Periodicity

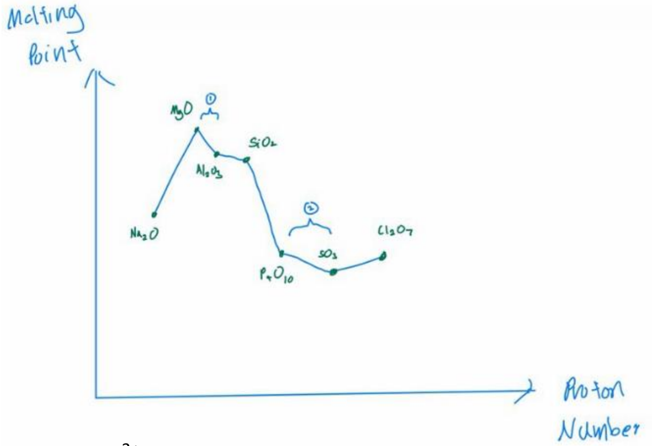
Ionic Radii Trend

- look at number of shells
- look at nuclear charge
- assess the effective nuclear charge
- explain the ionic radii trend
- (Refer to Atomic Structure Masterclass for more details)

Melting Point Trend of Period 3 Oxides

General Trend

- Recap from Chemical Bonding Masterclass
- Na_2O, MgO and Al_2O_3 are giant ionic lattice
- SiO_2 is giant molecular structure
- P_4O_{10} and SO_3 are simple molecular structure

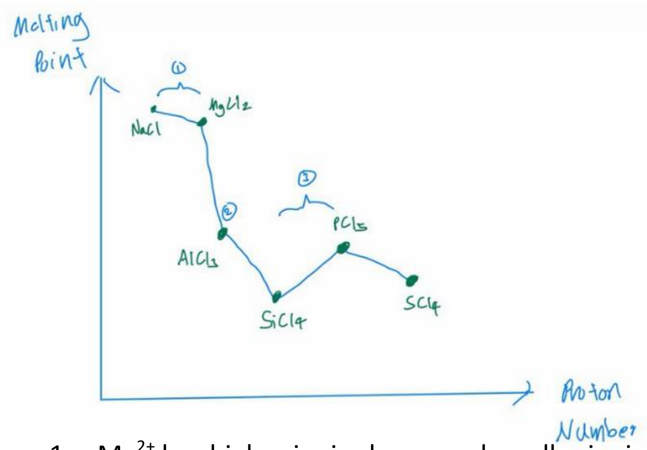


1. Al^{3+} has higher ionic charge and smaller ionic radius than Mg^{2+}
   a. Al^{3+} has higher charge density -> higher polarizing power
   b. Al_2O_3 has covalent character, weakening ionic bonds in Al_2O_3
2. More e^- in P_4O_{10} than SO_3
   a. Increase in polarizability of electron cloud
   b. More energy to overcome stronger id-id

Melting Point Trend of Period 3 Chlorides

General Trend

- Recap from Chemical Bonding Masterclass
- NaCl, $MgCl_2$ are giant ionic lattice
- $AlCl_3$, $SiCl_4$ and PCl_5 are simple molecular structure



1. Mg^{2+} has higher ionic charge and smaller ionic radius than Na^+
   a. Mg^{2+} has higher charge density -> higher polarizing power
   b. $MgCl_2$ has covalent character, weakening ionic bonds in $MgCl_2$

   (Sounds familiar? Repeated Explanation)

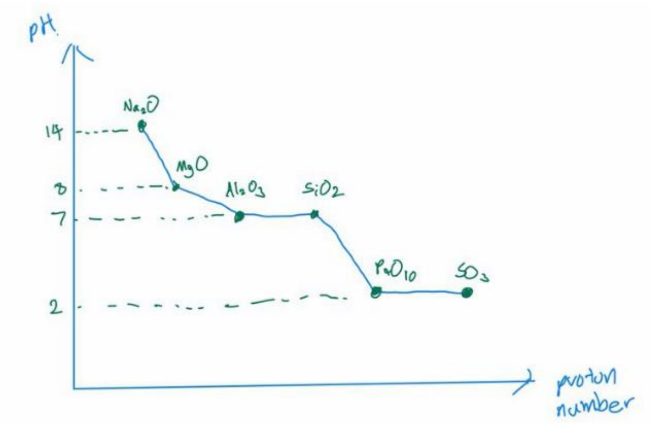
2. Al^{3+} has high ionic charge and small ionic radius.
   a. Al^{3+} has high charge density -> high polarizing power
   b. Al-Cl has a lot more covalent character, so $AlCl_3$ has simple molecular structure.

   (Sounds familiar? Repeated Explanation)

3. More e^- in PCl_5 than $SiCl_4$
   a. Increase in polarizability of electron cloud
   b. More energy to overcome stronger id-id

The Chembridge Institution All Rights Reserved.

Acid-Base Reaction of Period 3 Oxides



Na_2O

Dissolves completely in water

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$$

- Basic Oxide

$$Na_2O(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l)$$

MgO

Dissolves partially in water due to high lattice energy of MgO

$$MgO(s) + H_2O(l) \rightleftharpoons Mg(OH)_2(s)$$

- Basic Oxide

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

Al_2O_3

No reaction due to very high lattice energy of Al_2O_3 so a lot of energy required to break the strong ionic bonds

Amphoteric Oxide

Reaction with Acid

$$Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$$

Reaction with Base

$$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2NaAl(OH)_4(aq)$$

SiO_2

No reaction due to large energy required to break strong covalent bonds between Si and O atoms in giant molecular structure

$$SiO_2(s) + 2NaOH(conc) \rightarrow Na_2SiO_3(aq) + H_2O(l)$$

- Acidic Oxide

P_4O_{10}

Dissolves in water

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$$

- Acidic Oxide

$$P_4O_{10}(s) + 12NaOH(aq) \rightarrow 4Na_3PO_4(aq) + 6H_2O(l)$$

SO_3

Dissolves in water

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

- Acidic Oxide

$$SO_3(g) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

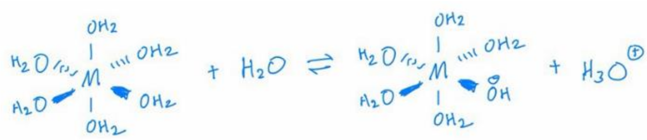
Acid-Base Reaction of Period 3 Chlorides

NaCl

No Hydrolysis

$MgCl_2$

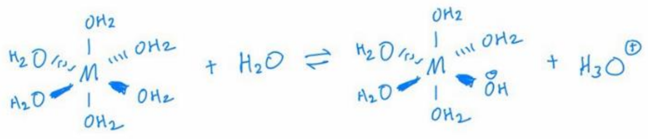
Undergoes slight hydrolysis



The Chembridge Institution All Rights Reserved.

$AlCl_3$

In Excess water: Undergoes more extensive hydrolysis than $MgCl_2$



In Limited water: Reacts vigorously with water and forms white solid with white fumes of HCl

$$AlCl_3\,(s) + 3H_2O\,(l) \rightarrow Al(OH)_3\,(s) + 3HCl\,(g)$$

OR

$$2AlCl_3\,(s) + 3H_2O\,(l) \rightarrow Al_2O_3\,(s) + 6HCl\,(g)$$

$SiCl_4$

Reacts vigorously with water to form white solid with white fumes of HCl

$$SiCl_4\,(l) + 2H_2O\,(l) \rightarrow SiO_2\,(s) + 4HCl\,(aq)$$

PCl_5

Reacts vigorously with water to form white solid with white fumes of HCl

$$PCl_5\,(s) + 4H_2O\,(l) \rightarrow H_3PO_4\,(aq) + 5HCl\,(aq)$$

<u>Trends of Group 2 Elements</u>

Atomic Radius, First I.E., Electronegativity, Melting Point

- Refer to Chemical Bonding and Atomic Structure Masterclass

Reducing Power/Chemical Reactivity

	$E^{\ominus}$
$Mg^{2+}\,(aq) + 2e^- \rightleftharpoons Mg\,(s)$	$-2.37\ V$
$Ca^{2+}\,(aq) + 2e^- \rightleftharpoons Ca\,(s)$	$-2.87\ V$
$Sr^{2+}\,(aq) + 2e^- \rightleftharpoons Sr\,(s)$	$-2.89\ V$
$Ba^{2+}\,(aq) + 2e^- \rightleftharpoons Ba\,(s)$	$-2.91\ V$

- Going down the group -> Atomic Radius increase -> Weaker EFOA btwn nucleus and valence e^- -> Easier to lose valence e^- -> Greater tendency to be oxidised = reducing power/chemical reactivity increase
- Look at electrode potential E° -> more negative E° = greater tendency to be oxidised = stronger oxidising power

Thermal Stability of Group 2 salt (with large anions)

e.g.

$$CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$$

$$Ba(NO_3)_2\,(s) \rightarrow BaO\,(s) + 2NO_2\,(g) + \tfrac{1}{2}O_2\,(g)$$

$$Sr(OH)_2\,(s) \rightarrow SrO\,(s) + H_2O\,(g)$$

- Size and Charge of Cation
  - Going down the group -> size of cation increases and charge stays the same -> charge density decreases -> e^- cloud of anion is polarized to lesser extent -> Bonds in anion are weakened to a lesser extent -> Thus, thermal stability increases down group
- Size of Anion
  - Note: Usually the anion does not change, but knowing the bigger size of the anion helps with increasing the polarizability of the e^- cloud could help

The Chembridge Institution All Rights Reserved.

Trend of Group 17

Boiling Point

- Refer to Chemical Bonding Masterclass

Oxidising Power/Reactivity

- Down the group -> Atomic radius increase -> Decrease in EFOA btwn nucleus and valence e^- -> Decreased tendency to accept e^- -> Decreased tendency to be reduced -> Oxidising Power decreases

Thermal Stability of HX

- Going down group -> Size of Halogen atom increase -> Effectiveness of Orbital overlap decrease -> Bond strength of H-X decrease -> Lesser energy needed to break H-X bond, thermal stability decrease

The Chembridge Institution All Rights Reserved.