

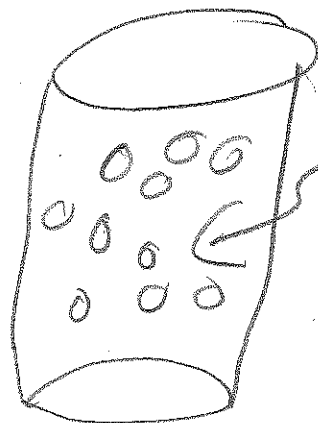
2A

11-20-13

CH14, CH15 = Lab on FRIDAY
11-22-13

CH15

N GAS molecules



GAS molecules in a container

$$n = \# \text{ of moles} = \frac{N}{N_A}$$

$$N_A = 6.02 \times 10^{23} \text{ mole}^{-1}$$

$$M = \text{molar mass} = N_A \cdot m$$

↑
MASS of a
single molecule.

$$= \left(\frac{\text{kg}}{\text{mol}} \right)$$

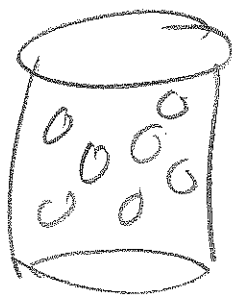
see 15.2

Ideal gas LAW

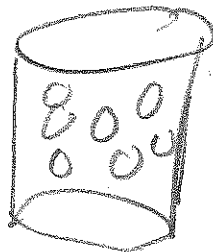
- (1) dilute gas
- (2) NO molecular interactions

$$P \cdot V = n R T; \quad V = \text{VOLUME}$$

$$R = 8.31 \frac{\text{J}}{\text{mol} \cdot \text{K}}; \quad T = \text{TEMPERATURE (K)}$$



V_1, T_1, n



V_2



← increase volume to V_2 from V_1

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = n \cdot R$$

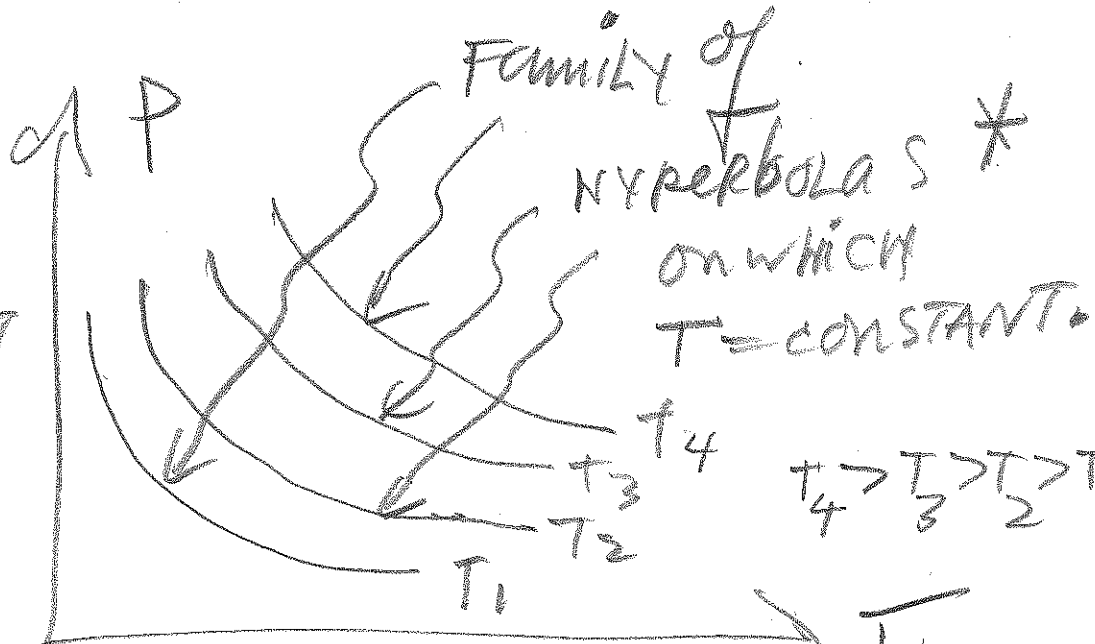
$n = \text{CONSTANT}$
(no LEAKS)

PV - diagrams

$$P = \frac{nRT}{V}$$

$T = \text{CONSTANT}$

IS.5

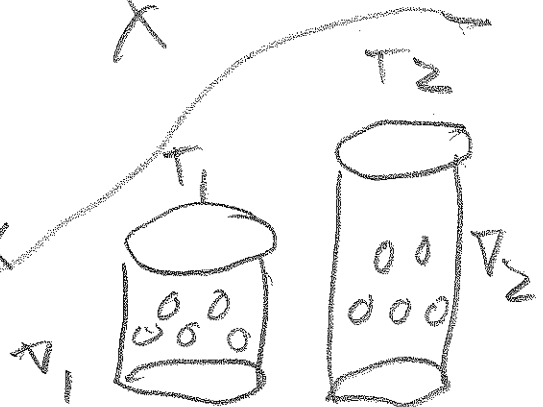


NOTE: $T = \text{CONSTANT} \Rightarrow$

KE OF MOLECULES
= CONSTANT

HYPERBOLA
REVIEW

$$y = \frac{1}{x}$$



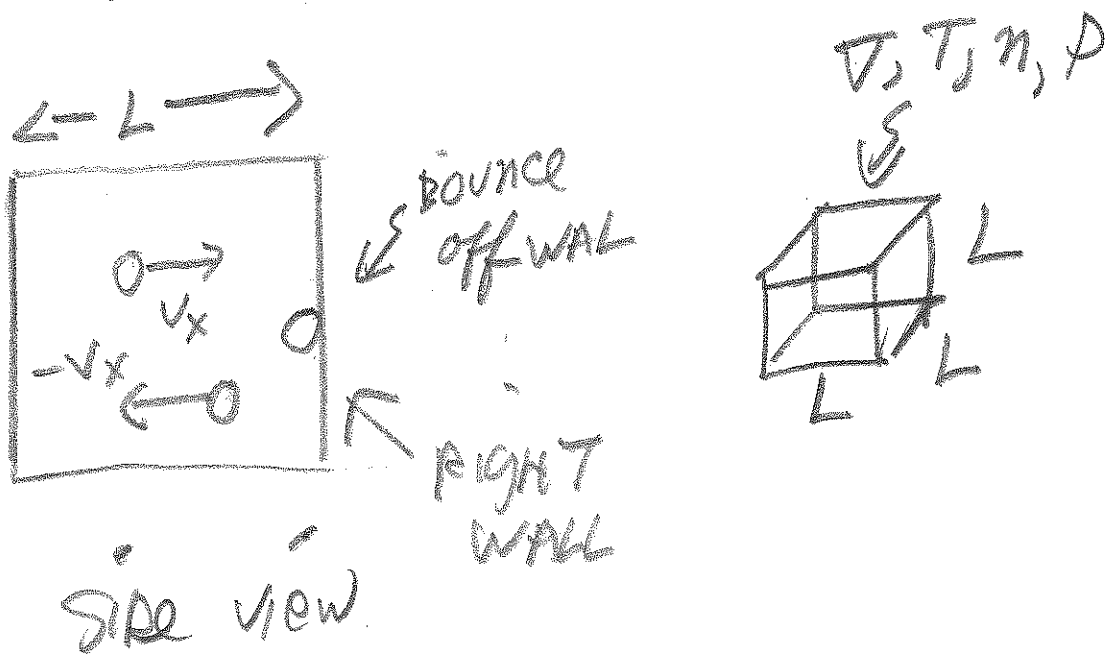
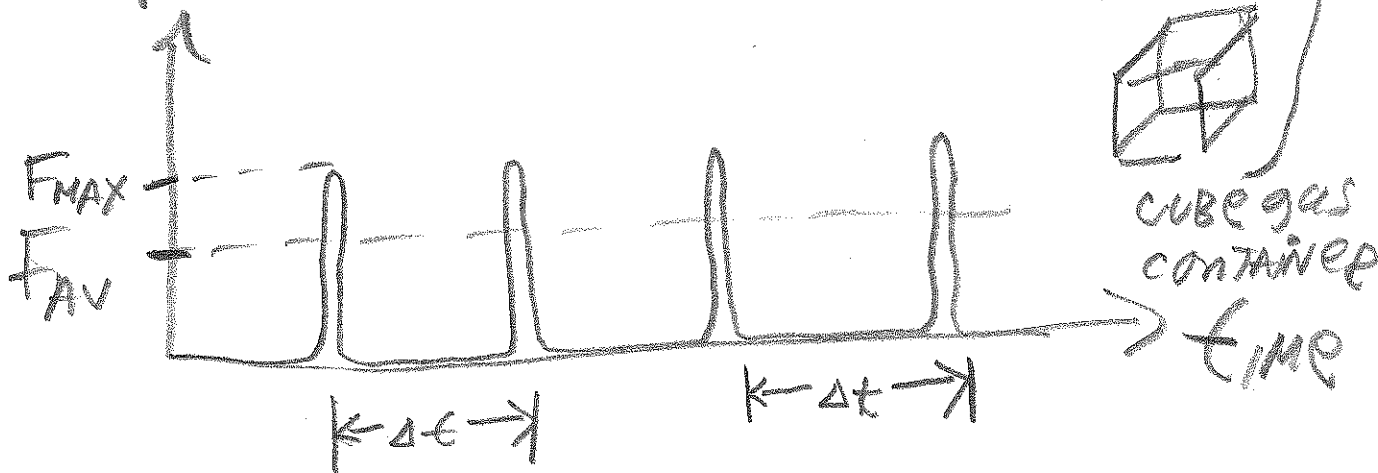
SAME # of
molecules hitting
WALL with SAME
force over a LARGER AREA: P DROPS

$$\left. \begin{array}{l} V_2 > V_1 \\ T_2 = T_1 \end{array} \right\} P_2 < P_1$$

Kinetic THEORY of GASSES

see 15.3

F on RIGHT WALL = $\Delta \epsilon = \frac{2L}{v_x}$



time between collisions @ RIGHT WALL is $\boxed{\frac{2L}{v_x}}$

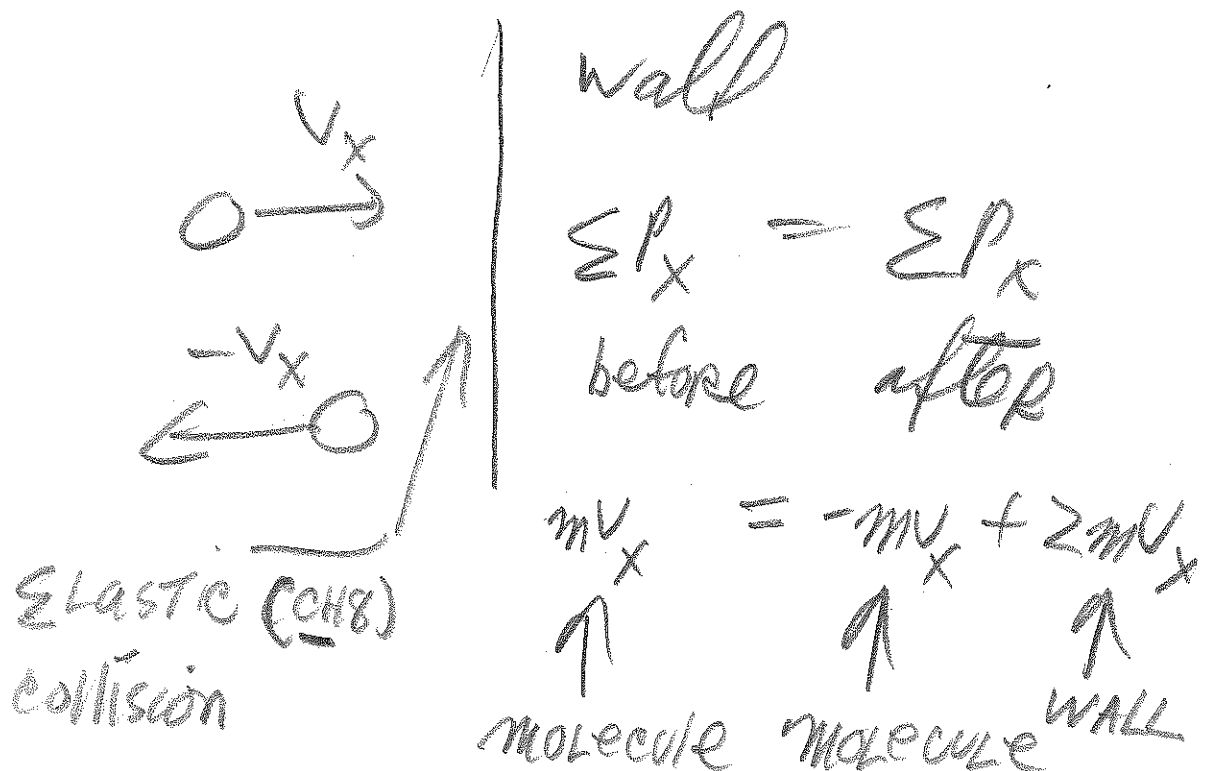
↙ ON WALL

$$F_{AV} = \frac{n \cdot 2m v_x}{n \cdot \Delta t}$$

↓

AVERAGE OVER n COLLISIONS

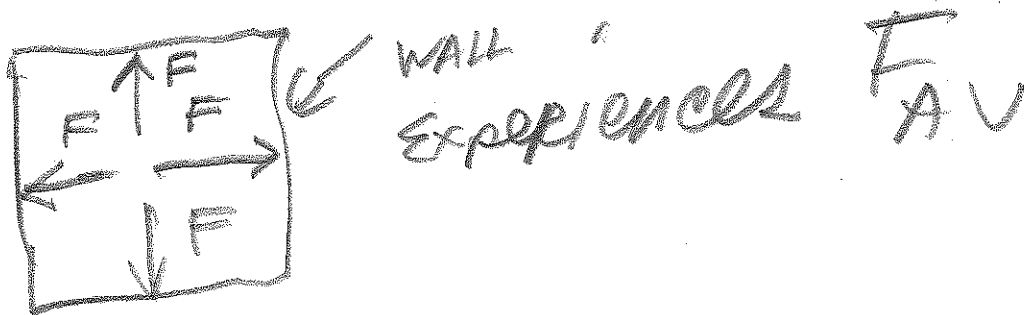
NOTE: $2m v_x =$ momentum
 TRANSFERRED TO WALL @
each collision.



$$F_{AV} = \frac{2mV_x}{\Delta t} \quad \overset{\text{CRS}}{=} \frac{\Delta p}{\Delta t}$$

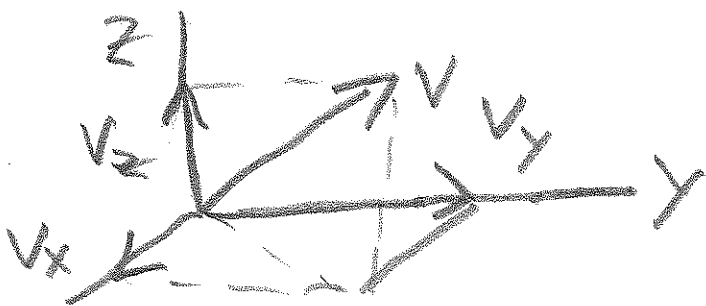
$$= \frac{2mV_x}{\frac{2L}{V_x}} \quad (F = \frac{\Delta p}{\Delta t})$$

$$= \frac{mV_x^2}{L}$$



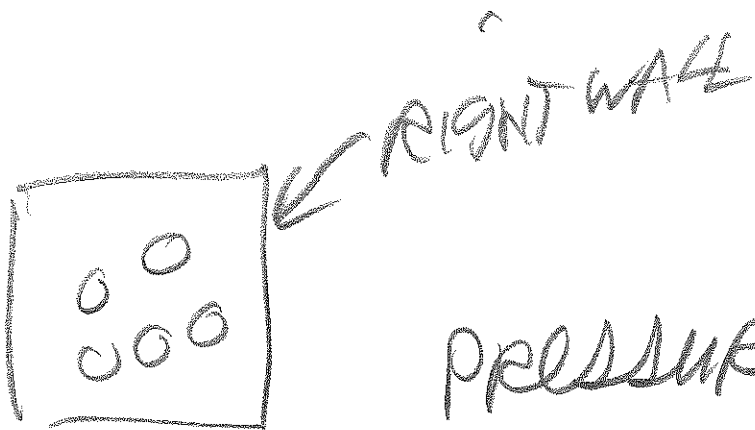
N molecules:

$$F = N \cdot F_{AV} = \frac{NmV_x^2}{L}$$



$$v^2 = v_x^2 + v_y^2 + v_z^2$$

PYTHAGOREAN
(300 B.C) PYTHAGORUS



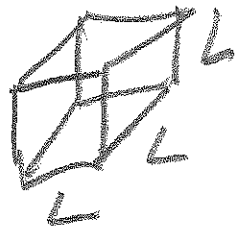
PRESSURE IN

$$WALL = \frac{F}{Area} = P$$

$$area = L^2$$

$$P = \frac{Nm v_x^2}{L^2} = \frac{Nm v_x^2}{L^3}$$

$$P = \frac{Nm v_x^2}{V}$$



$$P \cdot V = Nm v_x^2$$

$$P \cdot V = N \cdot m \overline{v_x^2}$$

$$v^2 = v_x^2 + v_y^2 + v_z^2$$

TAKE AVERAGE OF THIS

$$\overline{v^2} = \overline{v_x^2} + \overline{v_y^2} + \overline{v_z^2}$$

Since space is isotropic

$$\overline{v_x^2} = \overline{v_y^2} = \overline{v_z^2}$$

$$\Rightarrow \frac{\overline{v^2}}{3} = \overline{v_x^2} = \overline{v_y^2} = \overline{v_z^2}$$

$$\Rightarrow P \cdot V = N \cdot m \frac{\overline{v^2}}{3}$$

$$P \cdot V = N \cdot m \frac{\overline{V^2}}{3}$$

$$P \cdot V = N \cdot \frac{2}{3} \cdot \left(\frac{1}{2} m \overline{V^2} \right)$$

(Boyle)

ALSO KNOW?

MAXWELL-
BOLTZMAN

$$PV = n \cdot RT \quad (\text{Boyle})$$

$$nRT = N \cdot \frac{2}{3} \cdot \left(\frac{1}{2} m \overline{V^2} \right)$$

$$nRT = N \cdot \frac{2}{3} \cdot \overline{KE}$$

$$T \propto \overline{KE}$$

Temperature \propto AVERAGE
KINETIC
ENERGY

$$\frac{3}{2} n R T = N \cdot \overline{KE}$$

$$\overline{KE} = \frac{3}{2} \frac{n}{N} \cdot R \cdot T$$

$$\overline{KE} = \frac{3}{2} \frac{n}{N_A \cdot n} \cdot R T$$

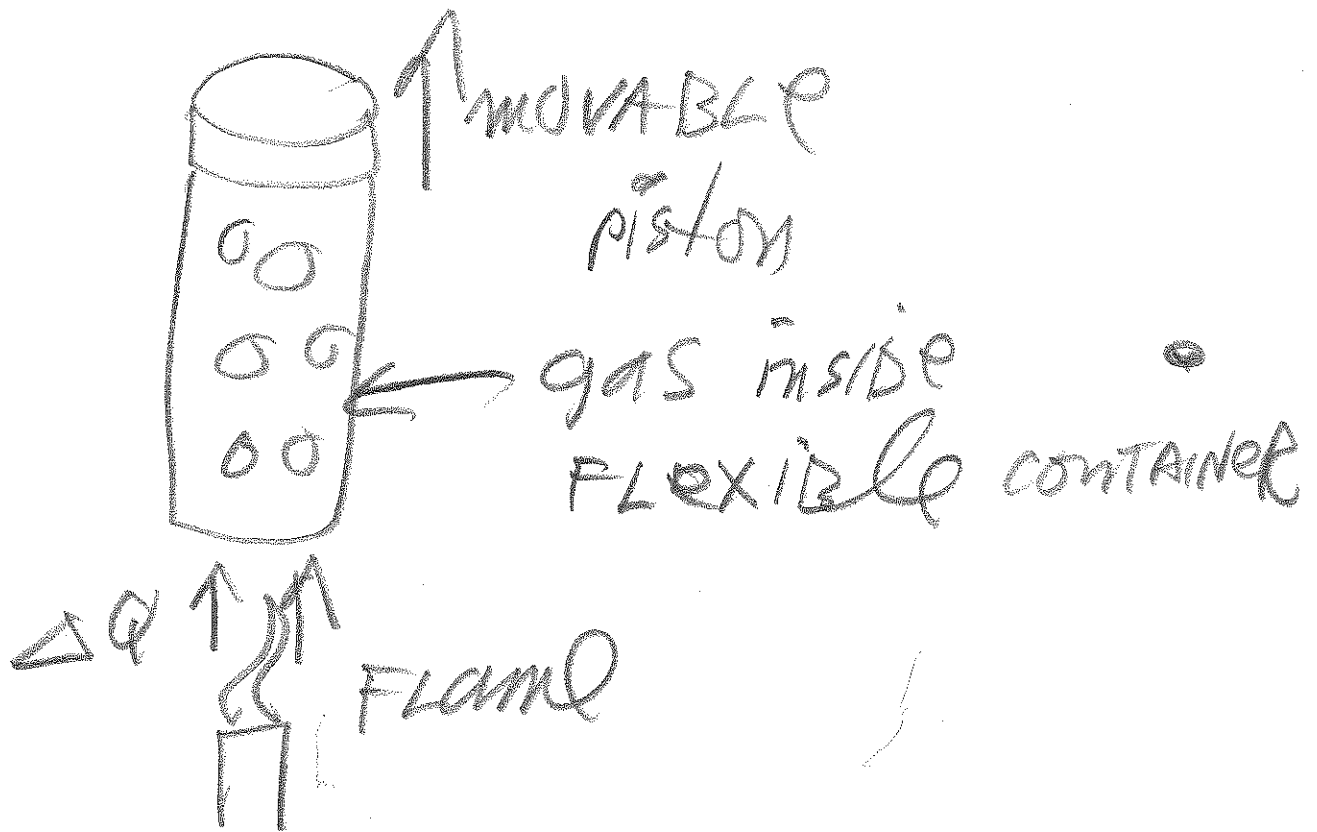
$$N = N_A \cdot n$$

$$\overline{KE} = \frac{3}{2} \frac{R}{N_A} \cdot T$$

$$\overline{KE} = \frac{3}{2} k T \Rightarrow T \propto \overline{KE}$$

$k =$ Boltzmann's constant
 $= 1.23 \times 10^{-38} \frac{\text{J}}{\text{K}}$ (Chem 1A)
(Chem 1B)

1st LAW OF THERMODYNAMICS
see 15.5



$$\Delta Q = \Delta U + W$$

W = WORK ON PISTON by gas

ΔU = CHANGE IN INTERNAL ENERGY of gas.

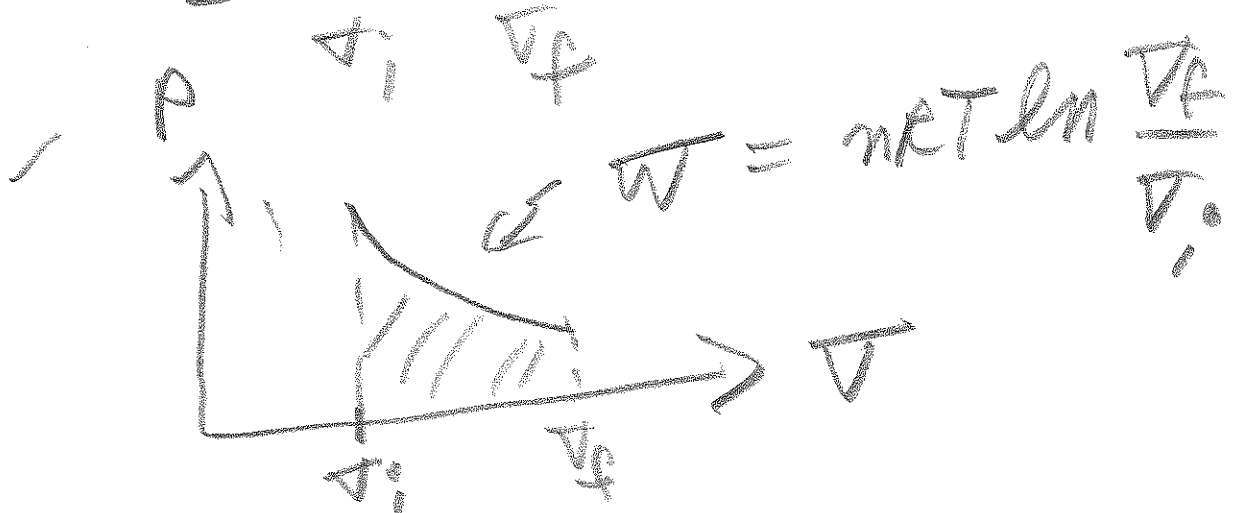
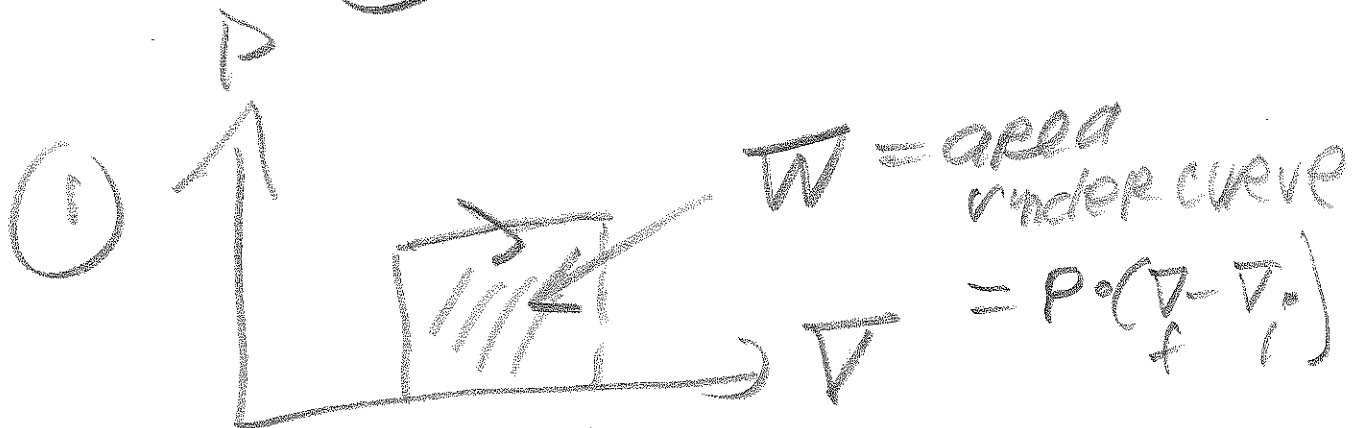
AFTER BREAK

3 OR 4 SPECIAL CURVES

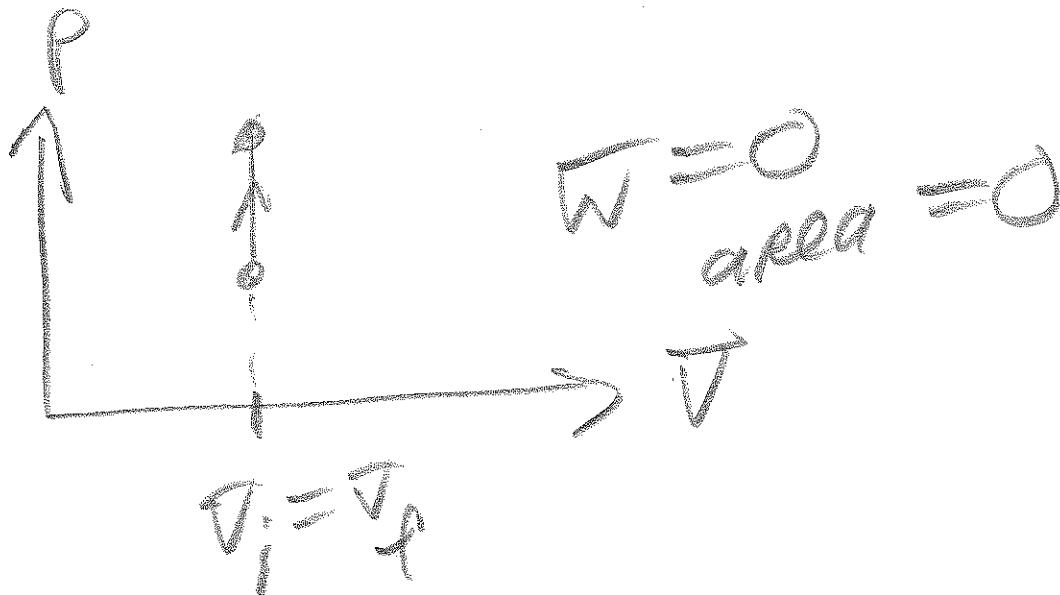
(1) Iso baric ($P = \text{const.}$)

(2) Isothermal ($T = \text{const.}$)

(3) Iso volume ($V = \text{const.}$)

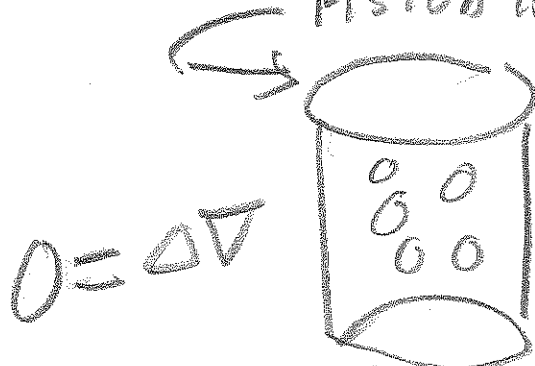


(3)



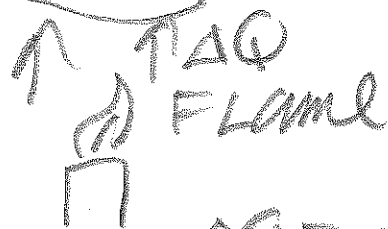
Before entering sec. 15.6 we
 BACK TRACK TO sec 15.4.

PISTON IS FIXED



$$\Delta Q = nC_v \cdot \Delta T$$

$C_v =$ SPECIFIC
 HEAT @
 CONST. VOLUME



$$\Delta Q = \Delta U \Rightarrow \Delta U = nC_v \Delta T$$

$$\Delta Q = \Delta Q + W \rightarrow \Delta Q = \Delta U$$

$c_v =$ specific heat @ constant volume

$$\Delta U = n c_v \Delta T$$

change in internal energy.

Ideal monoatomic gas.

$$N \cdot \overline{KE} = N \cdot \frac{3}{2} kT$$

NOTE: $R = k \cdot N_A$ (conversion)

$$N \overline{KE} = n \cdot N_A \cdot \frac{3}{2} kT$$

$$N \overline{KE} = \frac{3}{2} nRT$$

SINCE $N_A \cdot k = R$

OR $k = \frac{R}{N_A}$

THUS

$$\Delta U = n C_V \Delta T$$

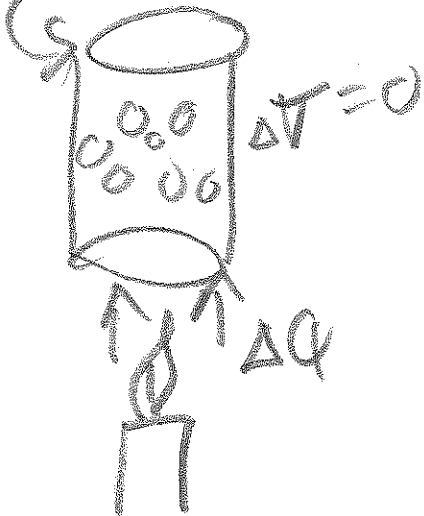
and

$$\Delta U = \frac{3}{2} n R \Delta T$$

implies

$$n C_V \Delta T = \frac{3}{2} n R \Delta T$$

piston fixed



$$C_V = \frac{3}{2} R$$

ideal monoatomic
gas.

$$\Delta Q = n C_V \Delta T$$

$$C_V = \frac{3}{2} R$$

pressure meter

OBJECTIVE---To measure pressure as a function of temperature and to extrapolate to absolute zero.

REFERENCE---CH. 14. See LECTURE NOTES 11-18-13. **Check out the T intercept !**

What do you see ? Why do the lines converge there ?

COMPUTATIONS---You should be able to find the slope and the x or y intercept of a line from two data points. You should also be able to make a simple chart in Excel.

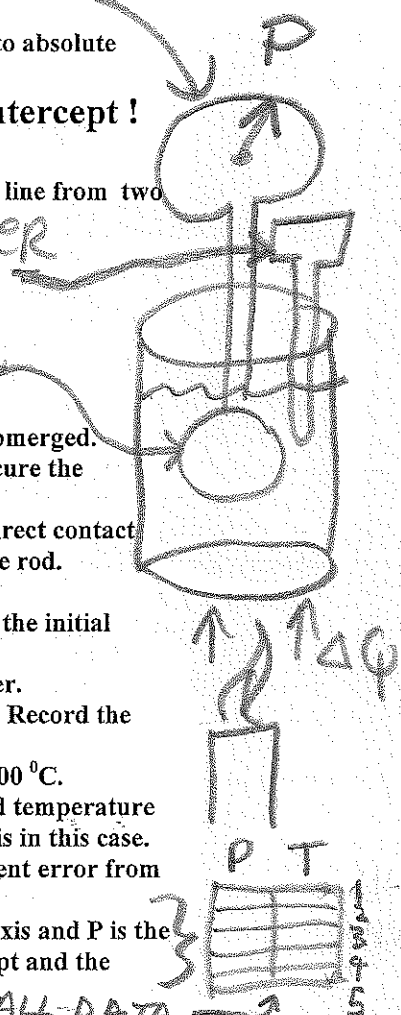
EQUIPMENT:

- Bucket
- Pressure gauge
- Thermometer *
- Electric range *

- Table clamp
- Long and short rod
- Rod clamps

* THERMOMETER

BULB of gas



PROCEDURE: Fill the bucket with water so that the bulb of the pressure gauge can be completely submerged.

1. Place the bucket on the electric range and submerge the bulb under the water; secure the pressure gauge with rods and clamps as in the demonstration set-up.
2. Submerge the thermometer probe under the water. The probe should not be in direct contact with the bottom of the bucket. You may have to tape the thermometer to the gauge rod.
3. Measure the temperature.
4. Measure the pressure. Note that the pressure may be offset from the true value at the initial temperature of the water.
5. Turn on the electric range to high. Observe the rise in the temperature of the water.
6. Record the pressure at the intermediate points of about 40 °C, 60 °C, and 80 °C. Record the exact values of the pressure and temperature.
7. Record the pressure at the maximum water temperature which should be about 100 °C.
8. Calculate the slope and **T-intercept** of the line P vs. T from the **initial** pressure and temperature and the **final** pressure and temperature. Note that P is the y-axis and T is the x-axis in this case. See figure 19.4 in the textbook. Calculate the T intercept in kelvin. Find the percent error from the theoretical value.
9. Plot the best-fit line of **T vs. P** in Excel using the data points. Note that T is the y-axis and P is the x-axis in this case. (Be careful!) Calculate the percent error between the T-intercept and the theoretical value.

T = VERTICAL AXIS
~ 210°C

T-intercept $P \approx -273^\circ\text{C}$ ALL-DATA

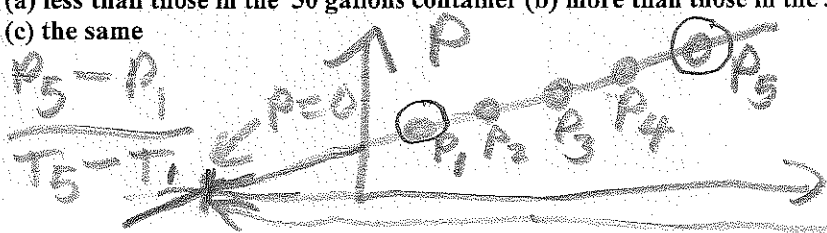
T ₁ =	TAP WATER FAUCET	P ₁ =	14.7 PSI ← IF CALIBRATED
T ₂ =	40°C	P ₂ =	P ₂
T ₃ =	60°C	P ₃ =	P ₃
T ₄ =	80°C	P ₄ =	P ₄
T ₅ =	100°C (BOILING)	P ₅ =	P ₅

**

Questions (0.5 points each.) Short answers.

1. What would happen to the kinetic energy of the molecules of a gas if its temperature could reach 0 K?
2. What is the lowest achieved temperature in Kelvin ?
3. Compute the product of the numerical answer to the last question and the temperature of the interior of the sun? (i.e. What answer do you get when you multiply them together?)
4. What happens at the triple point of water ?
5. What is the approximate value of the triple point temperature in °C to the nearest hundredth place?
6. What is the letter of the correct answer? The temperature of 1 cup of water is 25 °C. The temperature of 30 gallons of water is 25 °C. The average kinetic energy of the molecules in the cup is (a) less than those in the 30 gallons container (b) more than those in the 30 gallon container (c) the same

(8)
m =



$0 - P_1 = m \cdot (T_1 - T_L)$
FIND $T_L \approx -273^\circ\text{C}$

Test 3

CH 10, 9, 8, 7

Embedded E.C.

Includes Scantron

ON MONDAY 30 MINUTE

IN CLASS EXAM ON

SUBSET OF THE TOTAL

Exam = written + Scantron

WED.
DEC 18
7-10
8-11
OR 9-NOON

FINAL EXAM

Embeds

Test 4*

CH

16

15

14

13 *

12 *

11 *

} NEWER
FINAL

} OLD M
FINAL
(SEE T4)

AFTER
BREAK

CH 11
12
13