

PROPERTIES of PERIOD 3 ELEMENTS and their OXIDES

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REACTIONS WITH WATER

Na

Na has a very exothermic reaction with cold water:
 $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$

Mg

Mg reacts a little with cold water, but reacts more vigorously with steam:
 $\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2 + \text{H}_2$

Al

Burns white when powdered. Solid Al does not burn well due to layer of oxide on the surface.

Si

Strong heat causes Si to burn.

P

White phosphorus spontaneously combusts in air.

S

Gentle heating: S burns blue.

Cl

Neither of these elements reacts with oxygen.

Ar

REACTIONS WITH OXYGEN

IONIC LATTICES high melting point

Na₂O

REACTIONS WITH WATER

Strongly basic (due to O^{2-}).

$\text{Na}_2\text{O} + \text{H}_2\text{O} \rightarrow 2\text{NaOH}$

PRODUCT and pH (approx.)

NaOH
pH = 12

MgO

Strongly basic (not as strong as Na_2O).

$\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2$

Al₂O₃

No visible reaction with water, but is amphoteric (reacts with acids and bases).

Mg(OH)₂
pH = 9

no product

GIANT COVALENT high melting point

SiO₂

No reaction with water.

no product

COVALENT MOLECULES low melting point

P₄O₁₀

Weakly acidic.

$\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$

H₃PO₃
pH = 2

SO₂

Moderately acidic.

$\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$

H₂SO₃
pH = 1

SO₃

Strongly acidic. Reacts vigorously with water.

$\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

H₂SO₄
pH = 0

TRENDS

MELTING POINTS

IONIC LATTICES

Na_2O , MgO and Al_2O_3 have giant ionic structures.

Ionic lattices have a high melting point because...

Every ion is strongly bonded to several others around it.

GIANT COVALENT

SiO_2 has a giant covalent structure.

Giant covalent structures have a high melting point because...

Every atom forms multiple strong covalent bonds to the atoms around it.

COVALENT MOLECULES

P_4O_{10} , SO_2 and SO_3 are covalent molecules.

Covalent molecules have a low melting point because...

Molecules form weak van der Waals forces to the molecules around them.

REACTIONS WITH WATER

REACTIONS WITH ACIDS AND BASES

IONIC OXIDES

Na_2O and MgO have ionic bonding. The O^{2-} ion is very basic. It reacts with water to form OH^- ions.

ALUMINIUM OXIDE

The bonding in Al_2O_3 (mix of covalent and ionic character) is too strong to react with water.

SILICON DIOXIDE

The bonding in SiO_2 is covalent, and is too strong for SiO_2 to dissolve.

COVALENT MOLECULAR OXIDES

The covalent molecular oxides P_4O_{10} and SO_2 react with water to form acids. Here are their structures along with the anions formed when they deprotonate.

deprotonations

1 2 3

acid

$\text{HO}-\text{P}(\text{OH})_2-\text{OH}$

$\text{HO}-\text{P}(\text{OH})_2-\text{O}^-$

$\text{O}^{2-}-\text{P}(\text{OH})_2-\text{O}^{2-}$

$\text{HO}-\text{S}(\text{OH})_2-\text{OH}$

$\text{HO}-\text{S}(\text{OH})_2-\text{O}^-$

$\text{O}^{2-}-\text{S}(\text{OH})_2-\text{O}^{2-}$

BASIC OXIDES

Na_2O and MgO are basic and so react with acids in neutralisation reactions:

$\text{Na}_2\text{O} + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O}$

$\text{MgO} + 2\text{HNO}_3 \rightarrow \text{Mg(NO}_3)_2 + \text{H}_2\text{O}$

ALUMINIUM OXIDE

Aluminium oxide is amphoteric, meaning that it can act as an acid and a base.

Acting as an acid:

$\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$

Acting as a base:

$\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl(OH)}_4$

ACIDIC OXIDES

P_4O_{10} and SO_2 form acids which react with bases in neutralisation reactions:

$\text{H}_3\text{PO}_4 + 3\text{NaOH} \rightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$

$\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$

Silicon dioxide is not very reactive due to its structure and bonding. Under the right conditions, it will act as an acid, e.g.:

$\text{SiO}_2 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SiO}_3 + \text{H}_2\text{O}$