PHYS 250B

Ch 18: Thermal Properties of Matter

States of Matter:

Thermodynamic characteristics of a substance

<u>Physical</u>	<u>Compound</u>
mass	pressure
volume	temperature
energy	density
entropy	specific heat

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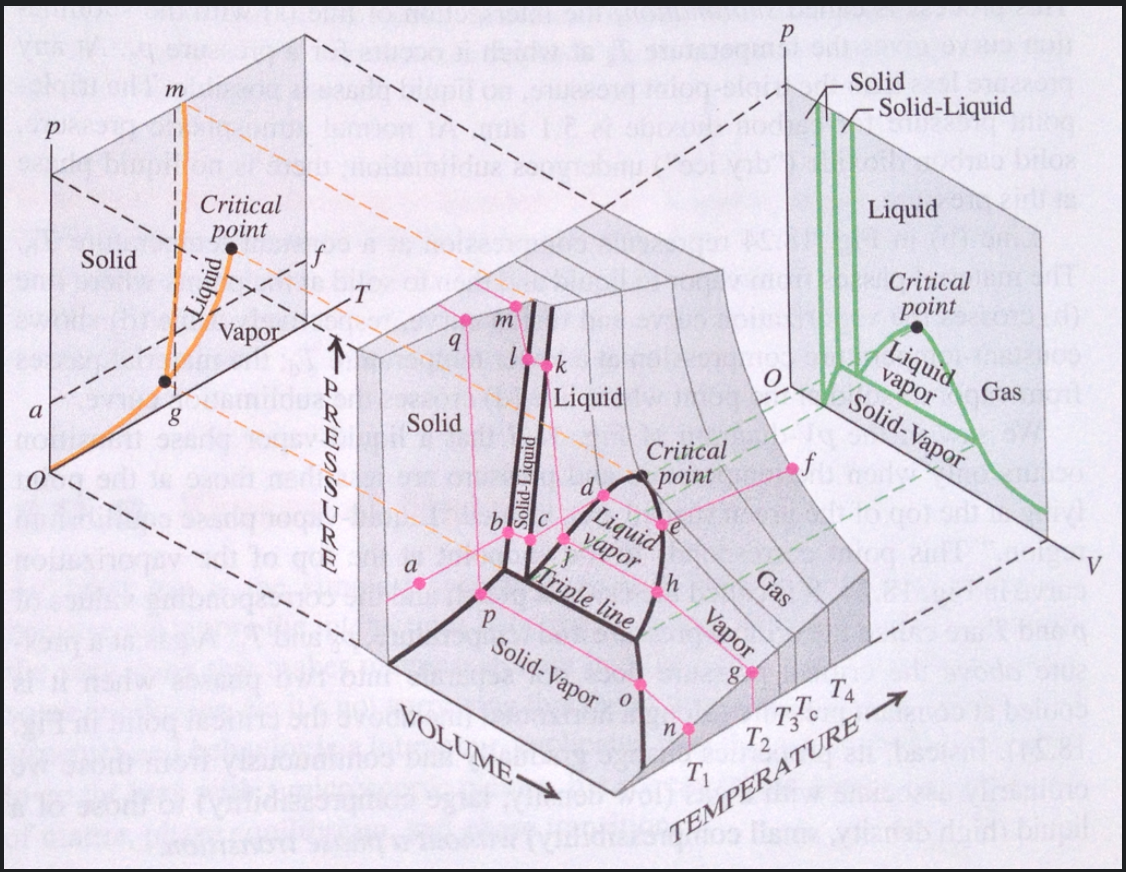
Phase and State Relationships



What is the relationship?

Thermodynamic state variables determine the phase of the system and the particle.

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Units for thermodynamic states

Corresponding extensive and intensive thermodynamic properties

Extensive property	Symbol	SI units	Intensive property**	Symbol	SI units
Volume	**V**	m^3 or L*	Specific volume***	**v**	m^3/kg or L*/kg
Internal energy	**U**	J	Specific internal energy	**u**	J/kg
Entropy	**S**	J/K	Specific entropy	**s**	J/(kg·K)
Enthalpy	**H**	J	Specific enthalpy	**h**	J/kg
Gibbs free energy	**G**	J	Specific Gibbs free energy	**g**	J/kg
Heat capacity at constant volume	C_V	J/K	Specific heat capacity at constant volume	c_v	J/(kg·K)
Heat capacity at constant pressure	C_P	J/K	Specific heat capacity at constant pressure	c_P	J/(kg·K)

* L = liter, J = joule

** specific properties, expressed on a per mass basis

*** Specific volume is the reciprocal of density.

Formulas

$Q=mC\Delta T$

J,kg,K

$pV=nRT$

J,mol,K

$U=Q-W$

J

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Ideal Gases

- Very low force of attraction between particles
- High Temperatures
- Low Pressures

Ideal Gas Equation:

$pV=nRT \qquad R=8.314\ \text{J/mol}\cdot\text{K}$

What relationship is described by the equation?

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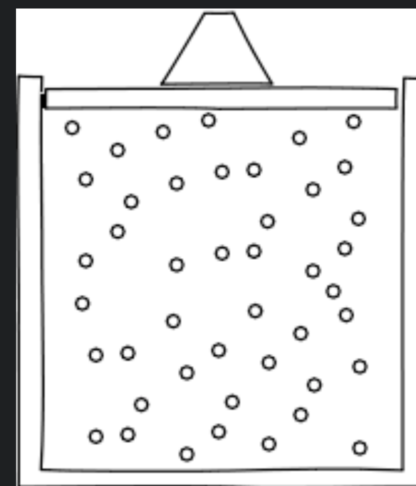
Kinetic Molecular Model:

The ***Temperature*** of an ideal is gas related to its ***Kinetic Energy***



http://www.pitt.edu/~jdnorton/Goodies/Einstein_stat_1905/kinetic%20

Entire System	Single Molecule
$K_{tr}={}^{3}/_{2}nRT$	${}^{1}/_{2}m(v^{2})_{av}={}^{3}/_{2}kT$

Temperature, Heat, & Kinetic Energy are <u>inter</u>dependent!

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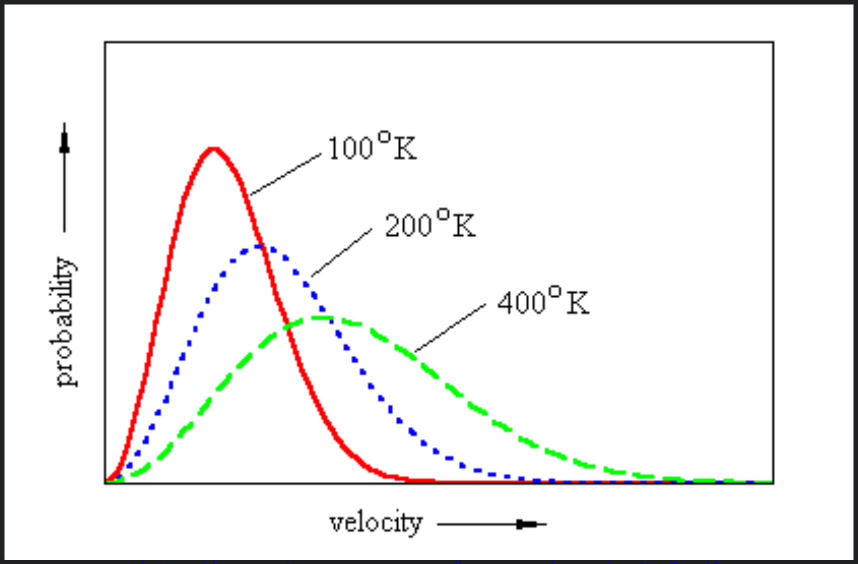
Molecular Speeds

$$f(v) = 4\pi \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-v^2 m/2kT}$$

$$\int_0^\infty f(v)\, dv = 1$$

If we account for all velocities, we should expect to account for all particles



http://www.tannerm.com/images/maxboltz2.gif

$$(v^2)_{av} = (v^2)_x + (v^2)_y + (v^2)_z$$

$$\tfrac{1}{3}(v^2)_{av} = (v^2)_x$$

Explains phase temperature relationship

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Heat Capacities

- Determined by the degrees of freedom
- Demonstrates the kinetic molecular model

$k = {}^R/N_A = 8.314$ J/mol·K ÷ 6.022×10^{23} molecules/mol
$k = 1.381 \times 10^{-23}$ J/molecule·K

$^1/_2 m(v^2)_{av} = \sum_1^n (^1/_2 kT)$ n=3 $pV=NkT$

$dK_{tr}={}^3/_2 nRdT$ $dQ=nC_v dT$ $C_v = {}^3/_2 R$

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Summary

- ★State variable
- ★State vs Phase
- ★Ideal Gas Equation
- ★Kinetic Molecular Model
- ★Molecular Speeds
- ★Heat Capacities

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Citation

Young, Hugh D., and Roger A. Freedman. University Physics with Modern Physics. 13th ed. Harlow: Addison-Wesley, 2011. Print.

"Intensive and Extensive Properties." Wikipedia. Wikimedia Foundation, 29 Aug. 2014. Web. 01 Sept. 2014.

Created by Alan Vitullo 2014