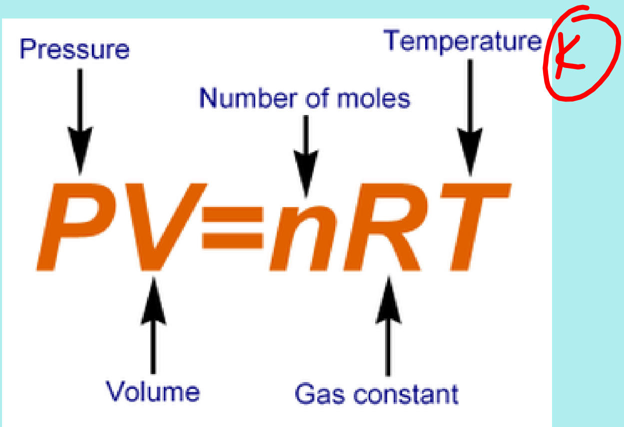
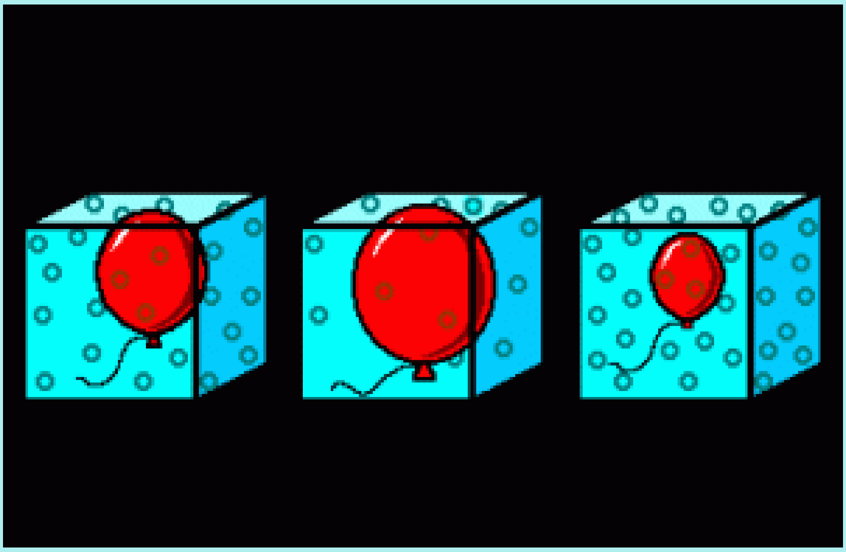
Ideal Gas Law





The ideal gas law:

PV=nRT

- **R**=univeral gas constant
- **P**ressure
- **V**olume
- **n**umber of moles
- **T**emperature

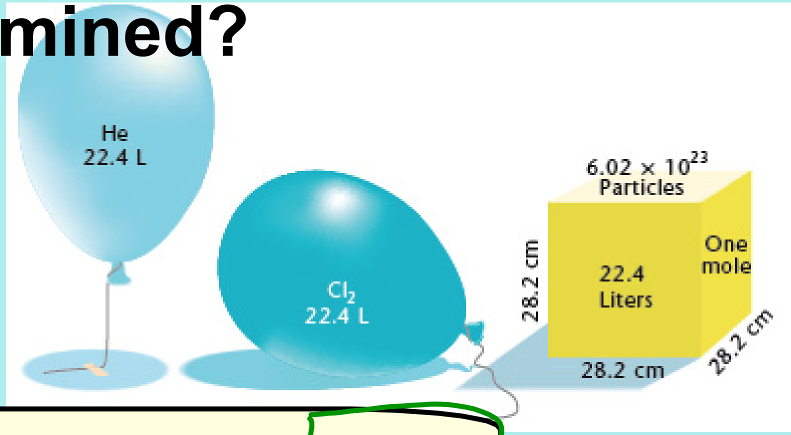
$$R=0.0821\ \frac{atm \cdot L}{mol \cdot K}$$

units

ideal

gas particles
-travel fast
-very far apart
-collisions are elastic
-no attractions or
repulsions

How is R determined?



At STP, 1 mol of gas takes up 22.4 L

STP stands for

Standard **T**emperature and **P**ressure

= 0^0C
= 273K

= 1 atm
=760 mmHg
=760 torr

solve for R

PV=nRT

$$R = \frac{PV}{nT} = \frac{1\ \text{atm} \cdot 22.4\text{L}}{1\ \text{mol} \cdot 273\text{K}} = 0.0821\ \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}}$$

unit

constant - not equation

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

* must have these units to use this constant!

Which Equation to Use?

look at variables

$$\frac{V_1P_1}{T_1} = \frac{V_2P_2}{T_2}$$

this one has a "before" and "after"

$$PV=nRT$$

this one has "n" as number of moles

If I have an unknown quantity of H_2 gas at a pressure of 1.2 atm a volume of 31 liters, and a temperature of 87 ^{0}C, how many moles of gas do I have? ~~How many grams~~ is this?

P=1.2 atm

V= 31 L

T = 87^{0}C + 273 = 360 K

n = ?

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

PV=nRT solve for n

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

$$n = \frac{PV}{RT} = \frac{(1.2\ atm)(31\ L)}{(0.0821 \frac{atm \cdot L}{mol \cdot K})(360 K)} = 1.26 \text{ mol } H_2$$

How many grams?

molar mass of H_2 = g/mol

$$\frac{1.26 \text{ mol } H_2}{} \left| \frac{2 \text{ grams}}{1 \text{ mol}} \right. = 2.52 \text{ g } H_2$$

Mar 18-7:44 PM

1. Determine the number of moles present in a red balloon that has a volume of 1.5L at STP

T=273 K
P= 1 atm
V=1.5 L
n = ?
R= 0.0821 $\frac{atm \cdot L}{mol \cdot K}$

$$\frac{PV}{RT} = \frac{nRT}{RT} = \frac{(1\,atm)(1.5\,L)}{(0.0821\,\frac{atm \cdot L}{mol \cdot K})(273\,K)}$$

n = 0.067 mol

2. What is the temperature of a sample of air that has a pressure of 1.5 atm, moles = .05 and a volume of 1.1 L.

P= 1.5 atm
n= 0.05 mol
V= 1.1 L
T?
R= 0.0821 $\frac{atm \cdot L}{mol \cdot K}$

$$\frac{PV}{nR} = \frac{nRT}{nR}$$

$$T = \frac{PV}{nR} = \frac{(1.5\,atm)(1.1\,L)}{(0.05\,mol)(0.0821\,\frac{atm \cdot L}{mol \cdot K})}$$

T = 402K

3. If a balloon has a temperature of 298K and a volume of 1.98L, what is the pressure if the balloon contains 1 mole of gas?

P?

T= 298 K
V= 1.98 L
n= 1 mol

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

$$\frac{PV}{V} = \frac{nRT}{V} = \frac{(1\,mol)(0.0821\,\frac{atm \cdot L}{mol \cdot K})(298\,K)}{1.98\,L}$$

P = 12.4 atm

1.What is the difference between an Ideal gas and a non-ideal gas?

Ideal gas: (good estimation)
we assume gas particles
- -travel fast
- -very far apart
- -collisions are elastic
- -no attractions or repulsions

non ideal gas:
real gases have slightly different parameters and we would have slight differences in values

2.What is the combined gas law?

$$\frac{V_1P_1}{T_1} = \frac{V_2P_2}{T_2}$$

T must be in Kelvin scale

3.The combined gas law is simply the combination the these three gas laws?

Guy-Lussacs Law

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

Boyles Law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Charles Law

$$P_1V_1 = P_2V_2$$

Combined Gas Law

$$\frac{V_1P_1}{T_1} = \frac{V_2P_2}{T_2}$$

4. What is the ideal gas law?

$$PV=nRT$$

T must be in Kelvin scale

5. A flask contains $O_{2(g)}$, first at STP and then at 100°C. What is the pressure at 100°C.

T_1= 273K
P_1=1 atm
T_2= 100°C + 273K = 373 K
P_2 = ?

$$\frac{1\text{ atm}}{273\text{K}} = \frac{P_2}{373\text{ K}}$$

$$P_2 = 1.37\text{ atm}$$

Mar 20-1:06 PM

1. What are the units on R? $\frac{atm \cdot L}{mol \cdot K}$

$R = 0.0821$

2. A sample of He gas has at STP has a volume of 5 L. How many moles are present?

STP (T= 273K
P=1 atm
V= 5 L

(1 atm) (5 L)= n (0.0821) (273K)

$PV = nRT$

n = 0.22 mol He

3. A balloon of Nitrogen gas at STP has a volume of 5 L. How many moles are present?

same as above-- the kind of gas does not matter (assuming ideal gas)

4. If a balloon ~~has~~ is at STP contains 10 moles of He what is the volume?

T= 273K
P=1 atm
n= 10 mol

(1 atm) V = (10 mol) (0.0821) (273K)
1 atm 1 atm

V = 224 L

5. What is the mass of helium in the previous problem?

$$\frac{10 \text{ mol}}{} \bigg| \frac{4 \text{ grams}}{1 \text{ mol}} = 40 \text{ g He}$$

6. A balloon contains 1 gram of nitrogen at STP. What is the volume?

$$\frac{1 \text{ g } N_2}{} \bigg| \frac{1 \text{ mol}}{28 \text{ grams}} = 0.036 \text{ mol}$$

T= 273K
P=1 atm
n= 0.036 mol

(1 atm) V = (0.036 mol) (0.0821) (273K)
1 atm 1 atm

V= 0.81 L

Mar 20-1:07 PM

4.A sample of hydrogen gas has a volume of 8.56L at a temperature of 0°C and a pressure of 1.5 atm. Calculate the moles of H_2 molecules present in this gas sample.

PV=nRT

V= 8.56L

T= 0°C + 273K = 273K

P = 1.5 atm

(1.5 atm)(8.56L) = n (0.0821) (273K)

n= 0.58 mol

5.Suppose we have a sample of ammonia gas with a volume of 3.5 L at a pressure of 1.68 atm. The gas is compressed to a volume of 1.35L at a constant temperature. Which gas law will be used in this example and what is the final pressure?

V_1=3.5 L

P_1= 1.68 atm

V_2= 1.35L

T constant

$P_1V_1 = P_2V_2$

$$\frac{(1.68\text{ atm})(3.5\text{ L})}{1.35} = \frac{P_2\,(1.35\text{L})}{1.35}$$

P_2 = 4.35 atm

6.A 5 g sample of Methane (CH_4) gas that has a volume of 3.8 L at 5° C is heated to 86°C at constant pressure of 2 atm. Calculate its new volume.

V= 3.8 L

T_1 = 5° C + 273 = 278K

T_2 =86°C + 273 = 359K

P is constant

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{3.8\text{ L}}{278\text{K}} = \frac{V_2}{359\text{K}}$$

V_2= 4.91 L

v