April 21, 2010
Wednesday.

Chapter 17:

1 mol of O_2 (oxygen molecule) = (mass of) N_A-many O_2 molecules (two O atoms)

N_A = ~~Avogardo's~~ Avogadro's Number $= 6.022 \times 10^{23}$

atom of oxygen → O

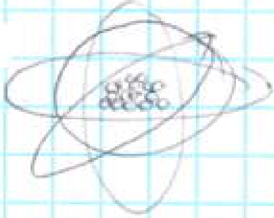
8 → 8 proton in an O atom

15.9994 → ≈ 16 means 8 protons & 8 neutrons in O

*(A small percentage of O atoms have, say, 7 neutrons)

Atomic mass

$2p^4$ → describes how 8 electrons "orbits" the protons and neutrons of O



(15.9994×2) g = 1 mol of O_2

$\frac{15.9994 \times 2 \text{ g}}{N_A}$ = mass of a single O_2 molecule

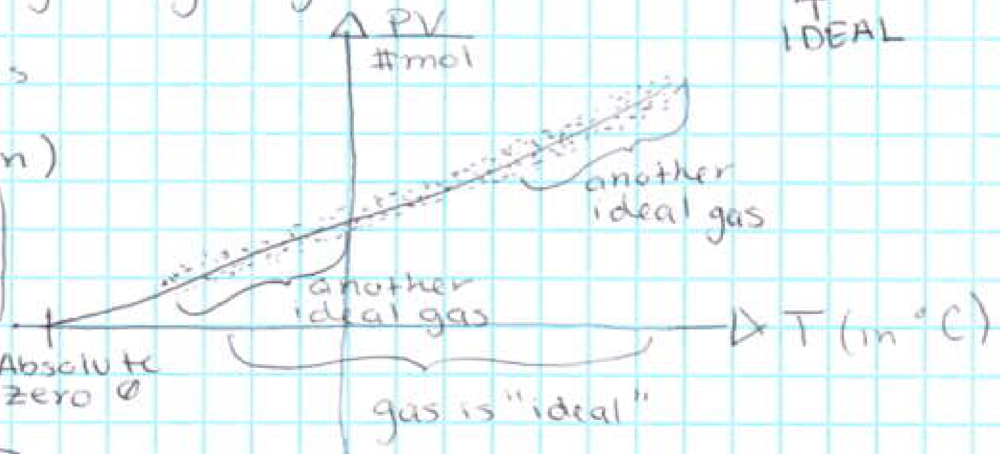
---

Take a gas, plot $\frac{\text{pressure} \times \text{volume}}{\# \text{mol}}$ vs. temperature

For "ideal" gases, you get a line.

(When the gas is no way near condensation)

SAME LINE FOR ALL GASES ← IDEAL



$y\,°C = (y + 273.15)\,K$

$x\,K = (x - 273.15)\,°C$

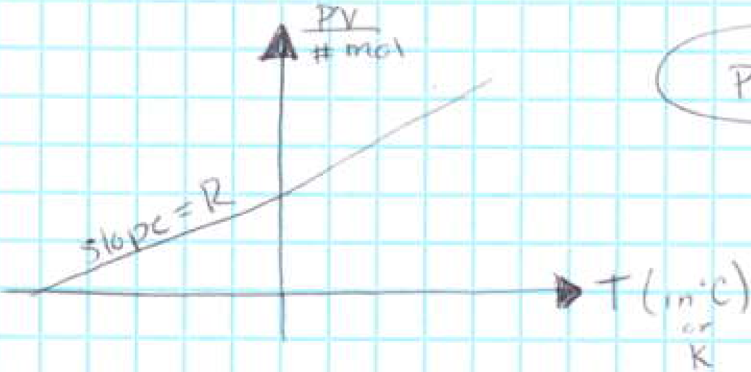
conversion between K & °C

Absolute Zero = 0 K (kelvin) $= -273.15°C$

$$\frac{\text{pressure} \times \text{volume}}{\#\text{ mol}} \Rightarrow \frac{PV}{n} = RT \leftarrow T \text{ is in K}$$

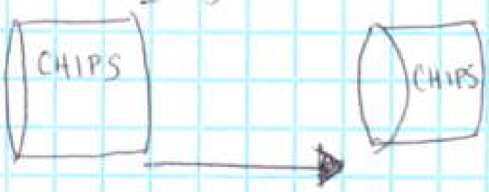
(R ↑ constant)

$PV = nRT$ — ideal gas law



ideal gas line

Ex. [Bag of CHIPS]

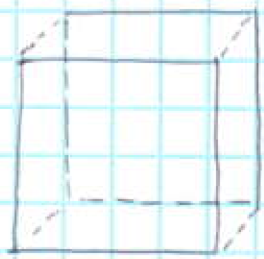


P decreases
V increases
n, T constant

Ex.

A container...

$$\beta = \frac{35 \times 10^{-6}}{1°C} = \frac{\Delta V}{V \Delta T}$$



...filled with gas.

T increases from ~~20 K~~ to ~~23 K~~ 20.00°C 23.00°C

n constant.

P was initially 1.000 atm

P.S. pg 460 [PHYS book]

coefficient of linear expansion
coefficient of volume expansion

What is P after the temperature increases?

→ Find $P + \Delta P$

Initially: $PV = nRT$ After: $(P+\Delta P)(V+\Delta V) = nR(T+\Delta T)$

$$\frac{(P+\Delta P)(V+\Delta V)}{PV} = \frac{nR(T+\Delta T)}{nRT}$$

$$\left(1+\frac{\Delta P}{P}\right)\left(1+\frac{\Delta V}{V}\right) = 1 + \frac{\Delta T}{T}$$

$$\left(1+\frac{\Delta P}{P}\right)(1+\beta\Delta T) = 1 + \frac{\Delta T}{T}$$

continued ⇒

Rewrite: $\left(\frac{P+\Delta P}{P}\right)(1+\beta\Delta T) = 1 + \frac{\Delta T}{T}$

$$P + \Delta P = P\,\frac{\left(1+\frac{\Delta T}{T}\right)}{(1+\beta\Delta T)}$$

Remember: (4 sig. fig.)

$P = 1$ atm (1.000)
$\Delta T = 3°C$ "=" 3 K intervals (3.000)
$T = 20°C = 20.000°C$ " $(273.15 + 20)$ K

β is very small, so often $\beta\Delta T$ is very small compared to 1, so often $1 \approx 1 + \beta\Delta T$.

What is P after the temperature increases?

$$P + \Delta P = 1.000 \text{ atm}\left(\frac{1.010234}{1.000105}\right)$$

$$P \cdot 1.01013 = 1.0101\,P = \boxed{1.010 \text{ atm}}$$

Same as what you ignore the expansion of the container ($\beta = 0$):

$P + \Delta P = 1.000$ atm $\times\ 1.01023$

$\boxed{1.010 \text{ atm}}$

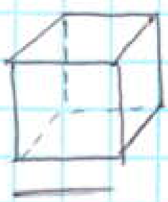
I don't know if I had to copy this...?

Binomial Theory:

$$\alpha = \frac{\Delta L}{L\Delta T} \qquad \beta = \frac{\Delta V}{V\Delta T}$$

$\beta = 3\alpha$ Why? 3D

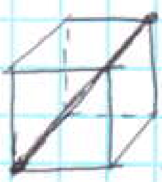
$V \propto L^3$

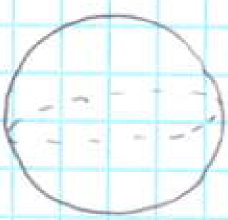


Cube

V = L

L





Sphere

$\frac{\pi L^3}{6}$

L

L

$V = \frac{L^3}{3\sqrt{3}}$

$\Delta V \propto \Delta(L^3)$

$$\Delta(L^3) = (L+\Delta L)^3 - L^3$$

$$\approx^{*} 3(\Delta L)L^2$$

Why?

$(1+a)^b \approx 1 + ab$ if $ab << 1$ ← small compared to 1

$$\frac{\Delta(L^3)}{L^3} = \left(1 + \frac{\Delta L}{L}\right)^3 - 1 \approx 1 + \frac{3\Delta L}{L} - 1 = 3\frac{\Delta L}{L}$$

(if $\frac{\Delta L}{L} << 1$)

$$\frac{\Delta(L^3)}{L^3} \overset{*}{\approx} 3\frac{\Delta L}{L} \Rightarrow \Delta(L^3) \approx 3(\Delta L)\,L^2$$

$$\left.\begin{array}{l} V = kL^3 \\ \Delta V = k\Delta(L^3) \end{array}\right\} \Rightarrow \frac{\Delta V}{V} = \frac{\Delta(L^2)}{L^3}$$

$$\frac{\Delta V}{V} \approx \frac{3(\Delta L)L^2}{L^3} = \frac{3\Delta L}{L}$$

Binomial Theory

$(1+a)^b \approx 1 + ab$ if $ab \ll 1$

$$\beta = \frac{\Delta V}{V\Delta T} \approx \frac{3\Delta L}{L\Delta T} = 3\alpha$$