

# Lecture 30 - Temperature and ideal gas laws

## Atomic Theory of Matter

A useful unit when discussing the mass of atoms is the atomic mass unit [ $u$ ]

Atoms and molecules are in continual motion, the amount of motion is prop

## Brownian motion, named

## Temperature Scales

To be able to measure temperature we need a scale. The temperature scale in common usage in the United States, [Fahrenheit](#), °F is based on what may now seem to be fairly arbitrary reference points.

To convert between Fahrenheit

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

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

If two objects with different temperatures are brought in to contact with one another thermal energy will flow from one to another until the temperatures are the same, and we then say that the objects are in thermal equilibrium.

The [zeroth law of thermodynamics](#) states that:

This law may seem obvious.

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Most, but not all, materi

$\alpha$  is the coefficient of linear expansion

The length of the object after its temperature has been changed by  $\Delta T$  is

A material expands in all directions, and if we are interested in the volume changes of a rectangular object, that is

$$\Delta V \equiv V - V_0 \equiv V_0(1 + \alpha \Delta T)^3 - V_0 \equiv V_0[3(\alpha \Delta T) + 3(\alpha \Delta T)^2 + (\alpha \Delta T)^3]$$

If  $\alpha\Delta T \gg 1$  then  $\beta \approx 3$

Coefficients of thermal expansion can be found [here](#) or your textbook.

Some material

Explains why the surface of lakes freezes, which helps prevent the water below from freezing, starting from the bottom.

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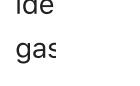
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cor	1780's <i>PV</i> Lussac has his own law..th it's not clear he should Charle Law states that at consta press the volum of a gas is propor to the tempe  	of constant mass, but we can see that the amount of mass should effect the volume (at a given pressure (at a given volume).  $PV$ $\propto mT$ Measurir the amount of mass in moles will allow us to write the ideal gas law in terms of a universal constant A mole of gas is a given number of molecule Avagadro number, $N_A$ $= 6.02$ $\times 10^{23}$ . If we have a certain mass $m$ of a gas which has a certain molecula mass (measure in atomic mass units, u, which are also the number of grams per mole.), the the number of moles $n$ is given by  $n$ $= \frac{r}{\text{molecu} \cdot \text{[g]} / \text{mol}}$	or molecu $N$ $PV$ $= nRJ$ $= \frac{N}{N_A} J$ $= NkJ$ where $k$ $= \frac{R}{N_A}$ $= 8.314$	most gases will liquefy before this point, but we can measu the pressu at a couple of referer points and extrapo down to zero pressu to get an estima for absolu zero.	mus be a large num of mole and they shou strikes the container wall gives the probabil $f(v)$ • The to one molecule is then given speed $v$ .  $F_{molecule}$ $= \frac{\Delta(mv)}{\Delta t}$ $= \frac{2mv_x}{2l/v_x}$ $= 4\pi$ $= \frac{m}{l}$ $(\frac{m}{2\pi kT})$  $F_{net}$ $= \frac{m}{l} \sum_i =$ $\frac{\sum_{i=1, N} v_{xi}^2}{N}$ $= v_x^2$ $+ v_y^2$ $+ v_z^2$ $\rightarrow$ $v^2$ $= \bar{v}_x^2$ $+ \bar{v}_y^2$ $+ \bar{v}_z^2$ $= 3\bar{v}_x^2$  $F_{net}$ $= \frac{m}{l} N \frac{\bar{v}^2}{3}$  $P$ $= \frac{F}{A}$ $= \frac{1}{3} \frac{Nm\bar{v}}{At}$ $= \frac{1}{3} \frac{Nm\bar{v}}{V}$  $PV$ $= \frac{2}{3} N$ $(\frac{1}{2} mv^2)$ $= NkT$  $KE$ $= \frac{1}{2} m\bar{v}^2$ $= \frac{3}{2} kT$	The plot below is for He atoms at various temperatu  	
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