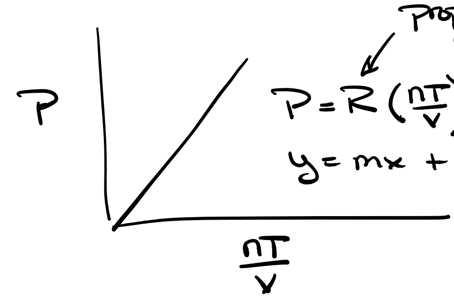
Chapter 8 gas Laws

$P \propto \frac{1}{V}$

$P \propto T$

$P \propto n$

$P \propto \frac{nT}{V}$



Proportionality Constant

$P = R\left(\frac{nT}{V}\right)$

$y = mx + b \mid b = 0$

$R = 0.0821 \frac{L\,atm}{mole \cdot K}$

Universal Gas Constant

$P = R\frac{nT}{V}$

$PV = nRT$ Ideal Gas Law

Typical problems

Given 3 varibles → Solve for 4th

($5^{th} = R$ = constant = alway $0.0821 \frac{L\,atm}{mole\,K}$)

units must be
P = atm
V = L
T = K
n = moles

Key Conversions

1 atm = 760 mmHg = 760 torr

°C + 273.15 = K

$mL \times \frac{1L}{1000\,mL}$

$g \xrightarrow{\text{molar mass}} mole$

Derivation

$PV = nRT$ solve for R

$$R = \frac{PV}{nT}$$

Two conditions

$$\frac{P_1V_1}{n_1T_1} = R \qquad \frac{P_2V_2}{n_2T_2} = R$$

$R = \not{c}$ constant

$$\boxed{\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}}$$

Combined Gas Law used for Changing Conditions

Also useful for finding
- Charle's Law
- Boyle's Law
- Avagadro's Law

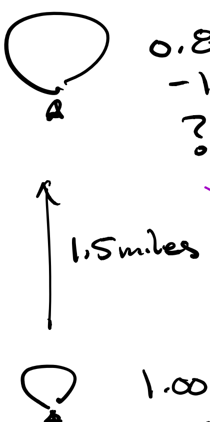
$$P_1V_1 = P_2V_2$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{P_1}{n_1} = \frac{P_2}{n_2}$$

Ex

A weather balloon is filled to a volume of 250. L at 1.00 atm and 25°C. The balloon is released and reaches an altitude of 1.5 miles where the pressure is now 0.852 atm and the temperature is -16°C. What is the new volume of the balloon.



0.852 atm = P_2
-16 °C = T_2
? L = V_2
~~? = n_2~~

1.00 atm = P_1
25 °C = T_1
250. L = V_1
~~? = n_1~~

$n_1 = n_2$

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

$$\cancel{n_1} \times \frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2V_2}{\cancel{n_1}T_2} \times \cancel{n_1}$$

$$\frac{T_2}{P_2} \times \frac{P_1V_1}{T_1} = \frac{\cancel{P_2}V_2}{\cancel{T_2}} \times \frac{\cancel{T_2}}{\cancel{P_2}}$$

$$V_2 = \frac{\overset{\cancel{K}}{T_2}\,\overset{\cancel{atm}}{P_1}\,\overset{L}{V_1}}{\underset{\cancel{K}}{T_1}\,\underset{\cancel{atm}}{P_2}}$$

$0.852\,atm = P_2$ ✓

$-16\,°C = T_2 = -16\,°C + 273.15 = 257.15\,K$

$?\,L = V_2$ ✓

P = atm

T = K

V = L

n = moles

$1.00\,atm = P_1$ ✓

$25\,°C = T_1 \quad 25\,°C + 273.15 = 298.15\,K$

$250.\,L = V_1$ ✓

$$V_2 = \frac{T_2 P_1 V_1}{T_1 P_2} = \frac{\overset{3}{(257.15\,\cancel{K})}\,\overset{3}{(1.00\,\cancel{atm})}\,\overset{3}{(250.\,L)}}{\underset{3}{(298.15\,\cancel{K})}\,\underset{3}{(0.852\,\cancel{atm})}}$$

$$= 253.07668\,L$$

$$= \boxed{253\,L \text{ is final volume}}$$

ex

1 atm

33 ft = 1 atm

Lungs hold ~4 L of air. If he holds his breath as he rises, how much would the air in his lungs expand?

150. ft under water

$$P_1 = 150\text{ft} = 1\text{atm} + \left(150.\text{ft} \times \frac{1\text{atm}}{33\text{ft}}\right) = \underset{3\text{ sf}}{5.45\overline{45}}\text{ atm}$$

$V_1 = 4\text{ L}$

$n_1 = x$

$T_1 = x$

$$\frac{P_1V_1}{\cancel{n_1}\cancel{T_1}} = \frac{P_2V_2}{\cancel{n_2}\cancel{T_2}}$$

$P_2 = 1.00\text{ atm}$

$V_2 = ?$

$n_2 = x$

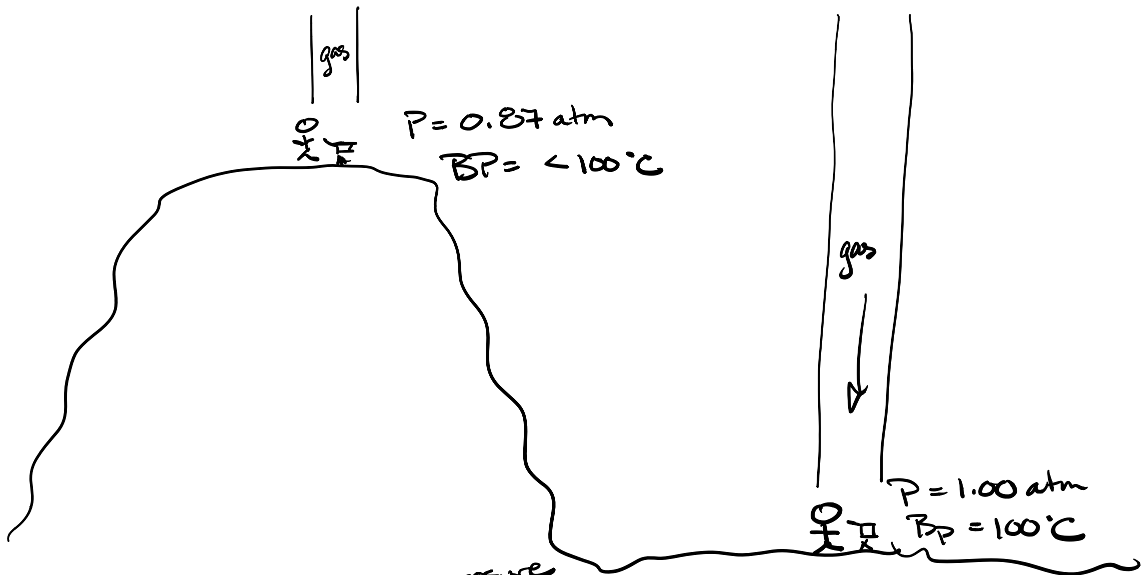
$T_2 = x$

$$\frac{1}{P_2} \times P_1V_1 = \cancel{P_2}V_2 \times \frac{1}{\cancel{P_2}}$$

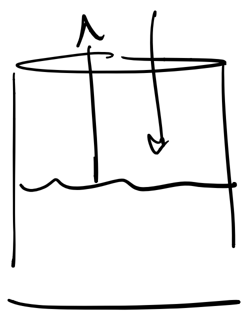
$$V_2 = \frac{P_1V_1}{P_2} = \frac{(\overset{3}{5.4\underline{5}4545}\text{ atm})(\overset{1}{4\text{L}})}{\underset{3}{1.00\text{ atm}}}$$

$= 22.\overline{18}\text{ L}$

$= \boxed{20\text{ L}}$

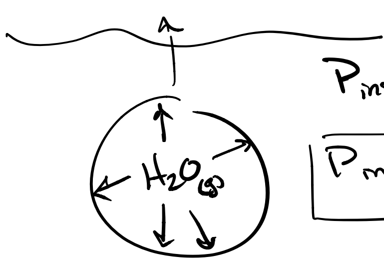


$H_2O_{(g)}$ = pressure



Boiling Point =

Vapor pressure = Atmospheric pressure



$P_{inside} < P_{outside}$ Collapse

$\boxed{P_{inside} = P_{outside}}$ Boiling

Partial Pressure

Daltons Law of Partial Pressure

$$P_{Total} = \underbrace{P_1 + P_2 + P_3 + \cdots + P_n}_{\text{Sum of all partial pressures}}$$

Example

if 2.6 atm of N_2 are added to a Container with 1.62 atm of air, what is the final pressure?

$$P_T = P_{air} + P_{N_2}$$

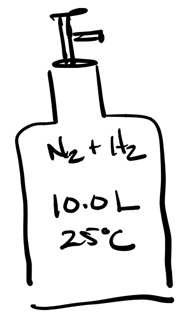
$$= 1.62\,atm + 2.6\,atm$$

$$P_T = 2.22\,atm$$

$$= \boxed{2.2\,atm}$$

Example

what is the pressure in a container with a volume of 10.0 L filled with 1.62 g N and 30.7 g H_2 if the temperature is 25°C?



$P = ?$

$V = 10.0\ L$

$n = 30.7\ g\ H_2\ \&\ 1.62\ g\ N_2 \Longleftarrow$

$T = 25°C$

$R = 0.0821\ \frac{L\ atm}{mol\ K}$

$$P_T = P_{N_2} + P_{H_2}$$

$$PV = nRT$$

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

$$P_T = \left(\frac{nRT}{V}\right)_{N_2} + \left(\frac{nRT}{V}\right)_{H_2}$$

$$P_T = \frac{n_{N_2}RT}{V} + \frac{n_{H_2}RT}{V}$$

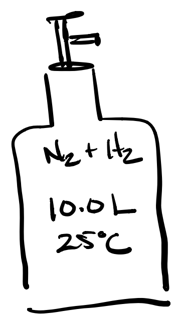
$$P_T = \frac{(n_{N_2} + n_{H_2})RT}{V}$$

$$P_T = P_1 + P_2 + \ldots + P_n$$

$$P_T = (n_1 + n_2 + \ldots + n_n)\frac{RT}{V}$$

Example

what is the pressure in a container with a volume of 10.0 L filled with 1.62 g N and 30.7 g H_2 if the temperature is 25°C?



$P = ?$

$V = 10.0\ L$

$n = 30.7\,g\,H_2\ \&\ 1.62\,g\,N_2 \Longleftarrow$

$T = 25°C + 273.15 = 298.15$

$R = 0.0821\ \frac{L\,atm}{mol\,K}$

$$n_T = 30.7\,g\,H_2 \times \frac{1\ mole\ H_2}{2.016\,g\,H_2} + 1.62\,g\,N_2 \times \frac{1\ mole\ N_2}{28.02\,g\,N_2}$$

$= 15.22817\ mole\ H_2 + 0.057816\ mole\ N_2$

$= 15.28598584\ moles\ gas\ (H_2 + N_2)$

$$P_T = \frac{(15.28598\ \cancel{moles})\left(0.0821\ \frac{\cancel{L}\,atm}{\cancel{mol}\,\cancel{K}}\right)(298.15\ \cancel{K})}{10.0\ \cancel{L}} = 37.4172119\ atm$$

$$\boxed{= 37.4\ atm}$$

1 atm you breath in 4 L air.
air is composed of 18% O_2 + 82% N_2
How many moles of O_2 in each breath?
Assume temp @ 25°C

$P = 1.00$ atm

$V = 4.00$ L

$n = ?$

$T = 25°C = 298.15$ K

$R = 0.0821 \frac{L\,atm}{mol\,K}$

$PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{(\overset{3}{1.00\,atm})(\overset{3}{4.00\,L})}{(\underset{3}{0.0821} \frac{L\,atm}{mol\,K})(\underset{3}{298.15\,K})}$

$n = 0.1634112$ mole

2
18% of moles are oxygen

$\overset{3}{0.1634112}\,mole\,gas \times \frac{\overset{2}{18}\ moles\ Oxy}{100\ mole\ gas} = 0.029414\ mole\ O_2$

0.029 mole O_2 / Breath

At base camp atm = 400mmHg. How many moles of oxygen in each breath.

$400.\,mmHg \times \frac{1\,atm}{760\,mmHg} = 0.5263\,atm$

$P = \cancel{1.00}\,atm$

$V = 4.00\,L$

$n = ?$

$T = 25°C = 298.15\,K$

$R = 0.0821\,\frac{L\,atm}{mol\,K}$

$PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{(\overset{0.5263\,atm}{\cancel{1.00}\,atm})(\overset{3}{4.00\,L})}{(\underset{3}{0.0821}\,\frac{L\,atm}{mol\,K})(\underset{3}{298.15\,K})}$

$n = \cancel{0.1634112}\,mole$

$= 0.08600593\,mole$

$0.08600593\,moles\,gas \times \frac{\overset{2}{18\,mole\,O_2}}{100\,mole\,gas} = 0.0154811\,moles\,O_2$

$= \boxed{0.015\,mole\,O_2 \text{ In each Breath}}$

At Sea level

0.029 moles O_2 / 4L air

At Base Camp

0.015 moles O_2 / 4L air

Summery

$PV = nRT$ Ideal Gas Law

$R = 0.0821 \frac{L\ atm}{mol\ K}$ 3 sf

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$ Combined Gas Laws

$\Rightarrow$ Changing Conditions

$P_1V_1 = P_2V_2$ | n & T are constant

$\frac{P_1}{n_1} = \frac{P_2}{n_2}$ | V & T are constant

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ | n & V are constant

$P_T = P_1 + P_2 + \ldots$ Dalton's of Partial Pressure

$P_T = \frac{(n_1 + n_2 + \ldots)RT}{V}$ P_T = sum of moles plugged into

$PV = \underset{\Sigma \text{ moles}}{n}RT$

unit

P = atm 1 atm = 14.7 lbs/in^2 = 760 mmHg = 760 torr

1 torr = $\frac{1}{760}$ atm 1 torr ~ 1 mmHg

Skip Chapter 9, 11, 12

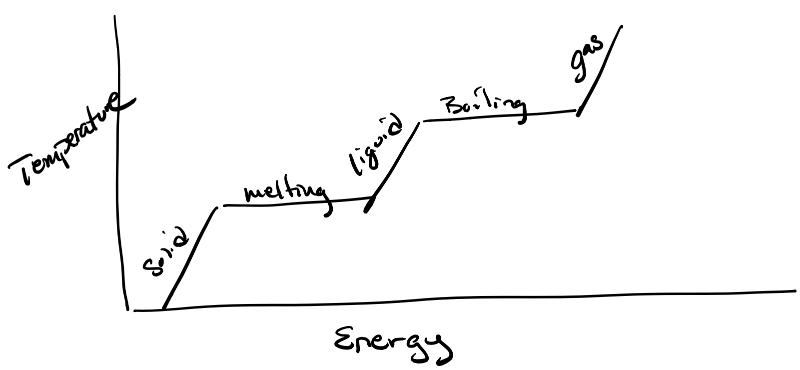
Do Chapter 10, 13 equilibrium, 14 acid/base

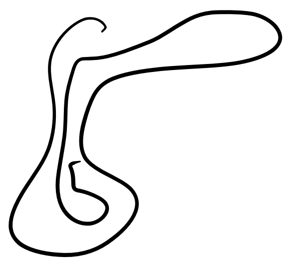
Chapter 10 Phase Transitions

Solid → liquid How much energy is required

Solid $\xrightarrow[\text{melting}]{\overset{?}{\text{Heat}}}$ liquid $\xrightarrow[\text{vaporizing}]{\overset{?}{\text{heat}}}$ gas

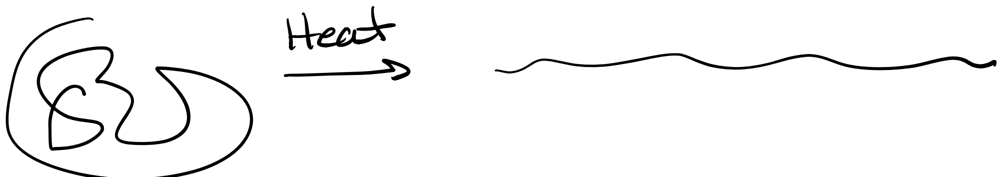
phase transitions





Globular
soluble
Blood, eggs

linear protein
insoluble
Connetive tissue



globular

linear