Lattice Energy

- Energy change required to separate 1 mol of ionic solid into widely spaced gaseous ions.
- Negative of energy released if ions fall back together.
- ...for NaCl $\Delta H^\circ_{Lattice} = +786\ kJ/mol$
- Determined via the Born-Haber cycle (pg. 334-335)...an application of Hess's Law.

Differences in Lattice Energy

MgS: $\Delta H^\circ_{Lattice}$ **>** **KCl:** $\Delta H^\circ_{Lattice}$

More difficult to pull Mg and S ions apart.

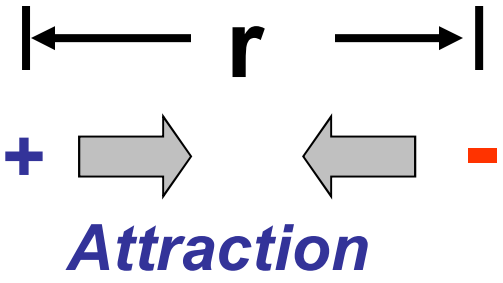
Easier to pull K and Cl ions apart.

Why the difference?

...need to look at the details of the attractive force holding the ions together.

Electrostatic Energy

From Physics...



$$\text{Lattice Energy} \propto \frac{\text{Positive Charge} \times \text{Negative Charge}}{r}$$

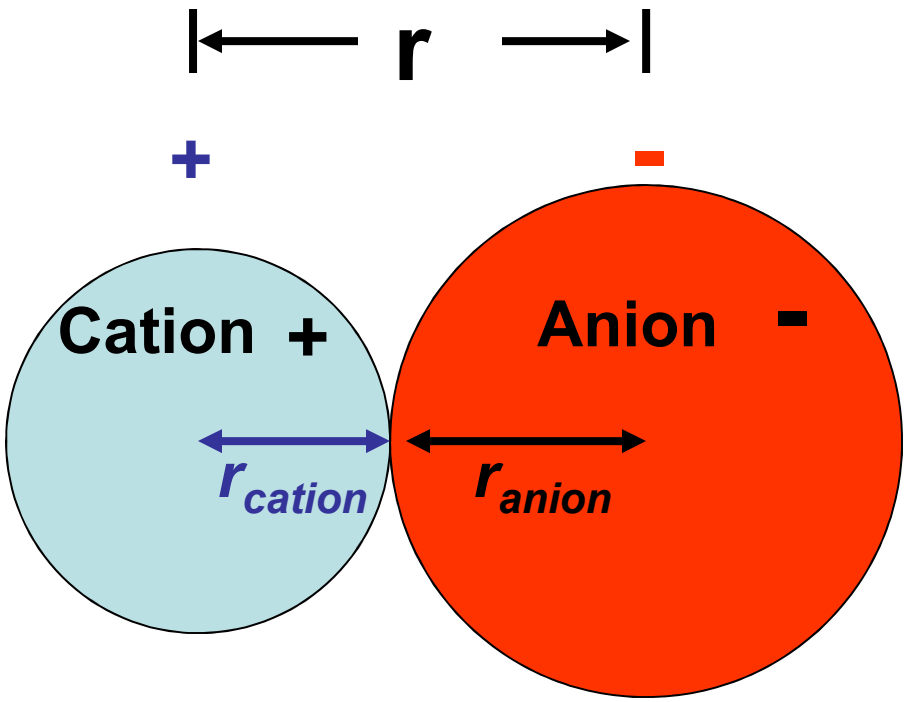
To increase the Lattice Energy:

1. Increase either the Pos. or Neg. charge
2. Decrease the distance between charges (r)

To Decrease the Lattice Energy:

1. Decrease either the Pos. or Neg. charge
2. Increase the distance between charges (r)

Electrostatic Energy



$$\text{Lattice Energy} \propto \frac{\text{Positive Charge} \times \text{Negative Charge}}{(r_{cation} + r_{anion})}$$

Lattice energy depends on the charge sizes and the ion radii

Factors Affecting Lattice Energy

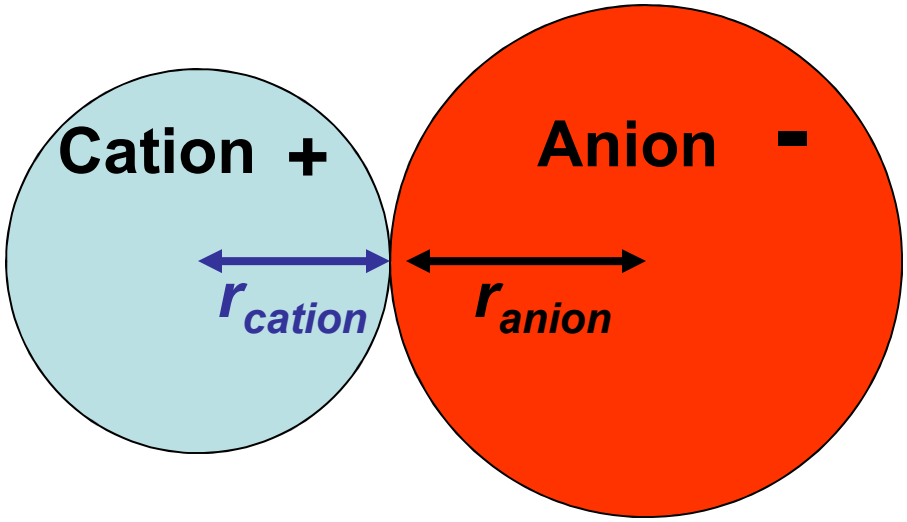
Two singly charged ions:

$$\text{Lattice Energy} \propto \frac{(1+) \times (1-)}{(r_{cation} + r_{anion})}$$

Two doubly charged ions: ***FOUR TIMES THE LATTICE E. !!***

$$\text{Lattice Energy} \propto \frac{(2+) \times (2-)}{(r_{cation} + r_{anion})} = 4 \times \frac{(1+) \times (1-)}{(r_{cation} + r_{anion})}$$

Factors Affecting Lattice Energy



For Large Lattice Energy:

1. Multiple Pos. and/or Neg. charges
2. Small ionic radii (small ions)

For Small Lattice Energy:

1. Low number Pos. or Neg. charges
2. Large ionic radii (r)

Lattice Energy Comparisons

Arrange the following ionic solids in order of decreasing lattice energy:

http://www.chemicool.com/elements/

http://www.webelements.com

	+1 -1 **KI**	+2 -2 **MgO**	+1 -1 **NaI**	+1 -1 **LiF**
Cation Radius	**0.152 nm**	**0.086 nm**	**0.116 nm**	**0.090 nm**
Anion Radius	**0.206 nm**	**0.126 nm**	**0.206 nm**	**0.119 nm**
	+2/-2 charges important **MgO**	***Small ionic radii*** **LiF**	***Larger ionic radii*** **NaI**	***Largest ionic radii*** **KI**
Lattice Energy:	3791 kJ/mol	1036 kJ/mol	704 kJ/mol	649 kJ/mol
	T_{melt} = 2852 °C	**T_{melt} = 845 °C**	**T_{melt} = 661 °C**	**T_{melt} = 680 °C**