KINETIC MOLECULAR THEORY

1. GAS MOLECULES ARE REPRESENTED by POINTS

- (NO VOLUME, NO ATTRACTIVE FORCES)

[ATTRACTIVE FORCES HOLD MOLECULES TOGETHER]

2. KINETIC ENERGY OF MOLECULES IS PROPORTIONAL TO THE ABSOLUTE TEMPERATURE ($KE \propto T$)

3. COLLISIONS BETWEEN MOLECULES ARE "ELASTIC" (NO ENERGY LOSS)

GASES THAT BEHAVE IN THIS MANNER ARE KNOWN AS <u>IDEAL GASES</u>

WHEN IS A REAL GAS IDEAL?

HIGH PRESSURE, LOW TEMP

NORMAL CONDITIONS

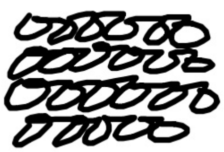
LOW PRESSURE, HIGH TEMP

HIGH PRESSURE, HIGH TEMP

LOW TEMP, LOW PRESSURE

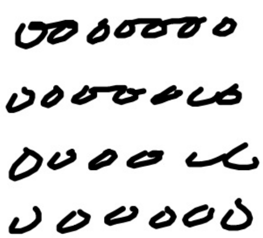
CHANGES OF STATE

Solid → LIQUID

 + heat → 

MELTING

LIQUID ⟶ GAS



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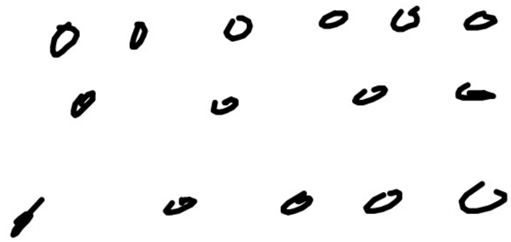


evaporation

LIQUID ⟵ GAS

CONDENSATION

Solid ⟵ LIQUID

FREEZING

GASES

GAS BEHAVIOR

VOLUME (V) OCCUPIED SPACE

UNITS: mL, L, kL

TEMPERATURE (T) MEASURES K.E.

MEASURE IN °C

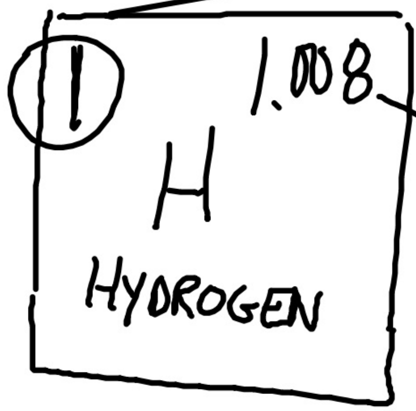
CALCULATE IN K $K = °C + 273$

AMOUNT OF GAS

mole (mol, $\underline{\underline{\underline{n}}}$)

1 mole OF ANY SUBSTANCE CONTAINS 6.022×10^{23} atoms OR molecules AND HAS A MASS OF ITS ATOMIC OR MOLECULAR MASS IN GRAMS.

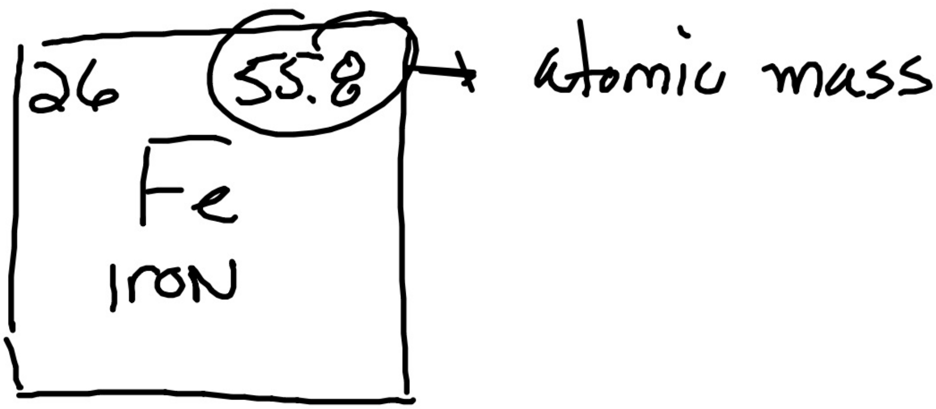
6.022×10^{23} IS AVOGADRO's CONSTANT (N_A)



→ atomic Number (Z)
NUMBER OF PROTONS

→ atomic mass =
1.008 atomic mass units
(amu, u)

1 mol of H contains 6.022×10^{23} atoms of H with A MASS OF 1.008g



1 mol OF Fe CONTAINS 6.022×10^{23} atoms AND HAS A MASS OF 55.8 g

Molecular mass

TABLE SALT (SODIUM CHLORIDE, NaCl)

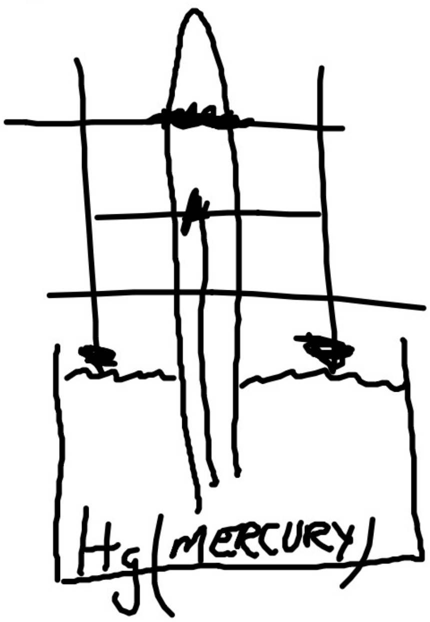
Molecular mass = at. mass of ALL ELEMENTS IN THE COMPOUND ADDED TOGETHER

Molecular MASS NaCl = 23 + 35.5

= 58.5 amu

1 mol of NaCl 6.022×10^{23} molecules with A MASS OF 58.5g

PRESSURE (P) = $\frac{\text{FORCE}}{\text{AREA}}$ $\left(P = \frac{F}{A}\right)$



BAROMETER

MEASURES AIR PRESSURE

AIR PRESSURE AT SEA LEVEL:

P_{ATM} = 30 in Hg =

TORRICELLI * 760 mm Hg = 1 atmosphere (atm)

P_{atm} = 30 in Hg = * 760 mm Hg

↓ = * 1 atmosphere (atm)

atmospheric pressure = 760 torr

= 14.7 pounds per inch (psi)

= 101.3 kPa = 1.013 bar

$$\text{PASCAL (Pa)} = \frac{1 \text{ NEWTON}}{1 \text{ m}^2}$$

CONVERT

$$\frac{mm\,Hg}{760} \longrightarrow atm$$

e.g. $$\frac{1520\ \cancel{mm\,Hg}}{760\ \cancel{mm\,Hg}/atm} = 2\ atm$$

$$\cancel{atm} \times \frac{760\ mmHg}{\cancel{atm}} \longrightarrow mmHg$$

e.g.

$$2\ \cancel{atm} \times \frac{760\ mmHg}{\cancel{atm}} = \underline{1520}\ mmHg$$

GAS LAWS

1698 Robert BoyLE (COMPRESSIBILITY)

THE VOLUME OF A FIXED AMOUNT OF GAS IS INVERSELY PROPORTIONAL TO THE PRESSURE PLACED ON THE GAS AT CONSTANT TEMPERATURE

BOYLE'S LAW

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

$\propto$ → PROPORTION

$$V = k\left(\frac{1}{P}\right)$$

k → CONSTANT

BOYLE'S LAW

$$\boxed{PV = k}$$

← not A USE FORM

USEFUL FORM OF BOYLE'S LAW

$$P_1 V_1 = P_2 V_2$$

"1" A GIVEN P + V (INITIAL)

"2" ANOTHER P + V (NEW)

Example

A GAS HAS A VOLUME of 100 mL (V_1) at 2 atm PRESSURE. WHAT VOLUME will THE GAS OCCUPY IF THE PRESSURE IS 4 atm?

$$P_1 V_1 = P_2 V_2$$

(V_2: new volume)

$$V_2 = \frac{P_1 V_1}{P_2}$$

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$P_1 = 2\ atm$

$V_1 = 100\ mL$

$P_2 = 4\ atm$

$V_2 = ?$

$$V_2 = \frac{(2\ \cancel{atm})(100\ mL)}{4\ \cancel{atm}}$$

$$= \frac{200\ mL}{4} = 50\ mL$$

EXAMPLE 2 BOYLE'S LAW

A GAS HAS A VOLUME OF 200 mL at 6 atm. If the volume CHANGES to 400 mL what is THE PRESSURE OF THE GAS?

$P_1 = 6\ atm$

$V_1 = 200\ mL$

$P_2 = ?$

$V_2 = 400\ mL$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$= \frac{(6\,atm)(200\,\cancel{mL})}{400\,\cancel{mL}}$$

$P_2 = 3\ atm$

1798 CHARLES' LAW

VOLUME OF A FIXED AMOUNT OF GAS IS PROPORTIONAL TO THE TEMPERATURE OF THE GAS AT CONSTANT PRESSURE.

$$V \propto T$$

$$V = kT \qquad \frac{V}{T} = k$$

USEFUL FORM:

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

MEASURE temp. IN °C

$$\frac{1}{0} = \text{UNDEFINED}$$

CONVERT °C → K

$K = °C + 273$

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

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

EXAMPLE 1 CHARLES' LAW

A GAS HAS A VOLUME OF 20.0 mL at 20.0°C. What IS THE GAS VOLUME AT 40.0°C?

$V_1 = 20.0\ mL$

$T_1 = 20.0°C + 273 = 293$

$V_2 = ?$

$T_2 = 40.0°C + 273 = 313$

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

$$V_2 = \frac{(20.0\ mL)(313\ K)}{293\ K} = 21.4\ mL$$

EXAMPLE #2 CHARLES' LAW

A GAS OCCUPIES 30.0 mL VOLUME AT 10.0°C. What is THE TEMPERATURE OF THE GAS IF THE VOLUME CHANGES 100 mL?

$V_1 = 30.0$ ml

$T_1 = 10.0°C + 273 = 283$

$V_2 = 100$ mL

$T_2 = ?$

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

$$= \frac{(100 mL)(283 K)}{30.0 mL} = 943 K$$

$$V_2 = \frac{P_1 V_1}{P_2} \qquad P_2 = \frac{P_1 V_1}{V_2}$$

1. $V_1 = 300\,mL$

$P_1 = 745\,mmHg$

$V_2 = ?$

$P_2 = 750\,mmHg$

$$V_2 = \frac{(745\,mmHg)(300\,mL)}{750\,mmHg}$$

$$V_2 = 298\,mL$$

BL Worksheet #1