Period 3 (Na to Ar): Oxides:

Oxides:

- **Binary compounds**
- **There may be oxides of all elements except fluorine.**

Physical Properties:

1) Structure:

Formula of oxide	$Na_2O_{(s)}$	$MgO_{(s)}$	$Al_2O_{3(s)}$	$SiO_{2(s)}$	$P_4O_{10(s)}$ $P_4O_{6(s)}$	$SO_{3(l)}$ $SO_{2(g)}$	$Cl_2O_{7(l)}$ $Cl_2O_{(g)}$
Oxidation number	+1	+2	+3	+4	+5/+3	+6/+4	+7/+1
Structure	Giant ionic			Giant covalent	Molecular covalent		

2) M.P/B.P :

- Giant structures of these (Na,Mg,Al) metal oxides and silicon dioxides (SiO_2) will have high melting and boiling points, because;

★ a lot of energy is needed to break the strong bonds of (ionic or covalent) operating in three dimensions.

- The oxides of phosphorous, Sulphur and chlorine will have low melting and boiling points, because;

★ these oxides consist of individual molecules (some small and simple and other polymeric), having weak attractive forces(Vander Waal's dispersion and dipole-dipole interactions).

- These forces vary depending on the
  - ★ size,
  - ★ shape and
  - ★ polarity of various molecules,

but will always be much weaker than the ionic or covalent bonds required in a giant structure.

- The oxides are either
  - ★ Gases,
  - ★ Liquids or
  - ★ Low melting solids.

3) Electrical conductivity:

- The ionic oxides of Na, Mg and Al are

★ good conductors in solution form or molten state (due to movement of ions)and

★ bad conductors in solid state (not have any free electrons).

- The covalent oxides of Si, P, S and Cl are

★ non-conductors because they are non-ionizable.

Chemical Properties: (Acid-Base behavior of oxides:)

(1) Trend:

Formula of oxide	$Na_2O_{(s)}$	$MgO_{(s)}$	$Al_2O_{3(s)}$	$SiO_{2(s)}$	$P_4O_{10(s)}$ $P_4O_{6(s)}$	$SO_{3(l)}$ $SO_{2(g)}$	$Cl_2O_{7(l)}$ $Cl_2O_{(g)}$
Nature of oxides	Basic (Alkaline)	Basic (Weakly Alkaline)	Amphoteric	Weakly Acidic	Acidic	Strongly Acidic	very strongly Acidic

(2) Reactions of oxides with water, acids and bases:

(1) Sodium oxide (Na_2O):

- It is simple **strongly** basic oxide.

Reason: It is basic because it contains the oxide ion O^{-2}, which is a very strong base with a high tendency to combine with hydrogen ions.

$$O^{-2} + H\text{-}OH \longrightarrow OH^- + OH^-$$

Reaction with water :

$$Na_2O + H_2O \xrightarrow[\text{Cold}]{\text{Highly exothermic reaction}} 2\,NaOH$$

Depending on its concentration, this will have a pH around 14

Reaction with Acids :

$$Na_2O + \text{dil. } 2HCl \longrightarrow 2\,NaCl + H_2O$$

(2) Magnesium oxide (MgO):

- It is simple basic oxide.

Reason: It is basic because it also contains the oxide ion O^{-2} , which is a very strong base with a high tendency to combine with hydrogen ions.

$$O^{-2} + H\text{-}OH \longrightarrow OH^- + OH^-$$

Reaction with water :

$$MgO + H_2O \xrightarrow[\text{Slow reaction \& } Mg(OH)_2 \text{ almost insoluble}]{\text{Shake}} Mg(OH)_2$$

White powder

Depending on its concentration, this will have a pH around 9 (slightly alkaline)

Reaction with Acids :

$$MgO + \underset{\text{Warm}}{\text{dil. } 2HCl} \longrightarrow MgCl_2 + H_2O$$

- MgO is less basic than Na_2O.

- MgO is not as strongly basic as Na_2O, because it's oxide ions O^{-2} are not so free.

Reason:

- In the Na_2O case, the solid is held together by attractions between Na^+ ion and O^{-2} ions.
- In the MgO case, the solid is held together by attractions between Mg^{+2} ion and O^{-2} ions.
- It takes more energy to break the crystal lattice of MgO having smaller ions.
- Thus, lattice energy of MgO is greater than Na_2O, so it is less basic.

(3) Aluminium oxide (Al_2O_3):

- It is an amphoteric oxide.(Act as both an acid and a base)

Act as a base: It is an ionic oxide, which allows it to act as a base.

Act as an acid: The ions in it have high charge density and hence has a partial covalent character allowing it to act as an acid.

Reaction with water:

- Aluminium oxide

★ does not react with water and

★ does not dissolve in it

because ions are held strongly in the solid lattice to react with water

Reaction with acids :

$$Al_2O_3 + \underset{\text{Hot}}{\text{dil. HCl}} \longrightarrow 2\,AlCl_3 + 3\,H_2O$$

Aluminium chloride solution

Reaction with bases :

$$Al_2O_3 + \underset{\text{Hot}}{\text{con. 2 NaOH}} + 3\,H_2O \longrightarrow 2\,Na[Al(OH)_4]$$

Sodium tetrahydroxoaluminate (colourless)

(4) Silicon dioxide (SiO_2): (weakly acidic)

Reaction with water :

- Silicon dioxide is insoluble in water, because of

★ difficulty of breaking up large and giant covalent structure.

Reaction with bases :

$$SiO_2 + \text{con. } 2\,NaOH + 3\,H_2O \xrightarrow{\text{Hot}} Na_2SiO_3 + H_2O$$

Sodium silicate

Note:

- It also reacts with basic metal oxides (Na2O, K2o, CaO, PbO, ZnO or mixture of oxides) forming silicates and glasses.

Balochistan Textbook board, Quetta:

Silicon dioxide is a stable compound and does not react with most of the acids at normal conditions. It reacts only with hydrofluoric acid (HF).

$$SiO_2 + 4HF \longrightarrow SiF_4 + 2H_2O$$

Tetrafluorosilane (SiF_4) reacts further with HF to produce hexafluorosilicic acid.

$$SiF_4 + 2HF \longrightarrow H_2[SiF_6]$$

(5) Phosphorous(v) oxide (P_4O_{10}): (Acidic)

Reaction with water :

$$P_4O_{10} + 6\,H_2O \xrightarrow{\text{Vigorous reaction}} 4\,H_3PO_4$$

Phosphoric acid

Reaction with bases :

$$P_4O_{10} + 12\,NaOH \longrightarrow 4\,Na_3PO_4 + 6\,H_2O$$

Sodium phosphate

$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

$$H_3PO_4 + 2\,NaOH \longrightarrow Na_2HPO_4 + H_2O$$

$$H_3PO_4 + 3\,NaOH \longrightarrow Na_3PO_4 + H_2O$$

Sodium phosphate

(6) Sulphur oxides (SO_x): (Strongly acidic)

Sulphur has two oxides i.e., SO_2 & SO_3.

(i) SO2:

Reaction with water :

$$SO_2 + H_2O \xrightarrow{\text{Fairly soluble}} H_2SO_3$$

Sulphurous acid

Reaction with bases :

$$SO_2 + 2\,NaOH \longrightarrow Na_2SO_3 + H_2O$$

$$Na_2SO_3 + H_2O + SO_2 \longrightarrow 2\,NaHSO_3$$

$$2\,SO_2 + 2\,NaOH \longrightarrow 2\,NaHSO_3$$

Reaction with basic oxides :

$$SO_2 + CaO \longrightarrow CaSO_3$$

(ii) SO3:

Reaction with water :

$$SO_3 + H_2O \xrightarrow{\text{Violent reaction}} H_2SO_4$$

Fog (Sulphuric acid)

Reaction with bases :

$$SO_3 + 2\,NaOH \longrightarrow Na_2SO_4 + H_2O$$

Reaction with basic oxides :

$$SO_3 + CaO \longrightarrow CaSO_4$$

(7) Chlorine oxides (Cl_2O_x):

Chlorine has many oxides, two of them are: Cl_2O_7, Cl_2O.

(i) Chlorine (VII) oxide ,Cl_2O_7: (Very strongly acidic)

Reaction with water :

$$Cl_2O_7 + H_2O \longrightarrow 2\,HClO_4$$

Perchloric acid (ph = Around 0)

Reaction with bases :

$$Cl_2O_7 + 2\,NaOH \longrightarrow 2\,NaClO_4 + H_2O$$

$$HClO_4 + NaOH \longrightarrow NaClO_4 + H_2O$$

(ii) Chlorine (I) oxide ,Cl_2O: (Far less acidic than chlorine (VII) oxide)

Reaction with water :

$$Cl_2O + H_2O \underset{\text{Some extent}}{\rightleftharpoons} 2\,HOCl$$

Hypochlorous acid / (Chloric(I) acid

Reaction with base :

$$Cl_2O + 2\,NaOH \longrightarrow 2NaOCl + H_2O$$

$$HOCl + NaOH \longrightarrow NaOCl + H_2O$$

Balochistan Textbook board, Quetta:

Phosphorus trioxide reacts directly with sodium hydroxide to produce two series of salts (sodium dihydrogenphosphite and sodium hydrogenphosphite).

$$4NaOH + P_4O_6 + 2H_2O \longrightarrow 4NaH_2PO_3$$

$$8NaOH + P_4O_6 \longrightarrow 4Na_2HPO_3 + 2H_2O$$

Phosphorus pentaoxide reacts directly with sodium hydroxide to produce three series of salts (sodium dihydrogen phosphate, sodium hydrogen phosphate and sodium phosphate).

$$4NaOH + P_4O_{10} + 2H_2O \longrightarrow 4NaH_2PO_4$$

$$8NaOH + P_4O_{10} \longrightarrow 4Na_2HPO_4 + 2H_2O$$

$$12NaOH + P_4O_{10} \longrightarrow 4Na_3PO_4 + 6H_2O$$

Balochistan Textbook board, Quetta:

$Na_2O + H_2O \longrightarrow 2NaOH$

$MgO + H_2O \longrightarrow Mg(OH)_2$

$Al_2O_3 + H_2O \longrightarrow$ No Reaction

$SiO_2 + H_2O \longrightarrow$ No Reaction

$P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$ (Phosphorous acid)

$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$ (Phosphoric acid)

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

$SO_3 + H_2O \longrightarrow H_2SO_4$ (Sulphuric acid)

$Cl_2O + H_2O \longrightarrow 2HClO$ (Hypochlorous acid)

$Cl_2O_7 + H_2O \longrightarrow 2HClO_4$ (Perchloric acid)