TECHNICAL CHEMISTRY - BETV 1013

Chemical Bonding

Chapter 5

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Valence electrons are the outer shell electrons of an atom. The valence electrons are the electrons that participate in chemical bonding.

Group	e^- configuration	# of valence e^-
1A	ns^1	1
2A	ns^2	2
3A	ns^2np^1	3
4A	ns^2np^2	4
5A	ns^2np^3	5
6A	ns^2np^4	6
7A	ns^2np^5	7

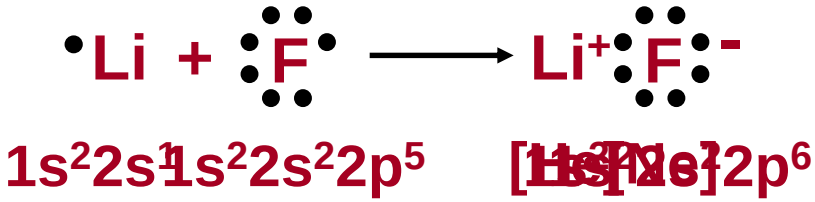
Lewis Dot Symbols

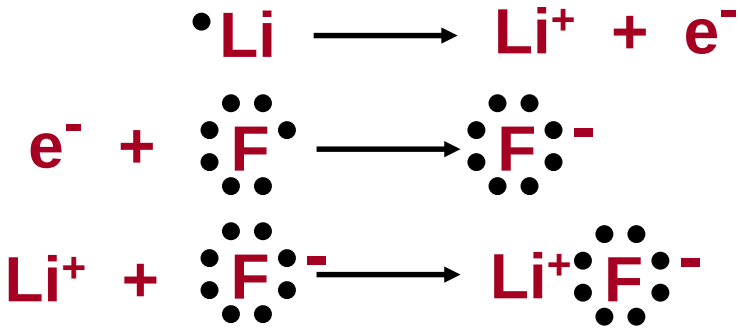
1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
·H																	He:
·Li	·Be·											·B·	·C·	·N·	·O·	:F·	:Ne:
·Na	·Mg·											·Al·	·Si·	·P·	·S·	:Cl·	:Ar:
·K	·Ca·											·Ga·	·Ge·	·As·	·Se·	:Br·	:Kr:
·Rb	·Sr·											·In·	·Sn·	·Sb·	·Te·	:I·	:Xe:
·Cs	·Ba·											·Tl·	·Pb·	·Bi·	·Po·	:At·	:Rn:
·Fr	·Ra·																

The Ionic Bond (Electrovalence)

An *Ionic bond* is the electrostatic force that holds ions together in an ionic compound

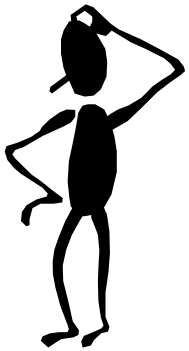
Ionic compound combine a Group IA & Group IIA metal with a halogen or oxygen



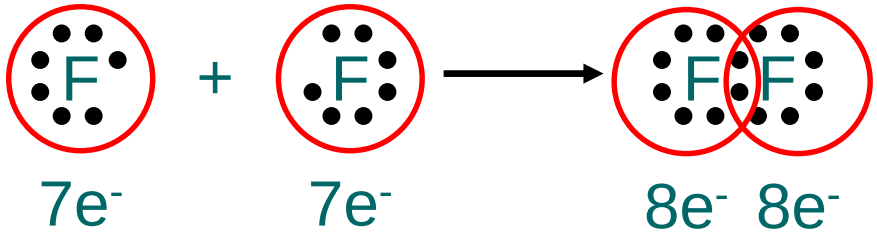


The Covalent Bond

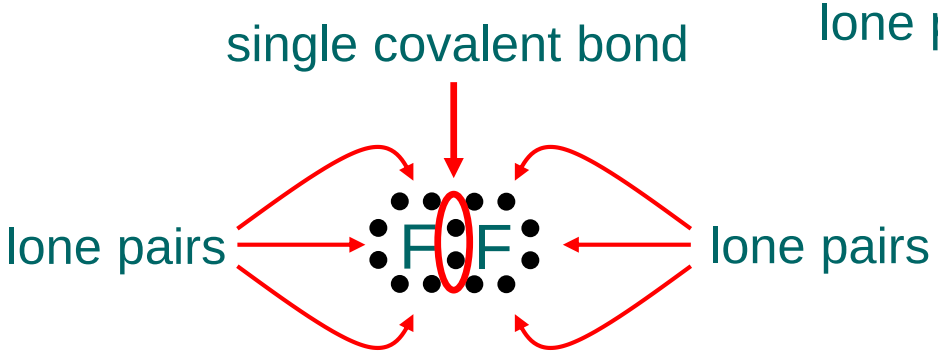
A ***covalent bond*** is a chemical bond in which two or more electrons are shared by two atoms. (Non metal & non metal)

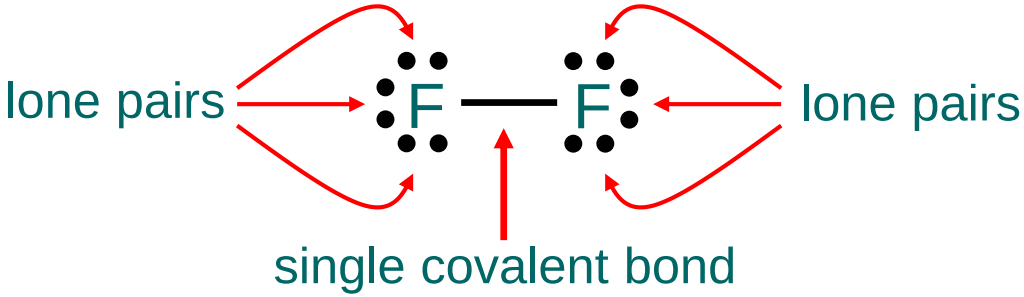


Why should two atoms share electrons?

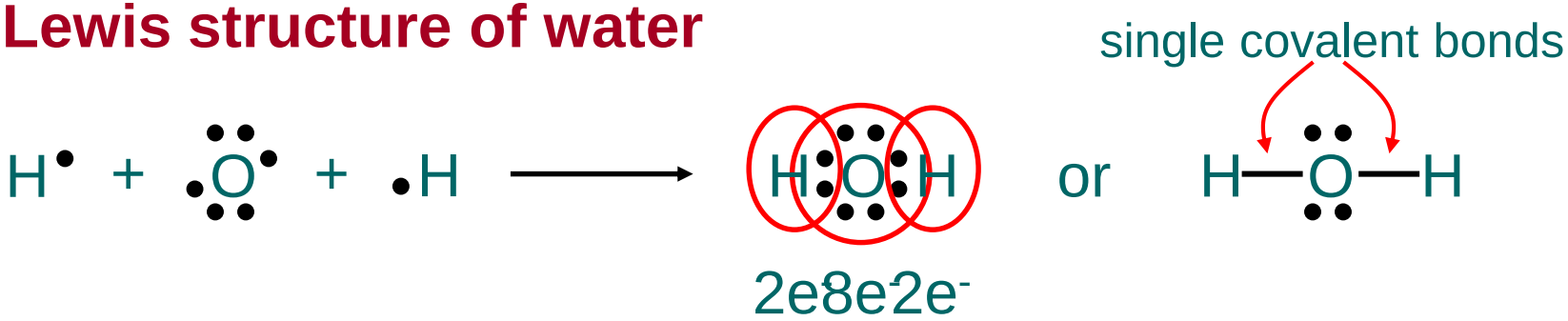


Lewis structure of F_2

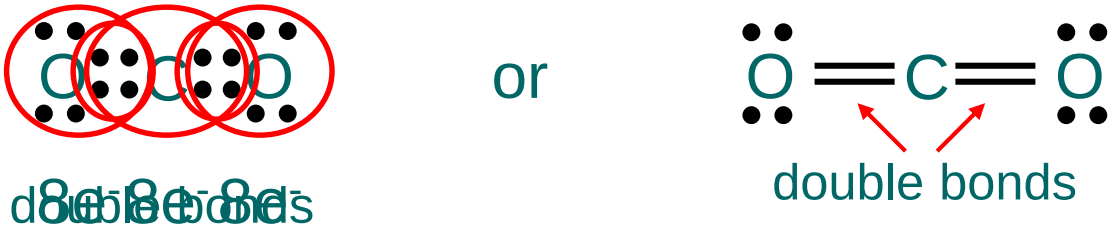




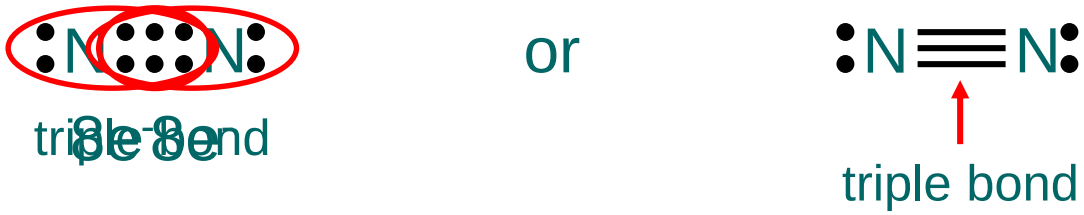
Lewis structure of water



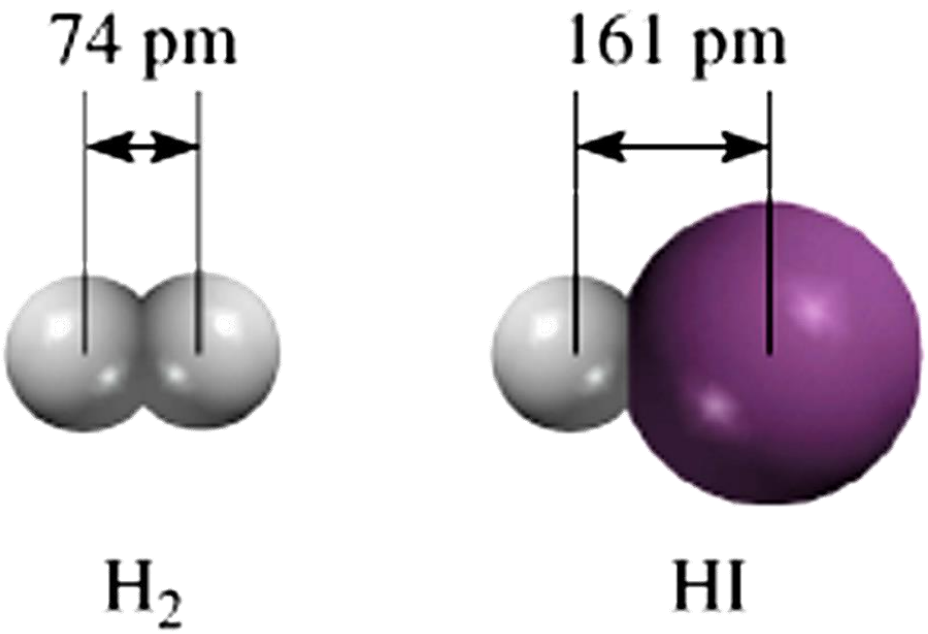
Double bond – two atoms share two pairs of electrons



Triple bond – two atoms share three pairs of electrons



Lengths of Covalent Bonds



Bond Type	Bond Length (pm)
C-C	154
C=C	133
C≡C	120
C-N	143
C=N	138
C≡N	116

Bond Lengths

Triple bond < Double Bond < Single Bond

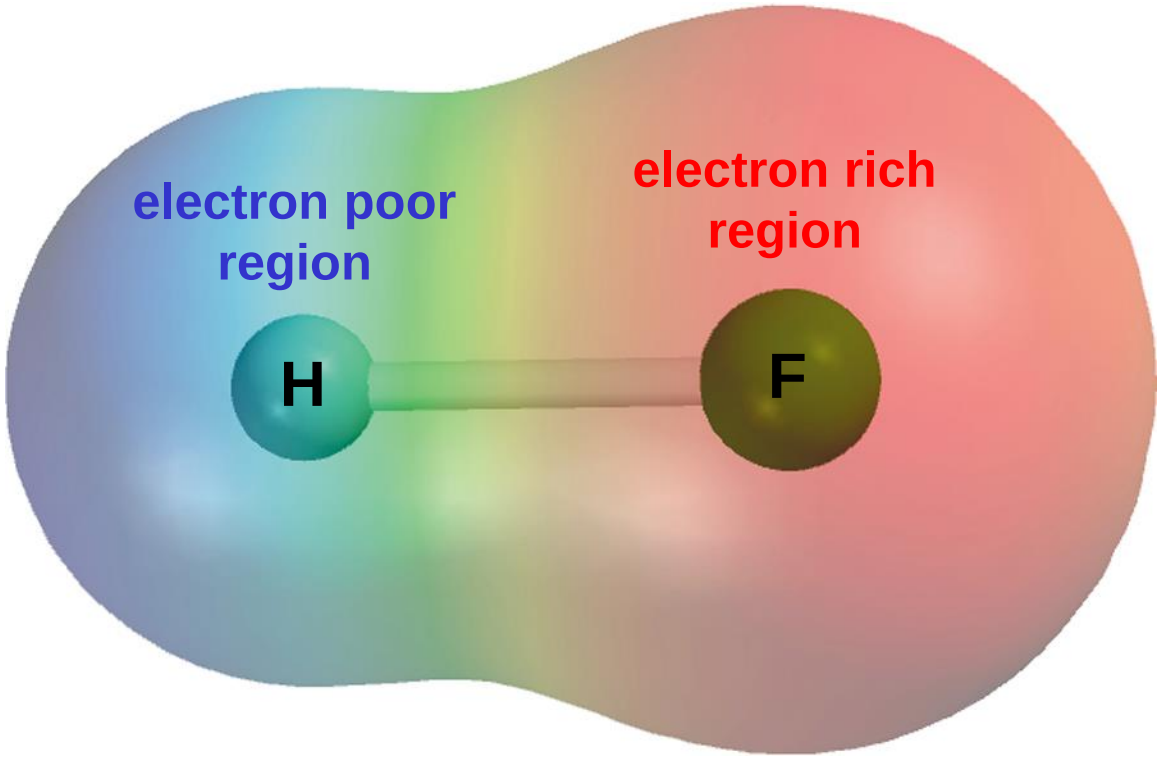
Comparison of Ionic and Covalent Compounds

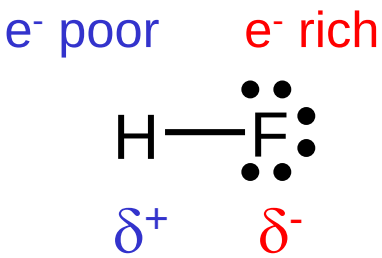
Table 9.3 Comparison of Some General Properties of an Ionic Compound and a Covalent Compound

Property	NaCl	CCl_4
Appearance	White solid	Colorless liquid
Melting point (°C)	801	−23
Molar heat of fusion* (kJ/mol)	30.2	2.5
Boiling point (°C)	1413	76.5
Molar heat of vaporization* (kJ/mol)	600	30
Density (g/cm^3)	2.17	1.59
Solubility in water	High	Very low
Electrical conductivity		
Solid	Poor	Poor
Liquid	Good	Poor

** Molar heat of fusion and molar heat of vaporization are the amounts of heat needed to melt 1 mole of the solid and to vaporize 1 mole of the liquid, respectively.*

Polar covalent bond or ***polar bond*** is a covalent bond with greater electron density around one of the two atoms

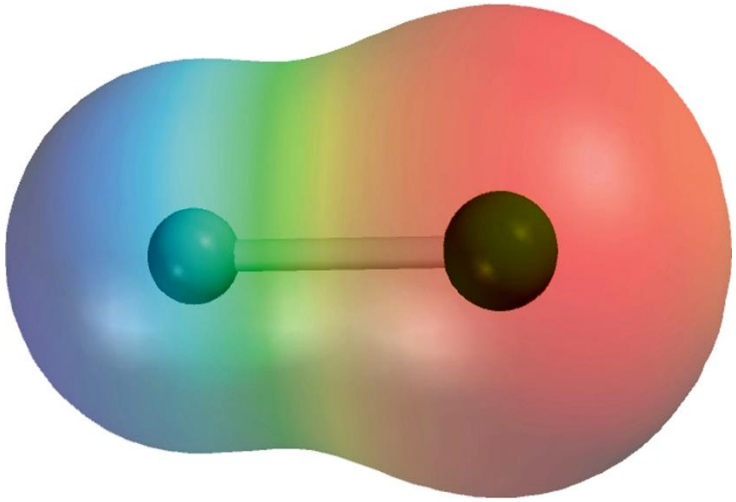




Electronegativity is the ability of an atom to attract toward itself the electrons in a chemical bond.

Electron Affinity - measurable, Cl is highest

Electronegativity - relative, F is highest



Both are related but different concepts. EA refers to an isolated atom and E refers to an atom in chemical bond. Usually, EA > then E >.

Electronegativities of Common Elements

Increasing electronegativity →

Increasing electronegativity ↑

1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
H 2.1																	
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	
Cs 0.7	Ba 0.9	La-Lu 1.0-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2	
Fr 0.7	Ra 0.9																

Classification of bonds by difference in electronegativity

Difference	Bond Type
0	Covalent
≥ 2	Ionic
0 < and <2	Polar Covalent

Increasing difference in electronegativity →

Covalent	→	Polar Covalent	→	Ionic
share e^-		partial transfer of e^-		transfer e^-

Classify the following bonds as ionic, polar covalent, or covalent: The bond in CsCl; the bond in H_2S; and the NN bond in H_2NNH_2.

Intermolecular Forces

Intermolecular forces are attractive forces **between** molecules.

Intramolecular forces hold atoms together in a molecule.

Intermolecular vs Intramolecular

- 41 kJ to vaporize 1 mole of water (**inter**)
- 930 kJ to break all O-H bonds in 1 mole of water (**intra**)

Generally, **inter**molecular forces are much weaker than **intra**molecular forces.

"Measure" of intermolecular force

boiling point

melting point

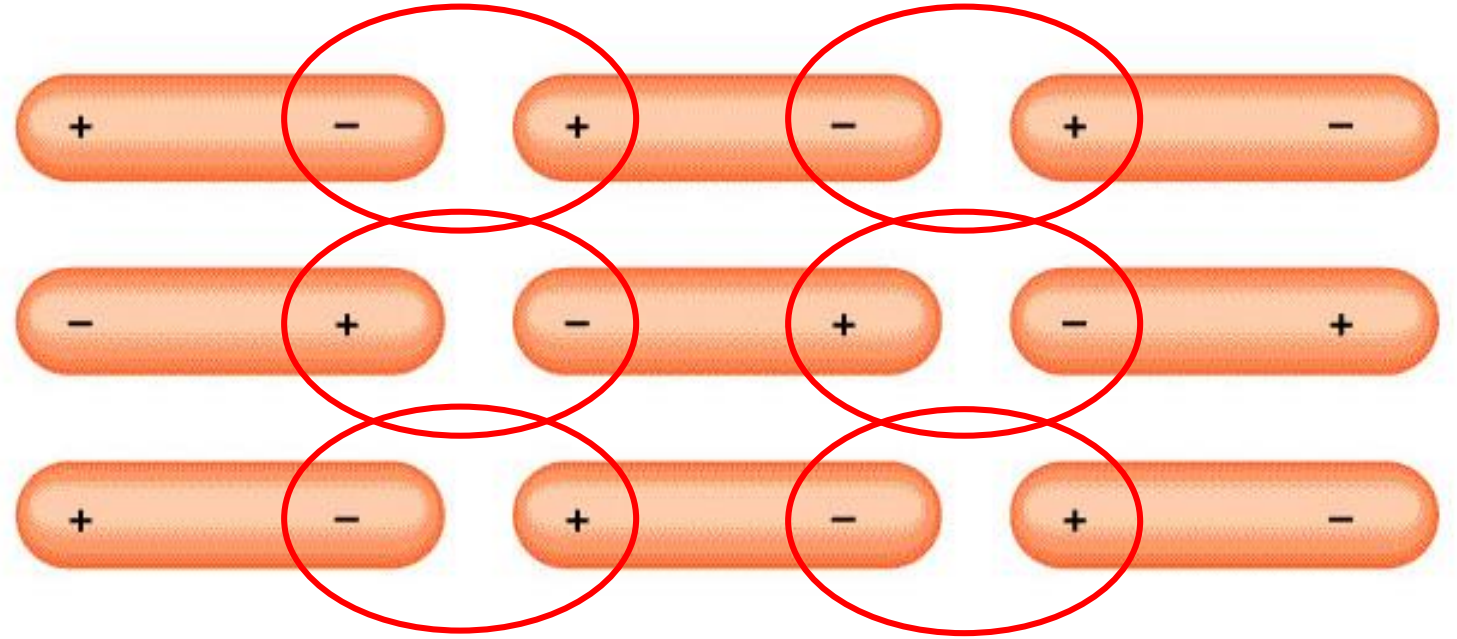
ΔH_{vap}

Intermolecular Forces

Dipole-Dipole Forces

Attractive forces between **polar molecules**

Orientation of Polar Molecules in a Solid

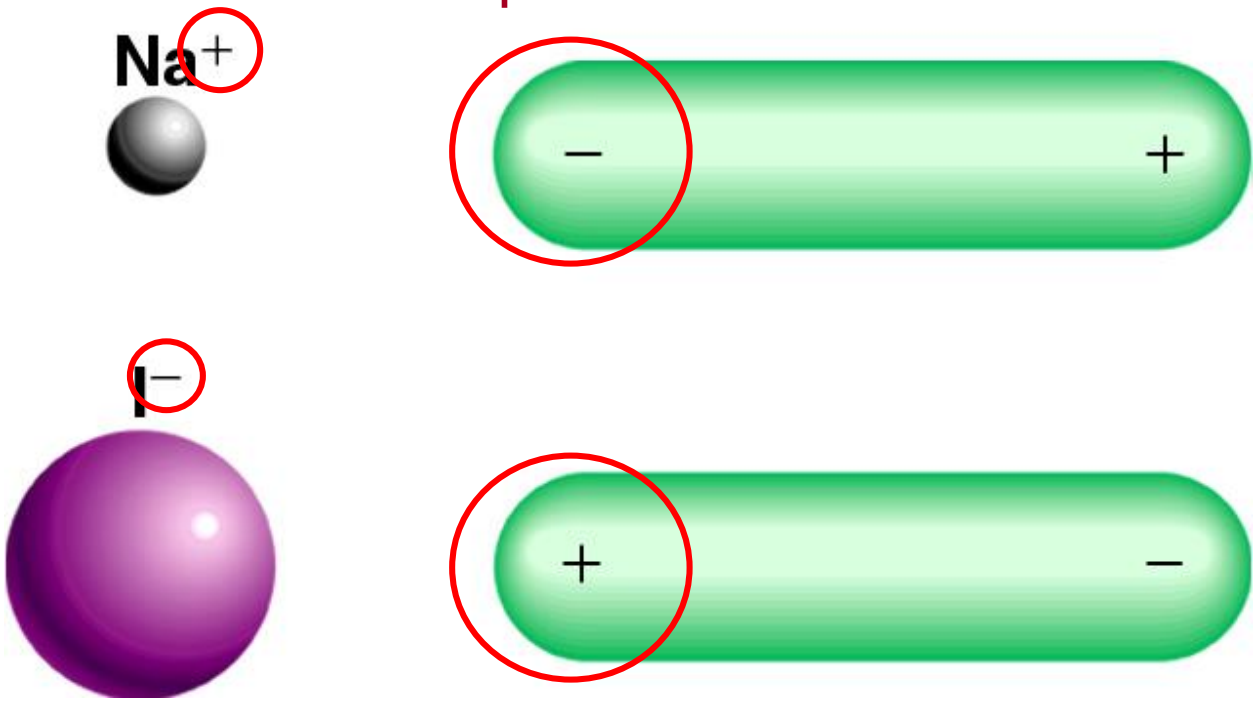


Intermolecular Forces

Ion-Dipole Forces

Attractive forces between an **ion** and a **polar molecule**

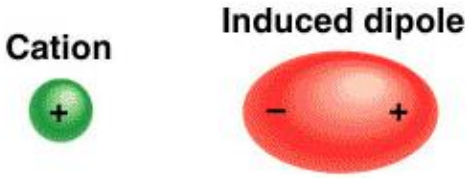
Ion-Dipole Interaction



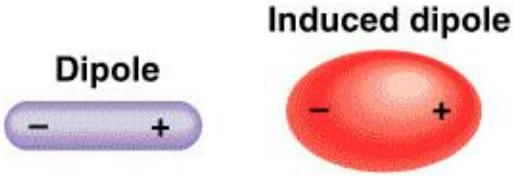
Intermolecular Forces

Dispersion Forces (London)

Attractive forces that arise as a result of **temporary dipoles induced** in atoms or molecules



ion-induced dipole interaction



dipole-induced dipole interaction

Intermolecular Forces

Dispersion Forces Continued

Polarizability is the ease with which the electron distribution in the atom or molecule can be distorted.

Polarizability increases with:

- greater number of electrons
- more diffuse electron cloud

Dispersion forces usually increase with molar mass.

Table 11.2 Melting Points of Similar Nonpolar Compounds

Compound	Melting Point (°C)
CH_4	−182.5
CF_4	−150.0
CCl_4	− 23.0
CBr_4	90.0
CI_4	171.0

What type(s) of intermolecular forces exist between each of the following molecules?

HBr

CH_4

SO_2

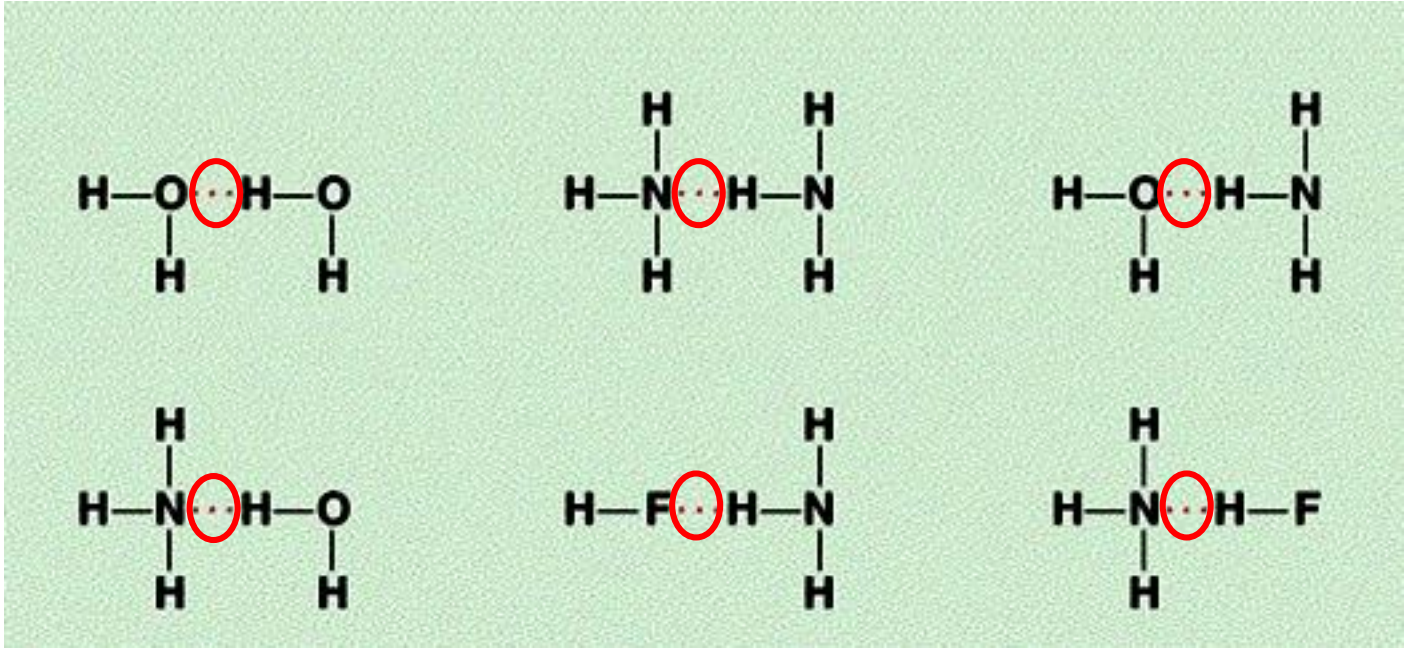
Intermolecular Forces

Hydrogen Bond

The ***hydrogen bond*** is a special dipole-dipole interaction between they hydrogen atom in a polar N-H, O-H, or F-H bond and an electronegative O, N, or F atom.

A — H--B or A — H--A

A & B are N, O, or F



Why is the hydrogen bond considered a “special” dipole-dipole interaction?