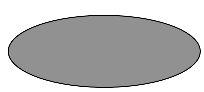
1.3 More bonding

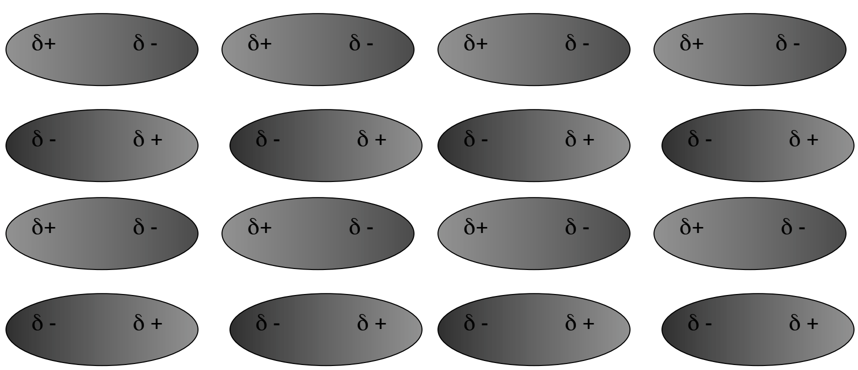
Van der Waals bonding: induced dipoles

On average, a symmetric molecule (like H_2) is electrically neutral:



Now bring two molecules together (cooling):

This can happen over a huge number of molecules:



A solid!!!

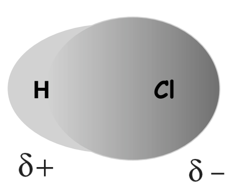
Does the shape of the molecule matter?

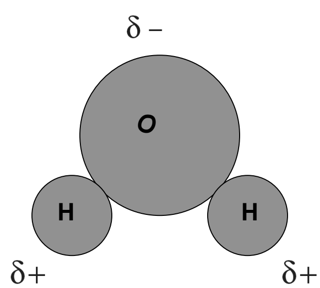
Why?

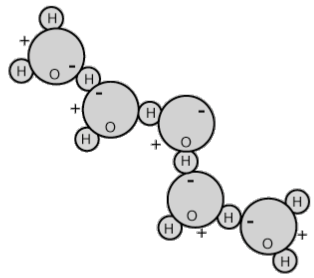
Van der Waals bonding:

permanent dipoles (hydrogen bonding)

Some molecules (HCl, H_2O) have permanent dipoles:

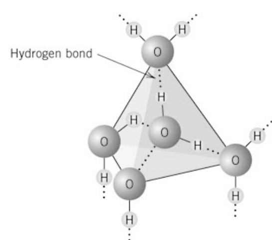






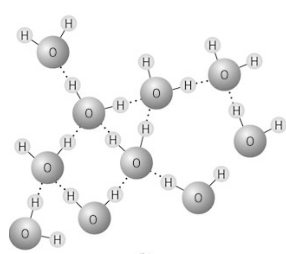
Why water expands upon freezing:

ICE:



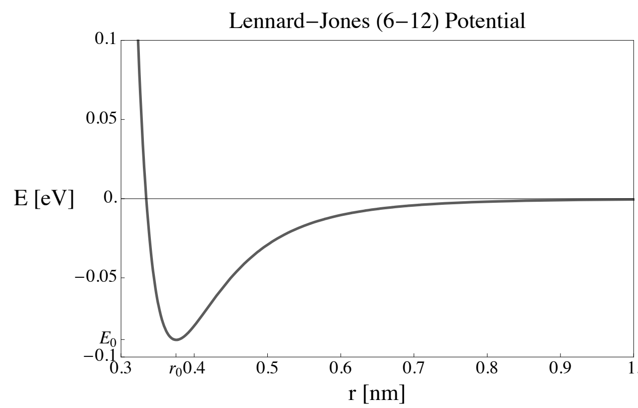
(a)

WATER:

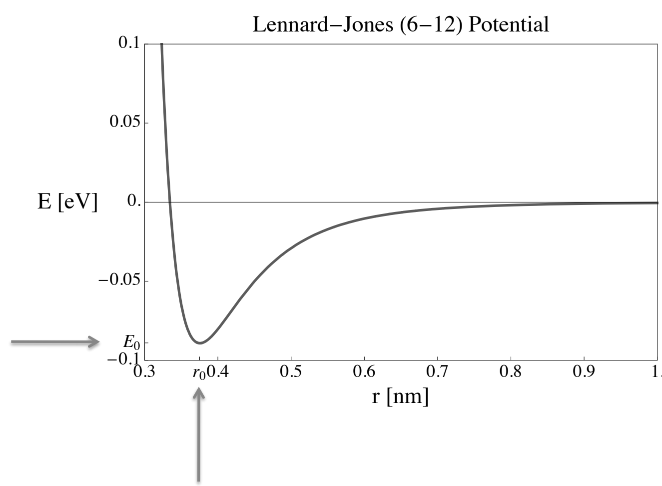


(b)

Van der Waals bonding



How do we find r_0? E_0?



Lennard-Jones (6-12) potential:

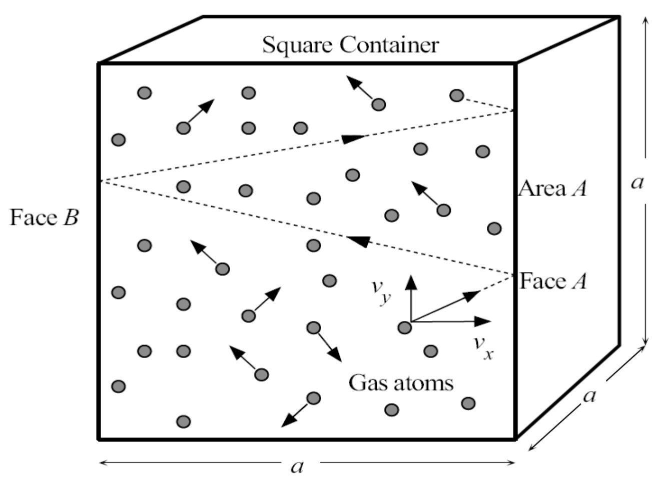
$E(r) = -A\, r^{-6} + B\, r^{-12}$

$dE/dr = 0 \rightarrow r_0$

$-E(r_0) = E_0$

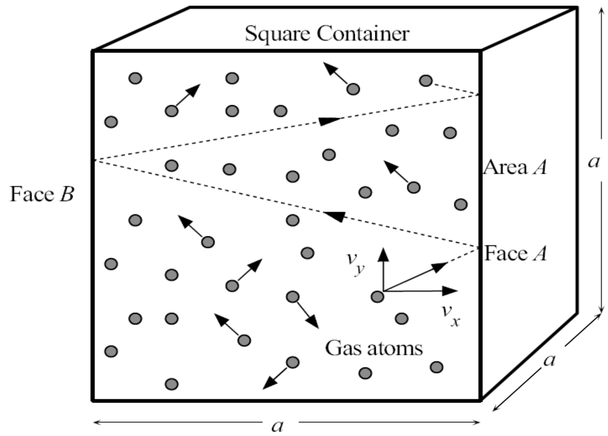
*** See Example 1.4 in Kasap

1.4.1 Mean Kinetic Energy and Temperature



Derivation for Exam #1

a) By considering a gas in a cubic container, derive an expression that relates the pressure (*P*), volume (*V*), and number of molecules (*N*) to the average kinetic energy per molecule ($\frac{1}{2}m\overline{v^2}$).



Derivation for Exam #1

b) By comparing the expression above to the empirical gas equation $PV = \frac{N}{N_A}RT$

obtain a relationship between the average kinetic energy per molecule and temperature (*T*).

$$PV = \left(\frac{N}{N_A}\right)RT$$

N = number of molecules,
R = gas constant,
T = temperature,
P = gas pressure,
V = volume,
N_A = Avogadro's number

$$PV = \frac{2}{3}N\left(\frac{1}{2}m\overline{v^2}\right)$$

P = gas pressure
$\overline{v^2}$ = mean square velocity

N = number of gas molecules
m = mass of the gas molecules

$$\overline{KE} = \frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$$

$k = R/N_A$ = Boltzmann constant

What is the mean translational kinetic energy of a single ideal gas molecule at room temperature (T = 293 K)?

A) 293 eV
B) 6.07 eV
C) 0.038 eV
D) 0.0127 eV

$$\overline{KE} = \frac{3}{2}kT$$

**Note that k = 1.38 x 10^{-23} J/K

What is the mean translational kinetic energy of a single ideal gas molecule at room temperature (T = 293 K)?

A) 293 eV

B) 6.07 eV

C) 0.038 eV ≈ 1/25 eV

D) 0.0127 eV

$$\overline{KE} = \frac{3}{2}kT$$