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 IDEAL GASES

WHEN IS A REAL GAS IDEAL?

HIGH PRESSURE, LOW TEMP

NORMAL CONDITIONS

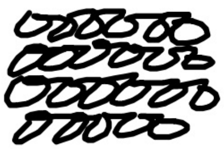
LOW PRESSURE, HIGH TEMP

HIGH PRESSURE, HIGH TEMP

LOW TEMP, LOW PRESSURE

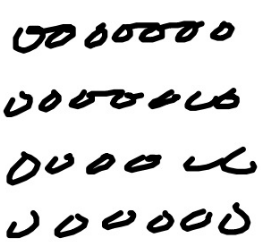
CHANGES OF STATE

Solid $\longrightarrow$ LIQUID

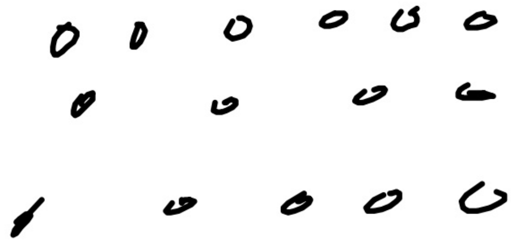
 + heat $\longrightarrow$ 

MELTING

LIQUID $\longrightarrow$ GAS



+heat



evaporation

LIQUID $\longleftarrow$ GAS

CONDENSATION

Solid $\longleftarrow$ LIQUID

FREEZING

GASES

GAS BEHAVIOR

VOLUME (V) OCCUPIED SPACE

UNITS: mL, L, kL

TEMPERATURE (T) MEASURES K.E.

MEASURE IN °C

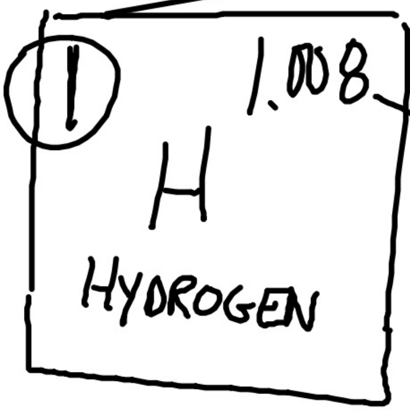
CALCULATE IN K $\quad K = °C + 273$

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

26 55.8 → atomic mass

Fe

IRON

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

Molecular mass

TABLE SALT (SODIUM CHLORIDE, $NaCl$)

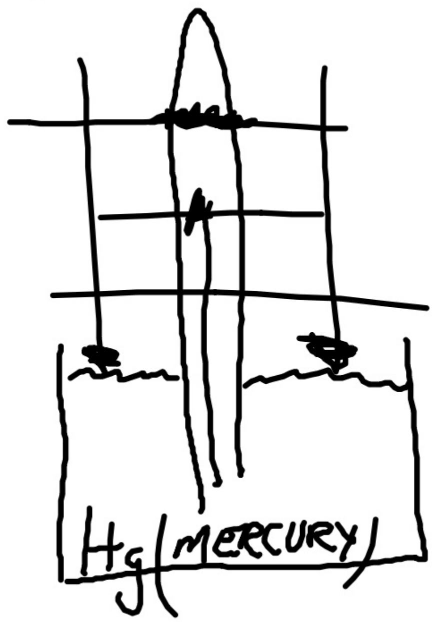
Molecular mass = at. mass of ALL ELEMENTS IN THE COMPOUND ADDED TOGETHER

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

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

<u>CONVERT</u>

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

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

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

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

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

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

PROPORTION

BOYLE'S LAW

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

CONSTANT

not A USE FORM

<u>USEFUL</u> 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 at 2 atm PRESSURE. WHAT VOLUME WILL THE GAS OCCUPY IF THE PRESSURE IS 4 atm?

V_1

new volume

$$P_1 V_1 = P_2 V_2$$

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

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

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

$P_1 = 2\,atm$

$V_1 = 100\,mL$

$P_2 = 4\,atm$

$V_2 = ?$

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

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

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.

$$V \propto T$$

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

USEFUL FORM:

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

MEASURE temp. IN °C

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

CONVERT $^{\circ}C \rightarrow K$

$$K = {}^{\circ}C + 273$$

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

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

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 ?

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

$V_1 = 20.0\ mL$

$T_1 = 20.0°C + 273 = 293$

$V_2 = ?$

$T_2 = 40.0°C + 273 = 313$

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

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?

$V_1 = 30.0\ mL$

$T_1 = 10.0°C + 273 = 283$

$V_2 = 100\ mL$

$T_2 = ?$

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

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

$$V_2 = \frac{P_1 V_1}{P_2} \qquad P_2 = \frac{P_1 V_1}{V_2} \quad P\uparrow \; V\downarrow$$

1. $V_1 = 300 \, mL$

$P_1 = 745 \, mmHg$

$V_2 = ?$

$P_2 = 750 \, mmHg$

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

$$V_2 = 298 \, mL$$

BL Worksheet #1

1. $V_1 = 100\,mL$ $\quad K = {}^{\circ}C + 273$

$T_1 = -73^{\circ}C \underset{+273}{=} 200K$ $\quad V_2 = \dfrac{V_1 T_2}{T_1}$ $\quad V\uparrow\ T\uparrow$

$T_2 = ?$ $\quad T_2 = \dfrac{V_2 T_1}{V_1}$

$V_2 = 150\,mL$

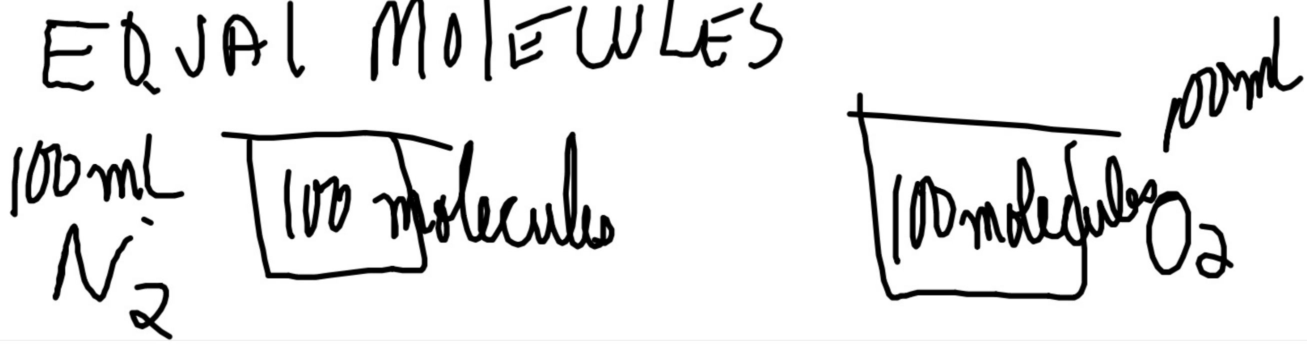
$$T_2 = \frac{(150\,\cancel{mL})(200\,K)}{100\,\cancel{mL}}$$

$T_2 = 300\,\cancel{K}$

1811 AVOGADRO

AVGODRO's Hypothesis

- equal VOLUMES OF GASES AT THE SAME PRESSURE AND TEMPERTURE CONTAIN EQUAL MOLECULES



AVOGADRO'S LAW

THE VOLUME OF A GAS AT CONSTANT TEMPERATURE AND PRESSURE IS PROPORTIONAL TO THE AMOUNT OF GAS (mols, n)

$$V \propto n$$

IDEAL GAS LAW

$$PV = n\underset{\text{constant}}{R}T$$

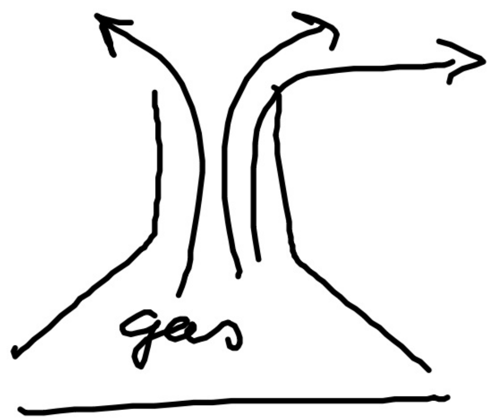
$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$ amount of gas constant

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

amount of gas and V constant

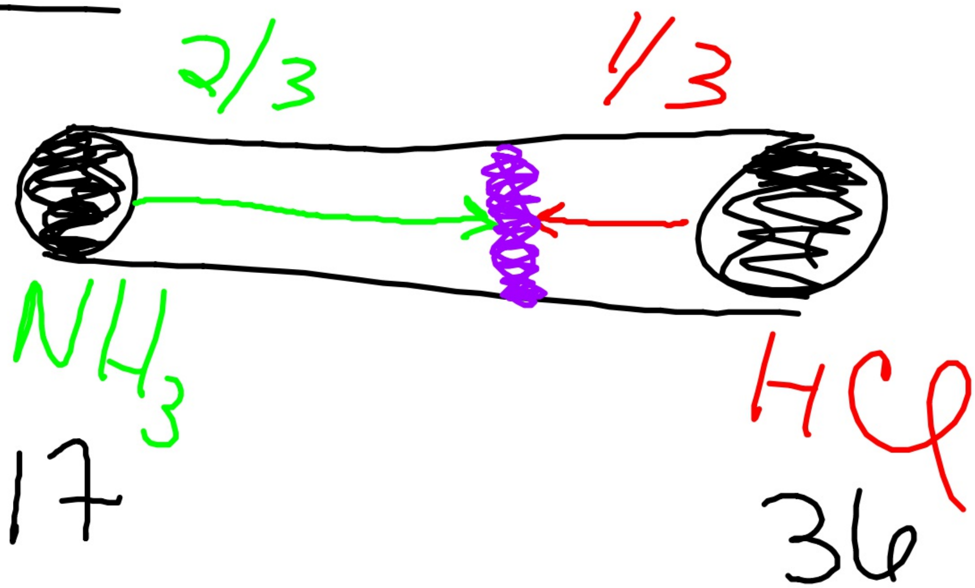
GAY-LUSSAC's LAW

DIFFUSION THE SPREAD OF A GAS THROUGH OUT ANOTHER GAS



EFFUSION GAS ESCAPES THROUGH A TINY OPENING.

rates



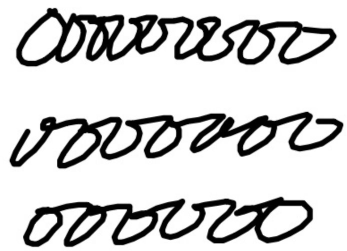
the heavier THE GAS

THE SLOWER IT MOVES

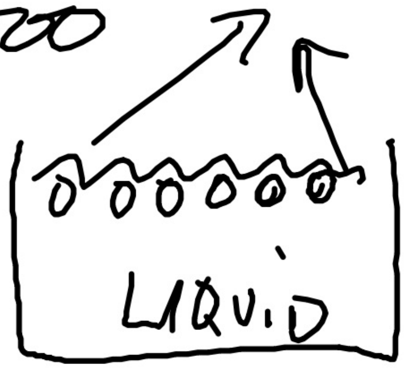
O_2 N_2

16 14

LIQUIDS

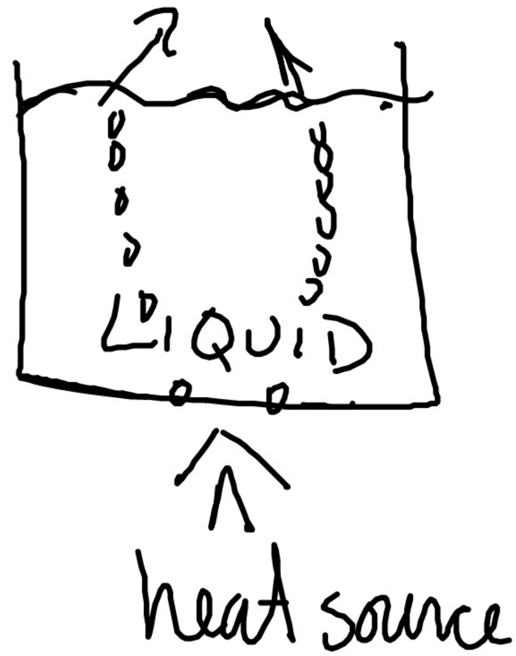


EVAPORATION.



SURFACE molecules GO FROM LIQUID TO vapor

boiling IS THE CHANGING OF A LIQUID TO A VAPOR AT A HEAT SOURCE

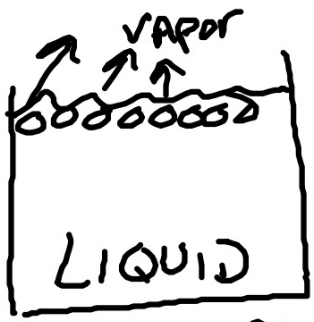


NORMAL BOILING POINT

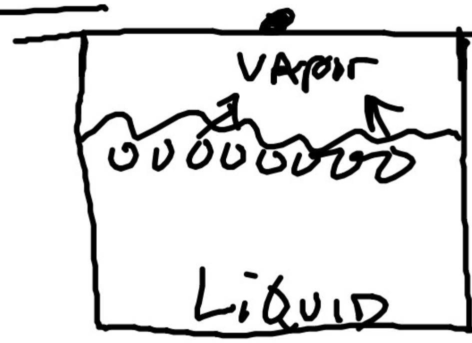
THE TEMPERATURE AT WHICH THE VAPOR PRESSURE OF THE LIQUID = ATMOSPHERIC PRESSURE

Vapor PRESSURE

– IS THE PRESSURE THE VAPOR OF A LIQUID EXERTS ON THE LIQUID



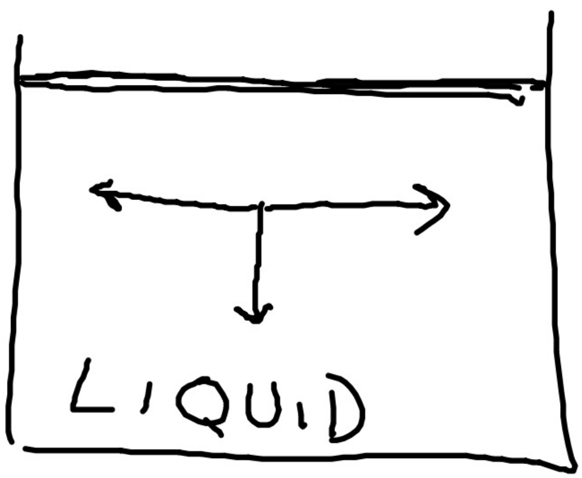
EVAPORATION

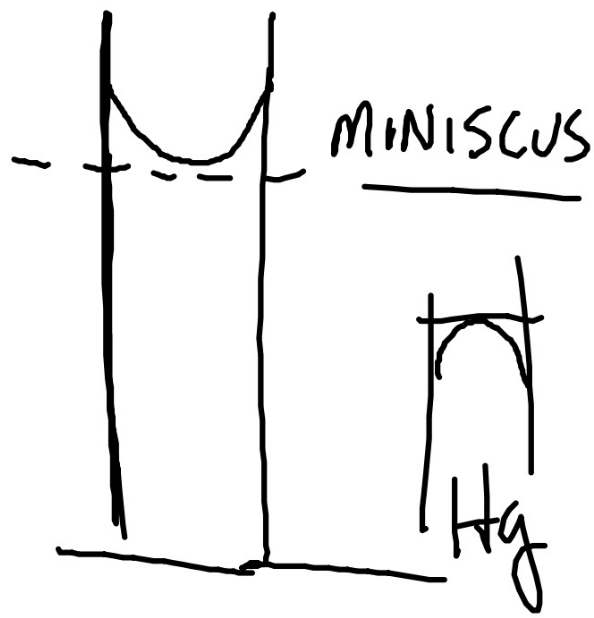


HIGH VP LIQUID EVAPORATES QUICKLY

LOW UP LIQUID EVAPORATES SLOWLY

SURFACE TENSION IS A THIN FILM OF molecules at the SURFACE OF THE LIQUID



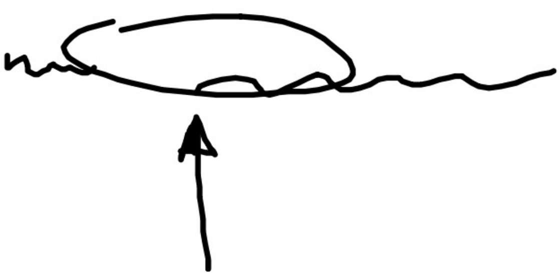


VISCOSITY - resistance to flow

slower a liquid moves higher viscosity

BOUYANT FORCE

a external force exerted on matter by a liquid



ARCHIMEDES PRINCIPLE:

THE BOUYANT FORCE ON AN OBJECT IN A FLUID IS AN UPWARD FORCE EQUAL TO THE WEIGHT OF FLUID THE OBJECT DISPLACES

weight here = weight of cylinder

VOLUME CYLINDER =
VOLUME H_2O DISPLACED

OBJECTS ALSO FLOAT OR SINK BASED ON DENSITY

$$d = \frac{\text{mass}}{\text{Volume}} \qquad d = \frac{m}{v}$$

$d = 1.00\,g/mL$ (H_2O)

$d > 1.00\,g/mL$ sink

$d < 1.00\,g/mL$ FLOAT

Example density $\left(d = \frac{m}{v}\right)$

Find the density of an object with a mass of 20.0g and a volume of 10.0 mL

$$d = \frac{m}{V} = \frac{20.0g}{10.0mL} = 2.0\,g/mL$$

<u>Example</u> mass ($m = d \times V$)

Find the mass of AN object with A DENSITY OF 3.0g/mL AND A VOLUME OF 24.0 mL.

$$m = d \times V = (3.0\,g/\cancel{mL})(24.0\,\cancel{mL})$$

$$= 72\,g$$

Example Volume $\left(V = \frac{m}{d}\right)$

FIND THE VOLUME OF A SUBSTANCE WITH A MASS OF 90.0g AND A DENSITY OF 6.0g/mL.

$$V = \frac{m}{d} = \frac{90.0\cancel{g}}{6.0\cancel{g}/mL} = 15.0\ mL$$

$3\,cm = h$

$4\,cm = l$

$2\,cm = w$

$V = l \times w \times h =$

$= 3_{cm} \times 4\,cm \times 2\,cm = 24\,cm^3$

$d = \frac{m}{V}$, $m = d \times V$, $V = \frac{m}{d}$