

Topic 5.2

PERIODICITY

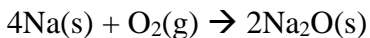
The oxides of period 3 elements

The reaction of period 3 elements with water

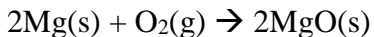
THE OXIDES OF PERIOD 3 ELEMENTS

1. Formation of oxides

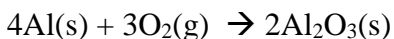
All the elements in Period 3 except chlorine and argon combine directly with oxygen to form oxides.



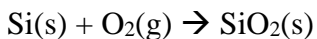
Na₂O is an ionic oxide.



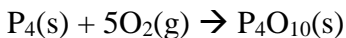
MgO is also an ionic oxide.



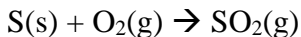
Al₂O₃ is mostly ionic, but there is significant covalent character.



SiO₂ is a giant covalent oxide.



P₄O₁₀ is a molecular covalent oxide. The oxidation number of P in this oxide is +5.



SO₂ is a molecular covalent oxide.

Another oxide, SO₃ is formed in a reversible process when SO₂ and O₂ are heated with a V₂O₅ catalyst (the Contact Process)

2. Physical properties of oxides

The physical properties of these oxides depend on the type of bonding.

Na₂O, Al₂O₃ and MgO are ionic oxides and hence have a high melting point. MgO and Al₂O₃ have a higher melting point than Na₂O since the charges are higher, resulting in a stronger attraction between the ions.

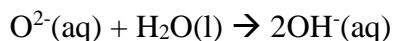
SiO₂ has a giant covalent structure and hence a high melting point. There are strong covalent bonds between all the atoms and thus lots of energy is required to break them.

P₄O₁₀ and SO₃ are molecular covalent and so only intermolecular forces exist between the molecules. The melting points are thus much lower. P₄O₁₀ is a much bigger molecule than SO₃ and so has a much higher melting point, as the van der Waal's forces are stronger.

Element	Na	Mg	Al	Si	P	S
Formulae of oxide	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₃
Structure of oxide	Ionic	Ionic	Mostly ionic	Giant covalent	Molecular covalent	Molecular covalent
Melting point of oxide /°C	1275	2852	2072	1703	300	-10

3. Acid-base character of oxides

Ionic oxides contain the O²⁻ ion. This is a strongly basic ion which reacts with water to produce hydroxide ions:



Thus all ionic oxides are BASIC.

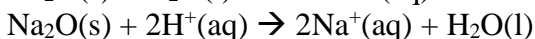
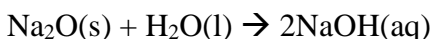
Covalent oxides do not contain ions, but have a strongly positive dipole on the atom which is not oxygen. This attracts the lone pair on water molecules, releasing H⁺ ions:



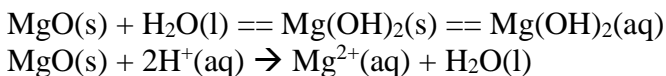
Thus all covalent oxides are ACIDIC.

Intermediate oxides can react in either of the above ways, depending on the conditions. They can thus behave as either acids or bases and are thus AMPHOTERIC.

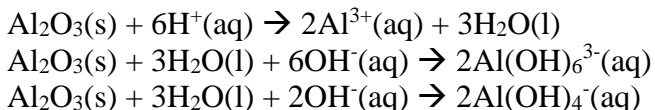
Na₂O is a basic oxide. It dissolves in water to give an alkaline solution (pH = 14). It also reacts with acids:



MgO is a basic oxide. It is only slightly soluble in water and so the solution is only slightly alkaline (pH = 9). It reacts readily with acids:



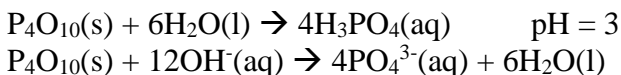
Al₂O₃ is an amphoteric oxide. It is insoluble in water (pH = 7) but dissolves in both acids and alkalis:



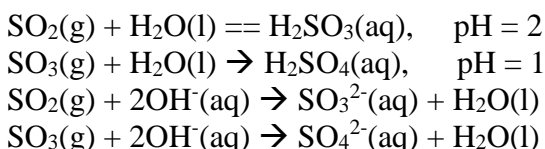
SiO₂ is an acidic oxide. It is insoluble in water (pH = 7) but dissolves in hot concentrated alkalis:



P₄O₁₀ is an acidic oxide. It dissolves in water to give acidic solutions and is also soluble in alkalis:



SO₂ and SO₃ are acidic oxides. They dissolve in water to give acidic solutions, and also react with alkalis:



SO₂ is a waste gas in many industrial processes. It is harmful because it dissolves in rain water to give acid rain. It can be removed from waste gases because it dissolves in alkali and so it is passed through an alkaline solution in waste gas outlets to minimise the amount which escapes into the atmosphere.

The acid-base properties of the oxides of Period 3 can be summarised in the following table:

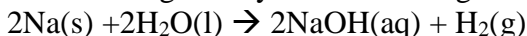
Element	Na	Mg	Al	Si	P	S
Formulae of oxides	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₂ SO ₃
Acid-base character of oxide	Basic	Basic	Amphoteric	Acidic	Acidic	Acidic
pH of solution when dissolved in water	12 - 14	8 - 9	7 (insoluble)	7 (insoluble)	2 - 4	2 - 4 (SO ₂) 1 - 3 (SO ₃)

The oxides therefore become more acidic on moving from left to right in the periodic table.

THE REACTION OF PERIOD 3 ELEMENTS WITH WATER

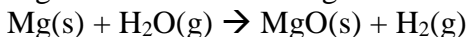
Na, Mg, Al and Si are more electropositive than H and can reduce the water to hydrogen gas:

Na reacts vigorously with water to give the hydroxide and hydrogen:



The resulting solution is strongly alkaline, and will have a pH of 14.

Mg reacts with steam to give the oxide and hydrogen:



The resulting solution is weakly alkaline, since the oxide is slightly basic (pH = 9).

Al and Si also react with steam under certain conditions.

P, S and Cl₂ do not reduce water to hydrogen gas. Phosphorus and sulphur do not react with water but chlorine will disproportionate to give an acidic solution:



The resulting solution contains HCl(aq) and is thus acidic (pH = 2).

The reactivity of the elements of period 3 towards water thus decreases from Na to Si, and then increases from P to Cl. The resulting solutions become increasingly acidic.