molecular Orbital Theory).
- Ozone is a triatomic diamagnetic allotropic form of oxygen. It is unstable and decomposes to O_2. $2O_3 \rightarrow 3O_2$
- Sulphur has more number of allotropic forms all these are non-metallic.
- Allotropes of Sulphur are :

a) α - Sulphur or Rhombic sulphur.
b) β -Sulphur or monoclinic sulphur or prismatic sulphur.
c) γ - Monoclinic sulphur.
d) χ - Sulphur or plastic sulphur.

- At 369K both Rhombic and monoclinic forms can co-exist in equilibrium. This temperature is called **transition temperature** of sulphur.
- The stable form at room temperature is rhombic a) Yellow (or) α - sulphur
- above 369K Rhombic sulphur transforms to monoclinic sulphur
- Rhombic sulphur is yellow in colour, M.P 385.8 K and specific gravity 2.06.
- Rhombic sulphur crystals are formed by evoparating the solution of roll sulphur in CS_2.It is insoluble in water but dissolves to some extent in benzene , alcohol and ether .It readly soluble in CS_2

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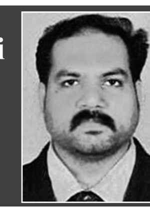
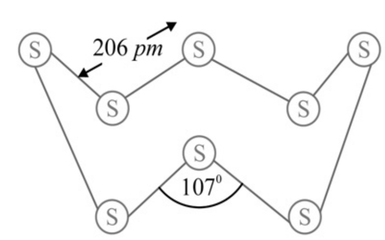
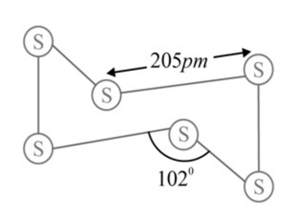


- β – Sulphur melts at 392 K and its specific gravity is 1.98
- It is soluble in CS_2
- β form of sulphur is prepared by melting Rhombic sulphur in a dish and cooling, till crust is formed . Two holes are made in the crust and the remaining liquid poured out on removing the crust, colourless needle shaped crystals of β – sulphur are formed .
- α, β and γ forms of sulphur are crystalline in nature and possess puckered ring structures (S_8) (crown structure)
- Sulphur persists with the S_8 units, just above the boiling point of sulphur (160^0C). Further increase in temperature leads to the dissociation of S_8 units successively into S_6 (Engel's sulphur), S_4 and S_2 units.
- In cyclo -S_6 the ring adopts the chair form. At elevated temperatures (1000K)S_2 is the dominant species and is paramagnetic like O_2.
- S_2 molecule has two unpaired electron in the antibonding π^* orbitals like O_2.
- Structure of S_8 ring (crown)

Structure of S_6 ring (chair)



Puckered ring S_8 molecule



S_6 Chair molecule

Sulphur Dioxide: When sulphur is burnt in air or oxygen SO_2 is formed along with 6-8% sulphur trioxide

- In the laboratory SO_2 is prepared by treating a sulphite with dilute sulphuric acid

$SO^{2-}_{3(aq)} + 2H^+_{(aq)} \rightarrow SO_{2(g)} + H_2O_{(l)}$

- Industrially it is produced as a by - product of the roasting of sulphide ores

$4FeS_{2(s)} + 11O_{2(g)} \rightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$

- Liquified SO_2 is stored in steel cylinders