Group-16 elements

Element	A.No	
O	8	$[He] 2s^2 2p^4$
S	16	$[Ne] 3s^2 3p^4$
Se	34	$[Ar] 3d^{10} 4s^2 4p^4$
Te	52	$[Kr] 4d^{10} 5s^2 5p^4$
Po	84	$[Xe] 4f^{14} 5d^{10} 6s^2 6p^4$
Lv	116	$[Rn] 7s^2 7p^4$

First four elements – Chalcogens

Po – Radioactive element
Shortest half life = 13.8 days

Lv – synthetic Radioactive

Po → decomposes Th, U

O is most abundant 46.6% by mass on Earth crust.

Dry air – 20.946% of O_2 volume

"O" has 3 isotopes

$^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$

99.762% 0.038% 0.2%

"S" – sulphates & sulphides

Gypsum – $CaSO_4 \cdot 2H_2O$

Epsom salt – $MgSO_4 \cdot 7H_2O$

Barytes – $BaSO_4$

Galena – PbS

Zinc Blende – ZnS

Copper pyrites – $CuFeS_2$

→ 'S' is present as H_2S in egg, garlic, onion, hair, wool and protein.

→ Native 'S' is present in volcanic areas.

General Properties

O_2 – Di $(O=O)$

S_8, Se_8, Te_8 – octa

Po – mono

→ physical state

O_2 – gas

S_8, Se_8, Te_8, Po – solids

→ covalent radius

O to Te ↑

→ I.P O to Po ↓

→ E.N O to Po ↓

O more electronegative element.

→ E. Affinity

S > Se > Te > Po > O

"O" has low E.A

Small size and $\bar{e}$ repulsion

→ M.P

S < Se < Po < Te

→ Density

O < S < Se < Te

→ B.P

O < S < Se < Po < Te

→ O, S - non metals

Se, Te - metalloids

Po - radioactive metals

→ Oxidation state

Common O. state -2 (O. state)

+2, +4, +6 O. state

O -2 (H_2O, MgO, Na_2O)

peroxides -1 (H_2O_2, BaO_2)

superoxides -1/2 (KO_2, RbO_2, CsO_2)

O_2F_2 +1

OF_2 +2

16/4/23

"O" does not exhibit higher oxidation state due to absence of d-orbitals.

"S"

Ground state - $3s^2$ $3p^4$ -2 (or) +2

$\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow|\uparrow|\uparrow}$

1st E. state - $3s^2$ $3p^3$ $3d^1$ +4

$\boxed{\uparrow\downarrow}$ $\boxed{\uparrow|\uparrow|\uparrow}$ $\boxed{\uparrow| | | | }$

2nd E. state - $3s^1$ $3p^3$ $3d^2$ +6

$\boxed{\uparrow}$ $\boxed{\uparrow|\uparrow|\uparrow}$ $\boxed{\uparrow|\uparrow| | | }$

→ Higher O. state ability ↓ decreases from top to bottom.

→ $^{16}O_8$ - Small size

- high EN

- high I.P

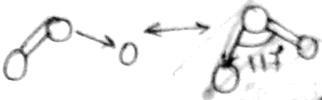
Max. covalency of ^{16}O is 4.

Allotrophy

→ O_2 – Two types of allotrophic forms

O_2	and O_3
para magnetic	diamagnetic
Colourless gas	pale blue gas
Diatomic	Triatomic

$\ddot{O}=\ddot{O}$



Bond length – 128 pm

→ "S" has more no of allotropic forms (has high catenation capacity in VIA group)

1) Rhombic sulphur (α-sulphur)
2) Monoclinic sulphur (β-sulphur)
3) γ – Monoclinic sulphur
4) Engel sulphur
5) plastic sulphur

→ Rhom "S" is most stable form (α-sulphur)

sulphur rolls in CS_2 – α sulphur

M.P = 385.8 K S.G (specific gravity) = 2.06 g/cm³

yellow colour insoluble in water

soluble in non-polar solvent in benzene, alcohol, ether and CS_2

→ α-sulphur is melted and cooled β-sulphur formed.

β-sulphur M.P = 392.2 K

S.G = 1.98 g/cm³

→ γ-sulphur

α, β and γ sulphur have S_8 rings

S_8 – puckered ring (or) crown structure

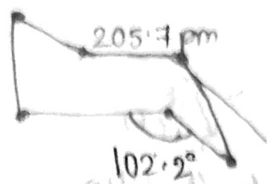
S–S bondlength 204 pm

→ Engel's sulphur

$Na_2S_2O_3$ with HCl

$H_2S_4 + S_2Cl_2 \longrightarrow S_6 + 2HCl$

S_6 has chair form



Sulphur heated ~1000K forms S_2

stable upto 2200°C

S_2 is paramagnetic like O_2

→ Se - 6 allotropic forms

3 - non metallic red colour forms

1 - red colour amorphous forms

2 - Grey colour forms

Grey forms are stable

→ Te - has only one allotropic forms

silvery white metallic forms

→ Po - 2 forms

α - form (cubic)

β - form (Rhombohedral)

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Hydrides : H_2M type hydrides of Group VIA

H_2O - water

H_2S - hydrogen sulphide

H_2Se - hydrogen selenide

H_2Te - hydrogen telluride

H_2Po - Hydrogen polonide

H_2S, H_2Se, H_2Te colourless, poisonous gases

H_2Po unstable at room temp.

→ Aq. solutions – acidic

$H_2O < H_2S < H_2Se < H_2Te$

→ B.P order $H_2S < H_2Se < H_2Te < H_2O$

H_2O has abnormally high B.P due to presence of H-bonds

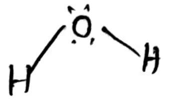
→ Order of volatility

$H_2S > H_2Se > H_2Te > H_2O$

→ Reducing property

$H_2O < H_2S < H_2Se < H_2Te$

H_2O



O – sp^3

104° 38'

→ In H_2S – 92.3°, H_2Se – 91°, H_2Te – 90° p-orbitals are involved in bond formation

→ Bond angle

$H_2O > H_2S > H_2Se > H_2Te$

Oxides :

Dioxides Trioxides

O_3, SO_2, SeO_2

TeO_2, PoO_2

O_3, SO_2 – gas

SeO_2 – white crystalline solid

TeO_2, PoO_2 – crystalline and ionic solids

Acidic nature

$SO_2 > SeO_2 > TeO_2$

$SO_2 + H_2O \rightarrow H_2SO_3$ sulphurous acid

$SeO_2 + H_2O \rightarrow H_2SeO_3$ selenous acid

TeO_2 & PoO_2 are amphoteric

$TeO_2 + 2NaOH \rightarrow Na_2TeO_3 + H_2O$

$TeO_2 + 2HNO_3 \rightarrow TeO_2 \cdot 2HNO_3$

SO_2 – strong reducing agent

Reducing property

$SO_2 > SeO_2 > TeO_2$

TeO_2 – oxidising agent

Trioxides

SO_3, SeO_3, TeO_3

Trioxides are more acidic than dioxides

$SO_3 + H_2O \rightarrow H_2SO_4$

$SeO_3 + H_2O \rightarrow H_2SeO_4$

$TeO_3 + 3H_2O \rightarrow H_6TeO_6$
telluric acid

SO_3 - oxidising agent

Halides : "S" forms

1) Monohalides (M_2X_2)
2) Dihalides (MX_2)
3) Tetrahalides (MX_4)
4) Hexahalides (MX_6)

Monohalides : S_2Cl_2, S_2Br_2, S_2F_2
Se_2Cl_2, Se_2Br_2
Te_2Cl_2

$2S + Cl_2 \rightarrow S_2Cl_2$ (yellow colour + liq)

S_2Cl_2 used for preparation of mustard gas

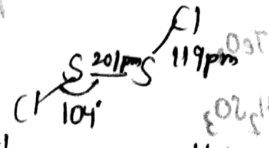
$2CH_2{=}CH_2 + S_2Cl_2 \longrightarrow Cl{-}CH_2{-}CH_2{-}S{-}CH_2{-}CH_2{-}Cl$

(or)

$(CH_2CH_2Cl)_2S$

$2S_2Cl_2 + 2H_2O \longrightarrow 2SO_2 + 4HCl + 2S$

S_2Cl_2 has open book structure



$2\overset{+1}{Se_2}Cl_2 \longrightarrow \overset{+4}{Se}Cl_4 + 3\overset{0}{Se}$

Monohalides undergo disproportionation reaction

Dihalides: SF_2, SCl_2, $TeCl_2$

"Se" dihalides are unstable

$S_2Cl_2 + Cl_2 \rightarrow 2SCl_2$

$S + Cl_2 \rightarrow SCl_2$

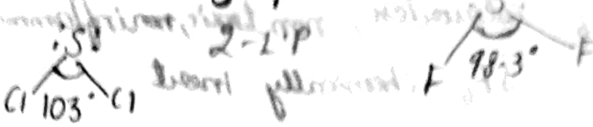
SCl_2 – Red colour foul smelling liquid

SCl_2 also forms mustard gas with ethylene

$(CH_2CH_2Cl)_2S$

SCl_2 S – sp^3

2 – l.p



Tetrahalides: MX_4

SF_4, SCl_4, $TeCl_4$, $SeCl_4$, $SeBr_4$

$S + 2Cl_2 \rightarrow SCl_4$

$Se + 2Cl_2 \rightarrow SeCl_4$

$3SCl_2 + 4NaF \rightarrow SF_4 + 4NaCl + S_2Cl_2$

$S + 4CoF_3 \rightarrow SF_4 + 4CoF_2$

SF_4 – gas SeF_4 – liquid TeF_4 – solid

$SF_4 + 2H_2O \rightarrow SO_2 + 4HF$

Lewis base

$SF_4 + BF_3 \rightarrow SF_4 \rightarrow BF_3$

Lewis acid

$SF_4 + 2F^- \rightarrow SF_6^{-2}$

Good fluorinating agent

$4BCl_3 + 3SF_4 \rightarrow 4BF_3 + 3SCl_2 + 3Cl_2$

$SCl_4 + 4H_2O \rightarrow S(OH)_4 + 4HCl$

$\downarrow -H_2O$

H_2SO_3

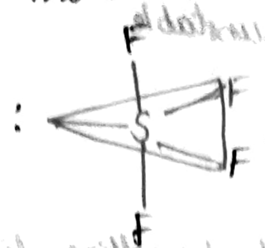
$SeBr_4 + 4H_2O \rightarrow Se(OH)_4 + 4HBr$

$\downarrow -H_2O$

H_2SeO_3

SCl_4, SF_4 $S - sp^3d$

$TeCl_4$ - more stable



Hexahalides (MX_6):

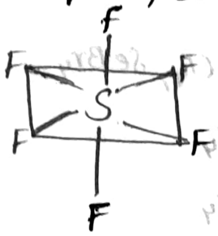
SF_6, SeF_6, TeF_6

$$S + 3F_2 \longrightarrow SF_6$$

SF_6 colourless, non toxic, noninflammable gas

SF_6 - chemically inert

$SF_6 \rightarrow S - sp^3d^2$, octahedral



Used as insulator in high voltage conductors

$$TeF_6 + 6H_2O \longrightarrow H_6TeO_6 + 6HF$$

Telluric acid

Dioxygen (O_2):

O_2 by thermal decomposition of chlorates, nitrates, permagnates.

$$2KClO_3 \xrightarrow[\Delta]{MnO_2} 2KCl + 3O_2$$

$$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$$

$$2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$$

Metal oxides on heating gives O_2

$$2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$$

$$2PbO_2 \xrightarrow{\Delta} 2PbO + O_2$$

$$2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$$

$2Na_2O_2 + 2H_2O \rightarrow 4NaOH + O_2$

Electrolysis of water gives O_2 at anode

Anode : $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

Cathode : $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

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$2H_2O_2 \xrightarrow{\Delta} 2H_2O + O_2$

→ $4KMnO_4 + 6H_2SO_4 \rightarrow 2K_2SO_4 + 4MnSO_4 + 6H_2O + 5O_2\uparrow$

→ $2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2\uparrow$

→ O_2 is colourless gas

liquifies at 90K & freezes at 55K

soluble in water

$3.08\ cm^3$ in $100\ cm^3$ of water

Reacts with metals & non-metals

$2Ca + O_2 \rightarrow 2CaO$

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$2Fe + 3O_2 \rightarrow Fe_2O_3$

$S + O_2 \rightarrow SO_2$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

$P_4 + 5O_2 \rightarrow P_4O_{10}$

Roasting process

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

Combustion reaction

$CH_4 + 2O_2 \rightarrow CO_2 + H_2O$

Deacon's process

$4HCl + O_2 \xrightarrow[700K]{CuCl_2} 2H_2O + 2Cl_2$

$4NH_3 + 5O_2 \xrightarrow[1100K]{Pt} 4NO + 6H_2O$

O_2 - used hospitals, liquid O_2 & N_2H_4 (hydrazene) as rocket fuel.

Oxides

Normal oxides – H_2O, MgO, Al_2O_3, Na_2O

Peroxides – H_2O_2, BaO_2, Na_2O_2

Superoxides – KO_2, RbO_2, CsO_2

Suboxides – C_3O_2, N_2O

Mixed oxides – Fe_3O_4, Pb_3O_4, Mn_3O_4

$Fe_3O_4 \leftarrow FeO + Fe_2O_3$

Acidic oxides – CO_2, B_2O_3, SiO_2, N_2O_3, SO_2, SO_3, P_4O_{10}, Cl_2O_7

$CO_2 + H_2O \rightarrow H_2CO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$

$Cl_2O_7 + H_2O \longrightarrow HClO_4$

Some of the metal oxides having acidic nature

$\underset{+7}{Mn_2O_7}$, $\underset{+6}{CrO_3}$

V_2O_5 – amphoteric acidic oxide

Basic oxides – metal oxides

Na_2O, MgO, CaO, FeO, Fe_2O_3, CuO

$CaO + H_2O \rightarrow Ca(OH)_2$

$NaO + H_2O \rightarrow 2NaOH$

Amphoteric oxides

SiO_2, ZnO, BeO, Al_2O_3, SnO_2, PbO, V_2O_5, Sb_2O_3

Neutral oxides – N_2O, CO, NO, H_2O

CrO – basic, Cr_2O_3 – amphoteric, CrO_3 – acidic

Ozone (O_3)

$$3O_2 \underset{\text{Endothermic}}{\overset{\text{electric silent charge}}{\rightleftharpoons}} 2O_3 \quad \Delta H = +284.5\ kJ$$

Siemenn's ozoniser

Brodie's ozoniser

Mixture $O_2 + O_3$ – Ozonised mixture

O_3 is paleblue gas
dark blue liquid
violet Black solid

O_3 in low concentration upto 100 ppm is harmless
>100ppm causes nausea, headache.

$$2O_3 \rightleftharpoons 3O_2$$

$\Delta H = -ve$
$\Delta S = +ve$ $\quad \Delta G = \Delta H - T\Delta S$
$\Delta G = -ve$
Spontaneous

Conversion of O_3 to O_2
takes place spontaneously

O_3 - good oxidising agent

$$O_3 \rightarrow O_2 + [O]$$

O_3 is weak O. Agent than F_2
strong O. Agent than H_2O_2

→ $PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$
Black $\quad$ white

→ $2KI + O_3 + H_2O \rightarrow I_2 + 2KOH + O_2$
Reaction of is useful for estimation of O_3

$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$
standard $\quad$ sodium tetra thionate

→ $2HCl + O_3 \rightarrow Cl_2 + H_2O + O_2$
→ $H_2S + O_3 \rightarrow H_2O + S + O_2$
→ $2K_2\overset{+6}{Mn}O_4 + O_3 + H_2O \rightarrow 2K\overset{+7}{Mn}O_4 + 2KOH + O_2$
→ $NaNO_2 + O_3 \rightarrow NaNO_3 + O_2$
→ $Na_2SO_3 + O_3 \rightarrow Na_2SO_4 + O_2$
→ $Na_3AsO_3 + O_3 \rightarrow Na_3AsO_4 + O_2$
→ $2K_4[\overset{+2}{Fe}(CN)_6] + H_2O + O_3 \rightarrow 2K_3[\overset{+3}{Fe}(CN)_6] + 2KOH + O_2$
potassium ferrocyanide $\quad$ potassium ferricyanide

→ $2I_2 + 3O_3 \rightarrow I_4O_9$ (unstable compound)

* SO_2 is oxidised to SO_3

$3SO_2 + O_3 \rightarrow 3SO_3$

$SnCl_2$ is oxidised to $SnCl_4$

$3SnCl_2 + 6HCl + O_3 \rightarrow 3SnCl_4 + 3H_2O$

Tailing of Mercury:

Mercury loses lusterous and meniscus nature in the presence of O_2 and it is stick on glass surface due to the formation of mercurous oxide. This is called tailing of mercury

Hg - Lusterous nature
Meniscus nature

$2Hg + O_3 \rightarrow Hg_2O + O_2$
Mercurous Oxide

$O_3 \rightarrow O_2 + [O]$

Bleaching agent

Coloured substance $+ [O] \rightarrow$ colourless

$O_3 \rightarrow$ Reducing agent

$Ag_2O + O_3 \rightarrow 2Ag + 2O_2$

$BaO_2 + O_3 \rightarrow BaO + 2O_2$

20/4/23 Oxidising properties

$I_2 + H_2O + 5O_3 \rightarrow 2HIO_3 + 5O_2$
Iodic acid

$S + H_2O + O_3 \rightarrow H_2SO_4 + O_2$

$P_4 + 6H_2O + 10O_3 \rightarrow 4H_3PO_4 + 10O_2$
phosphoric acid

$2NO + O_3 \rightarrow NO_2 + O_2$

Structure of O_3

Bond angle - 117°

Bond length - 128 pm

Bond order - 1.5

Uses of Ozone:

→ Germicide & Bactericide

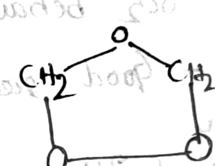
→ In sterilization of water

→ Atm. purification in mines, etc.

→ O_3 is used for detection of unsaturation.

$CH_2=CH_2 + O_3 \longrightarrow$

Ethylene

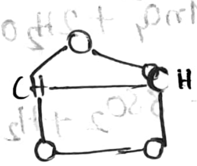


Ethylene ozonide

$\xrightarrow{Zn/H_2O} HCHO + H_2O_2$

$CH \equiv CH + O_3 \longrightarrow$

Acetylene



$\xrightarrow{Zn/H_2O}$ CHO–CHO

→ Bleaching agent, oils, flours, starch.

$O_3 \longrightarrow O_2 + [O]$

→ $O_3 + (CN)_2$ — Rocket fuel

(cyanogen)

SO_2 : sulphur dioxide

"S" burn in O_2

1) $S + O_2 \longrightarrow SO_2$

$4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$

2) In lab sulphite ion with dil. Acids

$SO_3^{-2} + 2H^+ \longrightarrow SO_2 + H_2O$

3) $S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$

$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + H_2O$

$2Ag + 2H_2SO_4 \rightarrow Ag_2SO_4 + SO_2 + 2H_2O$

SO_2 - colourless gas

Choking smell

It is condensed easily by applying 2 atm pressure

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

$$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$$
sodium sulphite

$$Na_2SO_3 + SO_2 + H_2O \rightarrow 2NaHSO_3$$
sodium bisulphite

Above reactions SO_2 behaves as CO_2.

SO_2 - Good reducing agent

$$2\overset{+3}{Fe} + \overset{+4}{SO_2} + 2H_2O \rightarrow 2Fe^{+2} + \overset{+6}{SO_4^{-2}} + 4H^+$$

$$5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 2Mn^+ + 5SO_4^{-2} + 4H^+$$

$$K_2Cr_2O_7 + 3SO_2 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$$

Orange-red Green

→ SO_2 bleaches colour of $KMnO_4$ (Pink) & $K_2Cr_2O_7$ (Orange red) by reduction.

→ SO_2 reduces halogen into halogen acid.

$$SO_2 + 2H_2O + Cl_2 \rightarrow 2HCl + H_2SO_4$$

→ SO_2 - Bleaching agent

$$SO_2 + 2H_2O \rightarrow H_2SO_4 + 2(H)$$

Coloured + (H) → Colourless

SO_2 acts as bleaching agent by reduction.

→ SO_2 acts as oxidising agent.

$$2H_2S + SO_2 \rightarrow 2H_2O + 3S$$

$$3Mg + SO_2 \rightarrow MgS + 2MgO$$

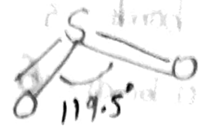
$3Fe + SO_2 \longrightarrow 2FeS + 2FeO$

$\overset{+2}{Sn}Cl_2 + SO_2 + HCl \longrightarrow \overset{+4}{Sn}Cl_4 + 2H_2O + S$

$2\overset{+1}{Hg_2}Cl_2 + SO_2 + 4HCl \longrightarrow 4\overset{+2}{Hg}Cl_2 + 2H_2O + S$

SO_2 S - sp^2 S - $3s^2\ 3p^4$

$\boxed{\uparrow\downarrow}\quad \boxed{\uparrow\downarrow\ \uparrow\ \uparrow}$



Exc. state - $3s^2\ 3p^3\ 3d^1$

$\underbrace{\boxed{\uparrow\downarrow}\quad \boxed{\uparrow\ \uparrow\ \uparrow}}_{sp^2}\quad \boxed{\uparrow\ \ \ \ }$

one $p\pi - p\pi$ bond

one $d\pi - p\pi$ bond

Angular

$SO_2 + Cl_2 \rightarrow SO_2Cl_2$

$SO_2 + PCl_5 \rightarrow$

1) SO_2 used in refining of petrol and oil.

2) SO_2 used as antichlor in textiles.

3) SO_2 used as bleaching agent in wool & silk

4) SO_2 used as preservative.

SO_3 (sulphur trioxide)

$2SO_2 + O_2 \rightarrow 2SO_3$

$SO_3 + H_2O \longrightarrow H_2SO_4$
sulphuric acid

SO_3 - oxidising agent

$SO_3 + 2HBr \longrightarrow Br_2 + H_2O + SO_2$

$SO_3 + PCl_5 \rightarrow POCl_3 + Cl + SO_2$

S - $3s^2\ 3p^4$

$\boxed{\uparrow\downarrow}\quad \boxed{\uparrow\downarrow\ \uparrow\ \uparrow}$

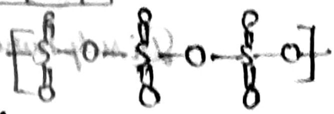
2nd E.S $3s^1\ 3p^3\ 3d^2$

$\boxed{\uparrow}\quad \boxed{\uparrow\ \uparrow\ \uparrow}\quad \boxed{\uparrow\ \uparrow\ \ \ }$

1st E.S $3s^2\ 3p^3\ 3d^1$

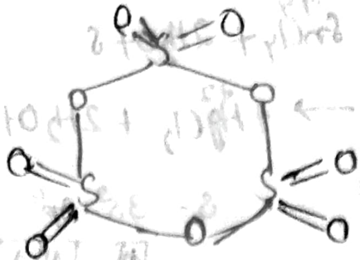
$\boxed{\uparrow\downarrow}\quad \boxed{\uparrow\ \uparrow\ \uparrow}\quad \boxed{\uparrow\ \ \ \ }$

α-form, β-form] → stable



γ-form → cyclic trimer

$(SO_3)_3$ (or) S_3O_9

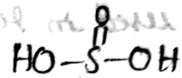
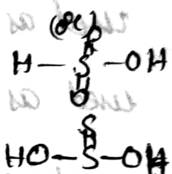
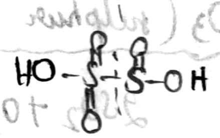


No. of S-O-S bonds = 3

No. of S=O bonds = 6

Oxoacids of sulphur

I. Sulphurous acid series

	M.F	Structure	Ts	C	Avg
1) Sulphurous acid	H_2SO_3		–	+4	4
2) Thiosulphurous acid	$H_2S_2O_2$		-2	+4	+1
3) Dithionous acid	$H_2S_2O_4$		+3	+3	+3
4) Pyrosulphurous acid	$H_2S_2O_5$		+3	+5	+4

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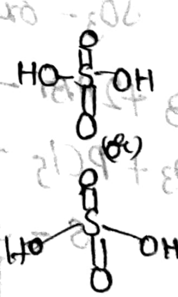
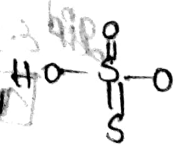
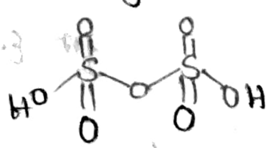
II. Sulphuric acid series

	M.F	Structure	T	C	Avg
1) Sulphuric acid	H_2SO_4		–	+6	+6
2) Thiosulphuric acid	$H_2S_2O_3$		-2	+6	+2
3) Pyrosulphuric acid (oleum) (or) Disulphuric acid	$H_2S_2O_7$		+6	+6	+6

→ When H_2O is added to it, it liberates heat.

→ The chemical reactions of sulphuric acid is due to its

a) low volatility
b) strong acidic character
c) acts as dehydrating agent
d) oxidising agent

H_2SO_4 – strong acid – dibasic acid

$$H_2SO_{4(aq)} + H_2O_{(aq)} \longrightarrow H_3O^+_{(Aq)} + HSO_4^-{}_{(Aq)} \quad K_{a_1} > 10$$

$$HSO_4^-{}_{(aq)} + H_2O \longrightarrow SO_4^{-2}{}_{(Aq)} + H_3O^+_{(Aq)} \quad K_{a_2} = 1.2\times10^{-2}$$

$K_{a_1} > K_{a_2}$

Low volatility

$$2MX + H_2SO_4 \longrightarrow 2HX + M_2SO_4$$

Here X = F, Cl, NO_3

$$2NaCl + H_2SO_4 \longrightarrow 2HCl + Na_2SO_4.$$

$$2CH_3COONa + H_2SO_4 \longrightarrow 2CH_3COOH + Na_2SO_4.$$

$$2Na_3PO_4 + 3H_2SO_4 \longrightarrow H_3PO_4 + 3Na_2SO_4$$

H_2SO_4 – dehydrating agent

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{con } H_2SO_4} 12C + 11H_2O$$

$$\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} \xrightarrow[\text{470°C}]{\text{con } H_2SO_4} CH_2=CH_2 + H_2O$$

$$\underset{\text{Formic acid}}{HCOOH} \xrightarrow{\text{Con. } H_2SO_4} CO + H_2O$$

$$\underset{\text{Oxalic acid}}{\begin{array}{c}COOH\\ |\\ COOH\end{array}} \xrightarrow{\text{Con } H_2SO_4} CO + CO_2 + H_2O$$

H_2SO_4 - Oxidising agent

$$Cu + 2H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2H_2O$$

$$S + 2H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$$

* $$C + 2H_2SO_4 \longrightarrow CO_2 + 2SO_2 + 2H_2O$$

Carbon forms two acidic oxides CO_2, SO_2 when it is oxidized with conc H_2SO_4.

Acid

$$NaOH + H_2SO_4 \longrightarrow NaHSO_4 + H_2O$$

$$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$$

→ decomposes carbonates and bicarbonates and liberates CO_2.

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$$

$$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$$

→ Reacts with metals liberates H_2↑

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2\uparrow$$

$$Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2\uparrow$$

$$Ca_3(PO_4)_2 + 3H_2SO_4 \longrightarrow 2H_3PO_4 + 3CaSO_4$$

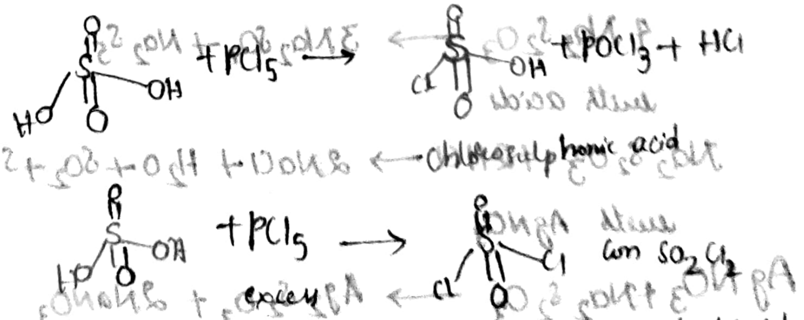
phosphoric acid

→ Ppt reaction

$$BaCl_2 + con.\ H_2SO_4 \longrightarrow BaSO_4\downarrow + 2HCl\uparrow$$

$$(CH_3COO)_2Pb + H_2SO_4 \longrightarrow PbSO_4\downarrow + 2CH_3COOH$$

→ Reaction with PCl_5



chlorosulphonic acid

sulphuryl chloride

Uses of H_2SO_4

→ Used as pickling agent (cleaning of metal surface)

→ Used in manufacture of fertilizers, paints & pigments.

→ Used as a nitration mixture along with con. HNO_3

→ Used in leather industry.

→ Used in petrol refining process.

→ Lead storage batteries & acid storage batteries

→ Used as laboratory reagent.

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Sodium thiosulphate ($Na_2S_2O_3$)

"Hypo" mixture of $Na_2S + Na_2SO_3$

Spring's method

$$Na_2S + Na_2SO_3 + I_2 \longrightarrow Na_2S_2O_3 + 2NaI$$

Boiled with sulphur

$$Na_2SO_3 + S \longrightarrow Na_2S_2O_3$$

$$6NaOH + 12S \longrightarrow Na_2S_2O_3 + Na_2S_5 + 3H_2O$$

sodium poly sulphide

$$2Na_2S + 3SO_2 \longrightarrow 2Na_2S_2O_3 + S$$

Hypo – colourless, crystalline, solid

soluble in water

Hypo is stable upto 488k

at 498k

$$4Na_2S_2O_3 \longrightarrow 3Na_2SO_4 + Na_2S_5$$

with acids

$$Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + H_2O + SO_2 + S$$

with $AgNO_3$

$$AgNO_3 + Na_2S_2O_3 \longrightarrow Ag_2S_2O_3 + 2NaNO_3$$

$$Ag_2S_2O_3 + H_2O \longrightarrow Ag_2S\downarrow + H_2SO_4$$

Black ppt

Excess of Hypo

$$3Na_2S_2O_3 + Ag_2S_2O_3 \longrightarrow 2Na_3[Ag(S_2O_3)_2]$$

Sodium argento thiosulphate

→ with AgBr

$$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

above reaction is useful in photography

Hypo is used as fixing agent in photography

→ with Cl_2

$$Na_2S_2O_3 + Cl_2 + H_2O \longrightarrow Na_2SO_4 + 2HCl + S$$

$$Na_2S_2O_3 + 4Cl_2 + 5H_2O \longrightarrow 2NaHSO_4 + 8HCl$$

→ with I_2

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

sodium tetra thionate

useful in iodometric and iodometric titrations

→ with $FeCl_3$

$$2FeCl_3 + 3Na_2S_2O_3 \longrightarrow Fe_2(S_2O_3)_3 + 6NaCl$$

Excess — violet

→ with $CuSO_4$

$$CuSO_4 + Na_2S_2O_3 \longrightarrow CuS_2O_3 + Na_2SO_4$$

→ with $BaCl_2$

$$BaCl_2 + Na_2S_2O_3 \longrightarrow BaS_2O_3\downarrow + 2NaCl$$

white

→ with $AuCl_3$

$$AuCl_3 + 2Na_2S_2O_3 \longrightarrow AuCl + Na_2S_4O_6 + 2NaCl$$

$$AuCl + 2Na_2S_2O_3 \longrightarrow Na_3[Au(S_2O_3)_2] + NaCl$$

$$2CuSO_4 + 4KI \rightarrow Cu_2I_2 + I_2 + 2K_2SO_4$$

Uses

- → As a antichlor agent
- → As a fixing agent in photography
- → Used as a iodometric and iodometric titrations
- → Used as antiseptic.