42-182 100 SHEETS Made in U.S.A. National Brand

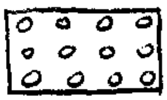
THERMAL PROPERTIES OF MATTER

I. PHASES OF MATTER

(A) SOLIDS, LIQUIDS AND GASES

SOLIDS

- CRYSTAL STRUCTURE

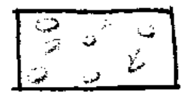


  - Rigid, Regular order of atoms
  - Tightly-bound – don't "flow"
  - Small volume change with P & T
  - e.g., Block of Fe
- amorphous Structure
  - Irregular order
  - don't "flow"

LIQUIDS

- "Flow" - not rigid
- Larger change in V with P & T.

GASES



- Take "shape" of container
- atoms/Molecules move-around freely (randomly)
- large V change with P & T.

(B) "Common Bond"

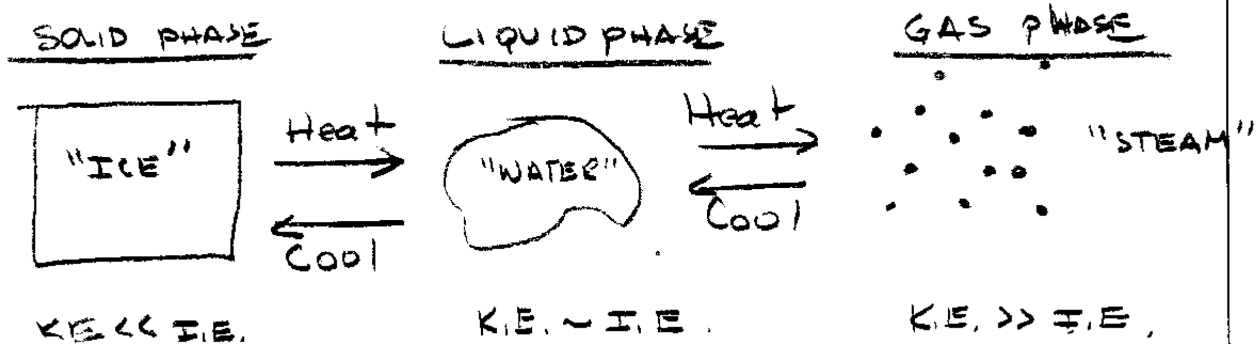
- Relationship between each can be qualitatively understood with one principle: (Kinetic Energy) vs. (Interaction Energy)

SOLIDS	LIQUIDS	GASES
K.E. << I.E.	K.E. ~ I.E.	K.E. >> I.E.

THERMAL PROPERTIES OF MATTER

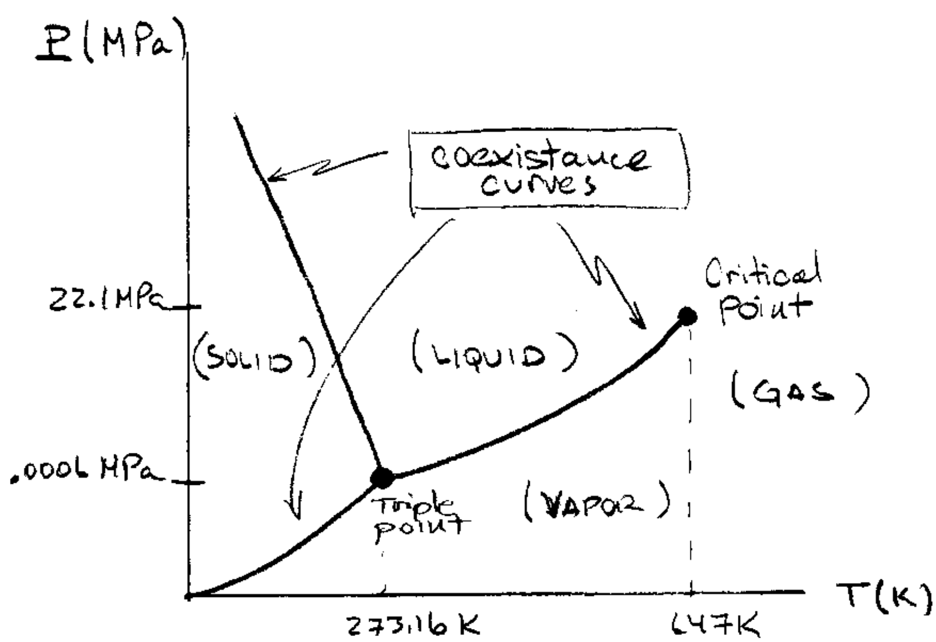
(C) PHASE TRANSITIONS

Example : H_2O



(D) Phase Diagrams

Example : H_2O



- Condensation
- Sublimation

THERMAL PROPERTIES OF MATTER

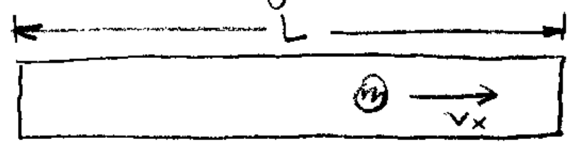
II. KINETIC THEORY (Boltzmann/Maxwell, 19th cy.)

(A) Democritus "atomists" (ca 300 B.C.)

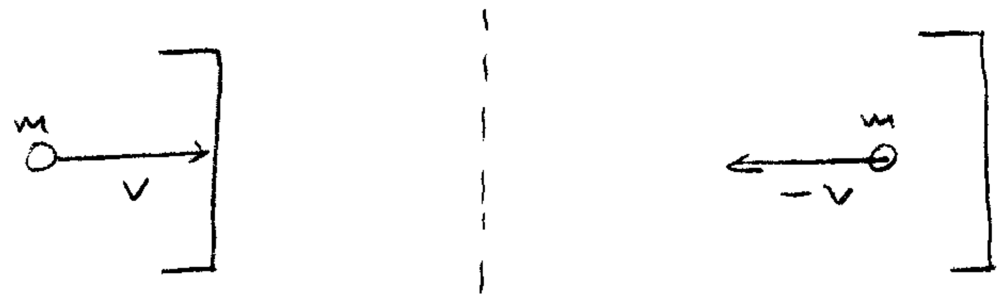
Thompson/Rutherford (ca. 1900)

Boltzmann/Maxwell (ca, 1850's)

(B) "1-dimensional gas"



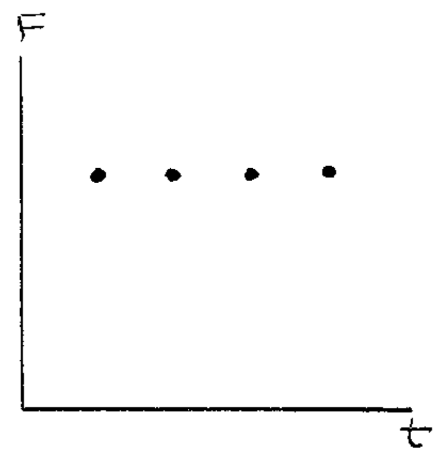
$$\Delta t = 2L/v_x$$



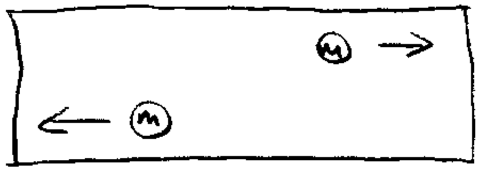
$p_1 = mv_1$ $\qquad$ $p_2 = mv_2$

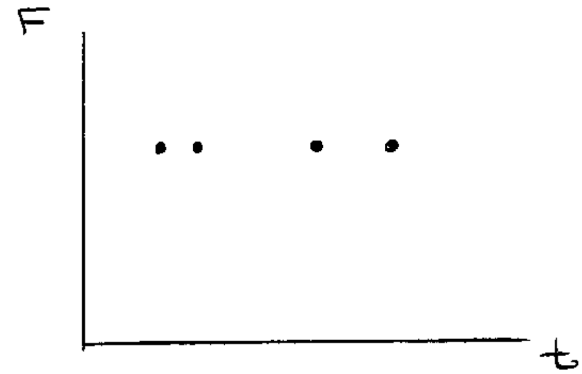
$$\Delta p = p_2 - p_1$$
$$= m(v_2 - v_1)$$
$$\Delta p = 2mv$$

$$F = \frac{\Delta p}{\Delta t} = \frac{2mv}{(2L/v)} = \frac{mv_x^2}{L}$$

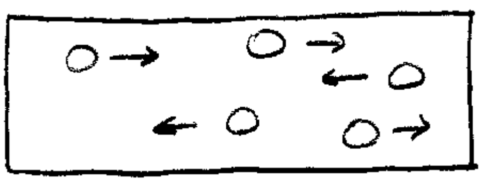


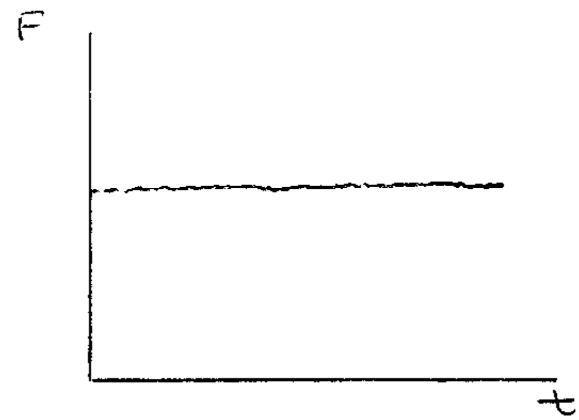
THERMAL PROPERTIES OF MATTER





$$\langle F \rangle = \frac{Nm\langle v_x^2 \rangle}{L}$$

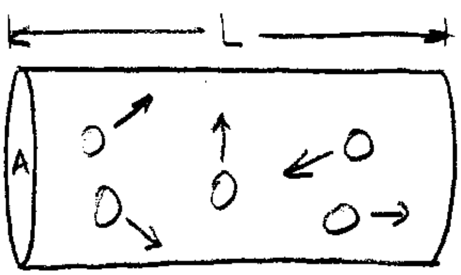




$$\langle F \rangle = \frac{Nm\langle v_x^2 \rangle}{L}$$

$\langle P_M \rangle \leftarrow$ "microscopic pressure"

$$\langle P_M \rangle = \frac{\langle F \rangle}{A} = \frac{Nm\langle v_x^2 \rangle}{LA}$$



$$\langle P_M \rangle = \frac{Nm\langle v^2 \rangle}{LA}$$

but $\langle v^2 \rangle = \langle v_x^2 + v_y^2 + v_z^2 \rangle \Rightarrow \langle v_x^2 \rangle = \frac{1}{3}\langle v^2 \rangle$

$$\langle P_M \rangle = \frac{Nm\langle v^2 \rangle}{3LA} = \frac{Nm\langle v^2 \rangle}{3V}$$

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THERMAL PROPERTIES OF MATTER

$$\langle P_M \rangle V = \frac{1}{3} N m \langle v^2 \rangle$$

Recall that

$$K.E. = \frac{1}{2} m v^2$$

So

$$\langle K.E. \rangle = \frac{1}{2} m \langle v^2 \rangle$$

$$\Rightarrow m \langle v^2 \rangle = 2 \langle K.E. \rangle$$

$$\langle P_M \rangle V = \frac{2}{3} \langle K.E. \rangle$$

From Ideal Gas Law –

$$PV = N k_B T$$

Postulate that

$$P = \langle P_M \rangle$$

$$\Rightarrow PV = \langle P_M \rangle V$$

$$N k_B T = \frac{2}{3} N \langle K.E. \rangle$$

$$T = \frac{2}{3} \frac{\langle K.E. \rangle}{k_B}$$

A Microscopic Definition of Temperature!

$$\langle KE \rangle = \frac{3}{2} k_B T = \frac{1}{2} m \langle v^2 \rangle$$

$$\Rightarrow \langle v^2 \rangle = \frac{3 k_B T}{m}$$

$$V_{rms} \equiv \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3 k_B T}{m}}$$

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