Themal 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

$$°F = \frac{9}{5}°C + 32$$

$$°C = \frac{5}{9}(°F - 32)$$

Absolute temp. scale

Kelvins (K) H_2O freezes at 273.15 K

ØK = lowest theoretically possible temp.

$$K = °C + 273.15$$

Physical Changes due to Heat

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

• Calorimetry: Heat & Temp. Change

Q = thermal energy

$$\boxed{Q = m \cdot c \cdot \Delta T}$$

c = specific heat

m = mass

$+Q$ = heat came in to substance

$-Q$ = 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

$$\boxed{Q = mL}$$

L = latent heat of transformation

Solid to liquid = latent heat of fusion

liquid to gas = latent heat of vaporization

We can relate $PV = NK_{avg.}$ since $T = K_{avg.}$

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

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

Average kinetic energy of a gas

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

μ = mass of each molecule

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

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

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

$k_B = R/N_A$

$\mu N_A = M$ (molar mass)

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

★ 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

$$\ell_f - \ell_i = \alpha L_i (T_f - T_i)$$

α = coefficient of linear expansion

$$\boxed{\Delta \ell = \alpha \ell_0 \Delta T}$$ linear expansion

- Change in Volume

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

β = coefficient of Volume expansion

for solids $\beta = 3\alpha$

✱ liquid water has a $-\beta$

Heat Transfer

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

rate of transfer is given by $H = \frac{Q}{t}$ 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.

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

- Alot of molecules in a gas $N = nN_A$

N = # of molecules

n = 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.

$CO_2 = 12_g + 2(16_g) = 44_g$

Ideal Gas Law

$$PV = nRT$$

n = # of moles

$R = 8.31$ J/mol·K

(universal gas constant)

also written as

$$PV = Nk_BT$$

N = # of molecules

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

(Boltzmann constant)