

Thermal Physics

Temperature - measure of the avg. kinetic energy of a substance's molecules.

heat - thermal energy that is in transfer from 1 substance to another. (Substances don't contain heat!)

Thermal Energy - the potential and kinetic energy of molecules that result in a substance's temperature. (includes mass)

Temp. Scales

$$^{\circ}\text{F} = \frac{9}{5}^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = \frac{5}{9} (^{\circ}\text{F} - 32)$$

Absolute temp. scale

Kelvins (K)

H_2O freezes at 273.15 K

0 K = lowest theoretically possible temp.

$$\text{K} = ^{\circ}\text{C} + 273.15$$

Physical Changes due to Heat

1. Substance can change temp.
2. Substance can undergo phase change

• Calorimetry: Heat & Temp. Change

Q = thermal energy

$$Q = m \cdot c \cdot \Delta T$$

c = specific heat

$+Q$ = heat came in to substance

m = mass

$-Q$ = heat left substance

Heat & Phase Change

- During phase change temp. does not change. The energy instead goes to intermolecular bond interactions.

$Q = mc\Delta T$ does not apply during phase change

$$Q = mL$$

L = latent heat of transformation

Solid to liquid = latent heat of fusion

liquid to gas = latent heat of vaporization

We can relate $PV = N K_{avg}$. Since $T = K_{avg}$.

• this shows that kinetic energy will indirectly affect pressure and volume.

Derived \rightarrow
$$K_{avg.} = \frac{3}{2} k_B T$$

Average kinetic energy of a gas

$$K_{avg} = \frac{1}{2} \mu v_{avg}^2$$

μ = mass of each molecule

$$\frac{1}{2} \mu v_{avg}^2 = \frac{3}{2} k_B T$$

$$\sqrt{v_{avg}^2} = \sqrt{\frac{3 k_B T}{\mu}}$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$k_B = \frac{R}{N_A}$$

$$\mu N_A = M \text{ (molar mass)}$$

$$\sqrt{v_{avg}^2} = \text{root-mean-square speed (} v_{rms} \text{)}$$

★ v_{rms} just means that the molecules of a gas are all going at different speeds. This is a type of average speed.

Thermal Expansion

• Depends on the substance.

- Change in Length

$$l_f - l_i = \alpha L_i (T_f - T_i)$$

α = coefficient of linear expansion

$$\boxed{\Delta l = \alpha l_0 \Delta T} \text{ linear expansion}$$

- Change in Volume

$$\boxed{\Delta V = \beta V_0 \Delta T} \text{ volumetric expansion}$$

β = coefficient of volume expansion

for solids $\beta = 3\alpha$

★ liquid water has a β

Heat Transfer

- Heat occurs only when there is a temperature difference between 2 objects.

rate of transfer is given by

$$H = \frac{Q}{t} \text{ or } \boxed{H = \frac{kA\Delta T}{L}}$$

k = thermal conductivity

A = cross-sectional area

L = thickness or distance between materials

Kinetic Theory of Gases

- Gases move around freely and rapidly
- A confined gas exerts force on walls of a container causing pressure.

$$P = \frac{F}{A}$$

• A lot of molecules in a gas $N = nN_A$

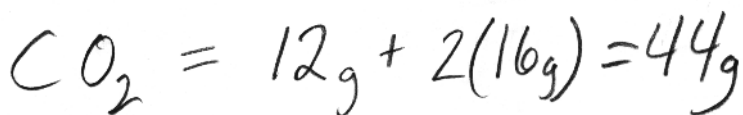
$N = \#$ of molecules

$n = \text{mole}$

$$N_A = \frac{N}{n}$$

$N_A = 6.022 \times 10^{23}$ molecules/mole
(Avogadro's constant)

1 mole of a given substance has a mass that can be found on the periodic table of elements.



Ideal Gas Law

$$PV = nRT$$

$n = \#$ of moles

$$R = 8.31 \text{ J/mol}\cdot\text{K}$$

(universal gas constant)

also written as

$$PV = Nk_B T$$

$N = \#$ of molecules

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

(Boltzmann constant)