Ionic Solids

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Characteristic of ionic solid

- Conductivity
  - Solid
    - Ion strongly bond at crystal site
    - Ion can not migrate
    - Not conduct current
  - Melt
    - Ion can migrate
    - Conductor
Characteristic of ionic solid

• Melting point
  – Ionic bond occur to all direction
  – Strong ionic bonding
  – Has high m.p.
Characteristics of an ionic solid

- Ductile
  - When force hits the solid
  - Bond length shorter
  - Attraction force becomes repulsion force
  - Readily broken
- Dissolves in polar solvent
Model & Size of Ionic Compound

Atomic number >>>

Nuclei charge >>>

Atomic radius <<<
Model & Size of Ionic Compound

- Cation
  - Released electron
  - Effective nuclei charge >>>>
  - Attraction force >>>>
  - Cation size <<<
  - Radius of Na = 186 pm, Na$^+$ = 116 pm
  - Volume Na$^+$ = 0.25 V Na
Model & Size of Ionic Compound

• Anion
  – Accept electron
  – Effective nuclei charge <<<<
  – Attraction force <<<<
  – Anion size >>>>
  – Radius of O = 74 pm, O^{2-} = 124 pm
  – Volume O^{2-} = 5 V O
Trends of Ionic Radius

- Cation
  - Radius of: $\text{Na}^+_{11}, \text{Mg}^{2+}_{12}, \text{Al}^{3+}_{13} = 116, 86, 28$ pm
  - Left to right: (+) charge $\gg$, effective nuclei charge $\gg$, ionic radius $\ll$
Trends of Ionic Radius

• Anion
  – Radius of: \( _7N^{3-}, _8O^{2-}, _9F^- = 132, 124, 117 \) pm
  – Left to right: (-) charge <<<, effective nuclei charge >>>>, ionic radius <<<
  – Radius of: \( F^-, Cl^-, Br^-, I^- = 117, 167, 182, 206 \) pm
  – Top to down (in a group): atomic number >>>>, number of shell >>>>, ionic size>>>
Trends of Melting Point

• Ionic bond
  – (+) charge are surrounded by (-) charge in crystal site
  – Attraction force between (+) and (-) charge
Trends of Melting Point

- Melting
  - Breaking of the attraction force
  - Ion can migrate freely in liquid phase
  - Ionic size <<, bond strength >>>, melting point >>>

- M.p. Of KF, KCl, KBr, KI = 857, 772, 735, 685 °C
Polarization & Covalency

- Polarization: distort from the ideal form of anion (sphere)
- Polarization property $\gg\gg\gg$, degree of covalence $\gg\gg\gg$, covalent property $\gg\gg\gg$, covalent compound.
- $\rho$ (charge density)
Polarization & Covalency

\[ \rho = \frac{+1 \times 1.6 \times 10^{-19} \, \text{C}}{4/3 \times (3.14) \times (1.16 \times 10^{-7})^3 \, \text{mm}^3} = 24 \, \text{C mm}^3 \]

\( n \) = muatan ion

\( p \) = muatan proton = 1.6 \times 10^{-19} \, \text{C}
Polarization & Covalence

eg : radius of natrium = 116 pm

= 1,16 \times 10^{-7} \text{ mm}

so:

\[ \rho = \frac{+1 \times 1,6 \times 10^{-19} \text{ C}}{4/3 \times (3,14) \times (1,16 \times 10^{-7})^3 \text{ mm}} = 24 \text{ C mm}^{-3} \]

\[ \rho \gg \gg, \text{ polarization capacity } \gg \gg \]
Kasimir Fajans`s Rules

1. Cation size $<< \rightarrow (+) \text{ charge } \gg \rightarrow$ polarize capacity $\gg \rightarrow$ covalent compound
   - Radius of Al $<< \text{ Na}$
     \[ \rho \text{ Na} = 24 \text{ C mm}^{-3} \]
     \[ \rho \text{ Al} = 364 \text{ C mm}^{-3} \]
   - Polarization capacity of Al $\gg \text{ Na}$,
   - Al $\rightarrow$ covalent compound ( m.p. $<<$ )
   - Na $\rightarrow$ ionic compound ( m.p. $>>$ )
Kasimir Fajans`s Rules

2. Anion size $\gg \rightarrow (-)\ charge\ >> \rightarrow$ readily polarized $\rightarrow$ covalent compound

- $\text{AlF}_3$ dan $\text{AlI}_3$
- $r\ \text{F}^- = 117\ pm$
- $r\ \text{I}^- = 206\ pm$
- Polarized capacity of $\text{I}^- \gg \text{F}^-$
- $\text{AlF}_3 \rightarrow$ ionic compound
- $\text{AlI}_3 \rightarrow$ covalent compound
Kasimir Fajans`s Rules

3. If the electronic configuration of the cation ≠ noble gas → polarize capacity >> → covalen compound

- $^{11}\text{Na} = [10\text{Ne}]\ 3s^1 \rightarrow \text{Na}^+ = [10\text{Ne}]
- $^{47}\text{Ag} = [36\text{Kr}]\ 4d^{10}\ 5s^1 \rightarrow \text{Ag}^+ = [36\text{Kr}]\ 4d^{10}$

- e- configuration ≠ noble gas
- polarize capacity of Ag$^+$ >> Na$^+$

- AgF → covalen compound, mp = $435^\circ$C
- NaF → ionic compound, mp = ± $735^\circ$C
AgF, AgCl, AgBr, AgI

• AgF
  – AgF $\rightarrow$ dissolves in water
  – Radius of F$^-$ is the smallest compared to other halide ions.
  – F$^-$ the most difficult to be polarized
  – Form ionic compound
  – Soluble in water
• AgCl, AgBr, AgI
  – Insoluble in water
Na$_2$O dan Cu$_2$O

- Na$^+$ = [10Ne] $\rightarrow$ ionic compound
- Cu$^+$ = [18Ar] 3d$^{10}$ $\rightarrow$ covalent compound

- e$^-$ configuration $\neq$ e$^-$ configuration of noble gas
- Polarized capacity $>>$
- Form covalent compound
Na$_2$O dan Cu$_2$O

- Electronegativity of
  Na = 0.9, Cu = 1.9, O = 3.5
  - $\Delta$ electronegativity in Na$_2$O = 2.6 $\rightarrow$ ionic
  - $\Delta$ electronegativity in Cu$_2$O = 1.6 $\rightarrow$ covalent

$\Delta$ electronegativity $>>$ $\rightarrow$ ionic compound
Hydration of Ion

• Why ionic compound is water soluble?
  – There is ion-dipol interaction between ion and water molecule
Hydration of Ion

- **Dissolution process of NaCl in water**

\[
\begin{align*}
\delta^+ & \quad 2\delta^- \\
H - O \quad \text{Na - Cl} \quad H - O \\
\delta^+ & \quad \delta^- \quad \delta^+ \quad 2\delta^- \\
\delta^+ & \quad \delta^+ \quad \delta^+ \quad \delta^+
\end{align*}
\]

- If the dipol interaction $\gg$ total interaction of ions and water molecule $\rightarrow$ soluble