Chemical Bonding

Valence electrons participate in chemical bonds

Valence e^- = Outer e^-

Representative elements – $ns^x np^y$

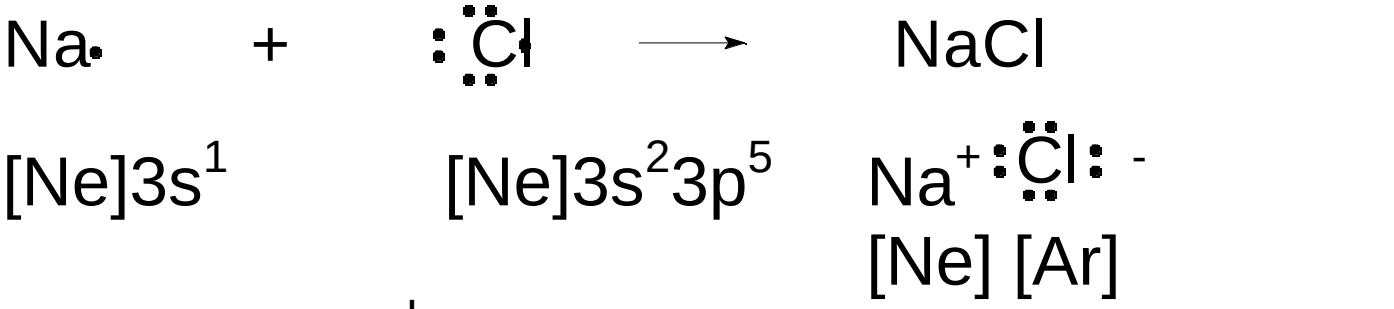
Transition Metals $(n-1)d^z ns^x$

Lewis Dot Symbol

One dot for each valence electron

Representative elements and inert gases only

Ionic Compounds



Na – Low E_1^I

Cl – Large negative E_1^A

$Na(g) + 496\ kJ/mol \rightarrow Na^+ + e^-$

$Cl(g) + e^- \rightarrow Cl^- + 348\ kJ/mol$

$Na(g) + Cl(g) + 148\ kJ/mol \rightarrow Na^+(g) + Cl^-(g)$

NOT NaCl(g or s)

We can estimate the bond energy for ionic compounds

$Na^+(g) + Cl^-(g) \rightarrow NaCl(g)$

$r_{Na+} = 95\ pm$

$r_{Cl-} = 181\ pm$

$$E = \frac{1}{4\pi\varepsilon_o}\frac{q_{Na}q_{Cl}}{r_{Na-Cl}}$$

$q_{Na} = +q_e \qquad q_{Cl} = -q_e$

$r_{Na-Cl} = 276pm$

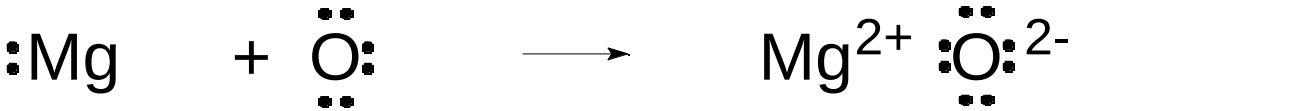
$-502kJ/mol$

$Na^+ + Cl^- \rightarrow NaCl(g) + 502\ kJ/mol$

$\therefore Na(g) + Cl(g) \rightarrow NaCl(g) + 354\ kJ/mol$

Net Energy Gain – Exothermic

Other Ionic Compounds



$[Ne]3s^2$ $1s^2 2s^2 2p^4$ [Ne] [Ne]

$[Ar]4s^2$ $[Ne]3s^2 3p^5$ [Ar] [Ar]

Characteristics of Ionic Compounds

Hard, brittle
Fairly high melting point
Good insulators – solid
Transparent in visible
Dissolve in polar solvents (H_2O) to yield electrically conductive solutions
Melts are good conductors

Properties determined by electrostatic (A^+B^-) binding force.

Lattice Energy

NaCl(g) is not as stable as NaCl(s)

Lattice – An ordered three dimensional array

Ionic Lattice – array of ions held to together by coulomb forces

$Na^+(g) + Cl^-(g) \_ NaCl(s) + \Delta H_{lattice}$

$Na^+(g) + Cl^-(g) \_ NaCl(g) + \Delta H_{ionic\ bond}$

$\Delta H_{lattice}$ (757 kJ/mol) > $\Delta H_{ionic\ bond}$ (502 kJ/mol)

How to determine the lattice energy?

Very difficult to measure directly

$NaCl + \Delta \_ Na + Cl$

Measure indirectly using Born-Haber cycle

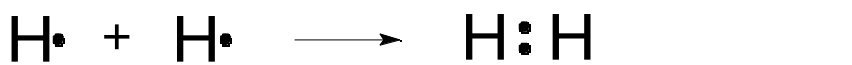
			kcal/mole
$Na(s)$	_	$Na(g)$	26
_ $Cl_2(g)$	_	$Cl(g)$	27
$e^- + Cl(g)$	_	$Cl^-(g)$	-88
$Na(g)$	_	$Na^+(g) + e^-$	117
$Cl^-(g) + Na^+(g)$	_	$NaCl(s)$	$-\Delta H_{lattice}$
$NaCl(s)$	_	$Na(s) + \frac{1}{2} Cl_2(g)$	99
$NaCl(s)$	_	$NaCl(s)$	0

$\Delta H_{lattice}$ = 181 kcal/mol x 4.184 kJ/kcal = 757 kJ/mol

$\Delta H_{lattice} + NaCl(s)$ _ $Na^+(g) + Cl^-(g)$

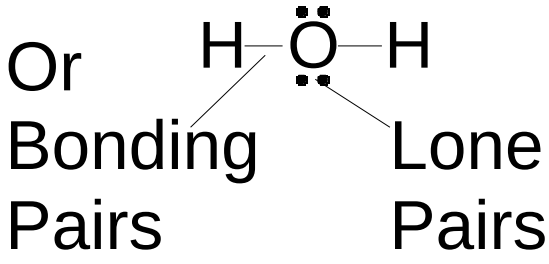
Defining equation for lattice energy

Covalent Bonds - Shared Electrons



$1s^1$ $1s^1$ single bond

$[Ne]3s^2 3p^5$



Molecular covalent compounds

Covalent Crystals

Network of covalent bonds

Si, C (graphite), C (Diamond)

Si_3N_4, SiC, SiO_2, Etc.

Very Hard

Very High Melting

All covalent compounds good insulators, poorly soluble in ionic solvents (H_2O)

How to predict whether two elements form ionic or covalent bonds?

Function of E^A and E^I

Pauling – electronegativity scale

Measures ability of an atom to attract e^- in a chemical bond

Empirical, Relative Scale

Large ΔEN _ More ionic

Small ΔEN _ More covalent

Working Definition:

$\Delta EN \geq 2 \rightarrow$ Ionic

$< 2 \rightarrow$ Covalent

	ΔEN	
H – H	0	Covalent (Pure)
H – Cl	0.9	Covalent (Polar)
NaCl	2.1	Ionic