Parameters of Gases

The characteristics of gases are described in terms of following four parameters

- Mass, Volume, Pressure, and Temperature

1. Mass (m):

The mass of the gas is related to the number of moles as

$$n = \frac{w}{M}$$

Where n = number of moles

Note/ One mole of material contains Avogadro's number (6.023 x 10^{23}) atoms

w = mass of gas in grams

M = molecular mass of the gas

Q1) how many atoms in 8 grams of helium.

2. Volume (V):

Since gases occupy the entire space available to them, therefore the gas volume means the volume of the container in which the gas is enclosed.

Units of Volume: Volume is generally expressed in **liter (L), cm^3** & **dm^3**

$1m^3 = 10^3$ liter $= 10^3\ dm^3 = 10^6\ cm^3$.

3. Pressure:

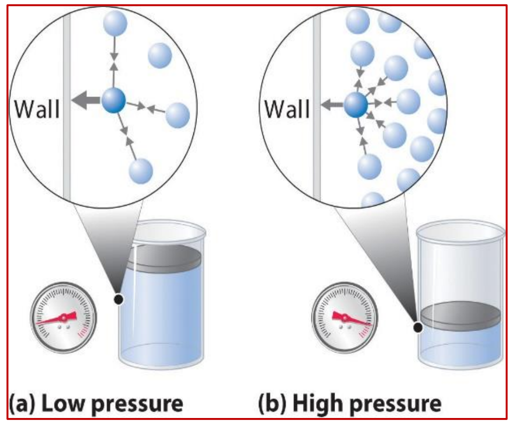
Pressure of the gas is due to its collisions with walls of its container *i.e.* the force exerted by the gas per unit area on the walls of the container is equal to its pressure.

$$P(pressure) = \frac{F(Force)}{A(Area)} = \frac{Mass \times Accelaration}{Area}$$

Pressure is exerted by a gas due to kinetic energy of its molecules.

Units of Pressure:

The pressure of a gas is expressed in **mm** of Hg, **atm, Pa, Nm^{-2}, bar** and **lb/In^2 (psi).**



760 mm of Hg = 1 atm = 101325 Pa = 101325 Nm^{-2}
760 mm of Hg = 760 Torr = 1.01325 bar = 14.7 lb/ln^2 (psi)

3. Temperature (T):

Temperature is defined as the degree of hotness. The SI unit of temperature is Kelvin. °C and °F are the two other units used for measuring temperature. On the Celsius scale water freezes at 0°C and boils at 100°C where as in the Kelvin scale water freezes at 273 K and boils at 373 K.

K = °C + 273.5

F = (9/5) °C + 32

Q2) what is the difference between temperature and heat?

Heat (symbol: q) is energy. It is the total amount of energy (both kinetic and potential) possessed by the molecules in a piece of matter. Heat is measured in Joules.

The Units of measurement

The international system of units (SI) was adopted by the General Conference on Weights and Measure in 1960, and the SI units are widely used today. All SI units are based on these basic units.

Seven Basic Quantities and Units		
Quantity	**Unit**	**Symbol**
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

Other units are called **derived units** the table below lists some examples:

Derived quantities and their SI units		
Quantity	**Unit**	**Symbol**
Area	square meter	m^2
Volume	cubic meter	m^3
Density	kg per cubic meter	$kg\ m^{-3}$
Velocity	meter per second	$m\ s^{-1}$
acceleration	meter per second per second	$m\ s^{-2}$

For some specific common quantities, the SI units have special symbols.

Special symbols of some SI units		
Quantity	**Unit**	**Explanation**
Force	N	Newton = $kg\ m\ s^{-2}$
Pressure	Pa	Pascal = $N\ m^{-2}$
Electric potential	V	Volt = J/C
Energy	J	Joule = N.m
Electric charge	C	Coulomb = A s
Electric potential	V	1 V = 1 J/C
Power	watt	1 watt = 1 J/s

The following units are still in common use for chemistry

Common units still in Use		
Quantity	**Symbol**	**Explanation**
Volume	L	liter = 1 dm^3, 1 dm = 0.1 m
Volume	mL	milliliter = 1/1000 L
Molarity	M	number of moles dissolved in 1 liter solution
Molality *	m	number of moles dissolved in 1 kg solvent

SI unit prefixes

Metric system or SI units are based on factors of ten. However, most units prefixes with names are 1000 times apart. The exception are near the base unit (centi-, deci-, kilo-,).

SI unit prefixes		
Factors	**Prefix**	**Symbol**
10^{12}	tera	T
19^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Conversion Factors

A conversion factor is a ratio of equivalent quantities used to express a quantity in different units.

Ex// How many cm are in 1.32 meters?

$$\frac{1\ \text{m}}{100\ \text{cm}} \quad \text{or} \quad \frac{100\ \text{cm}}{1\ \text{m}}$$

Unit conversation

$$X\ \text{cm} = 1.32\ \text{m}\left(\frac{100\ \text{cm}}{1\ \text{m}}\right) = \boxed{132\ \text{cm}}$$

Common conversion factors			
Quantity	**SI Unit**	**Other Unit**	**Conversion Factor**
Energy	joule	calorie erg	1 cal = 4.184 J 1 erg = 10^{-7} J
Force	newton	dyne	1 dyn = 10^{-5} N
Length	metre or meter	ångström	1 Å = 10^{-10} m = 10^{-8} cm = 10^{-1} nm
Mass	kilogram	pound	1 lb = 0.453592 kg
Pressure	pascal	bar atmosphere mm Hg lb/in^2	1 bar = 10^5 Pa 1 atm = 1.01325 x 10^5 Pa 1 mm Hg = 133.322 Pa 1 lb/in^2 = 6894.8 Pa
Temperature	kelvin	Celsius Fahrenheit	1°C = 1 K 1°F = 5/9 K
Volume	cubic metre	litre gallon (U.S.) gallon (U.K.) cubic inch	1 L = 1 dm^3 = 10^{-3} m^3 1 gal (U.S.) = 3.7854 x 10^{-3} m^3 1 gal (U.K.) = 4.5641 x 10^{-3} m^3 1 in^3 = 1.6387 x 10^{-6} m^3

Note// we use the idea of **unit cancellation** to decide upon which one of the two conversion factors we choose.

Ex// How many meters is 8.72 cm?

Unit conversation $\dfrac{1\ \text{m}}{100\ \text{cm}}$ or $\dfrac{100\ \text{cm}}{1\ \text{m}}$

$$X\ \text{m} = 8.72\ \text{cm}\left(\frac{1\ \text{m}}{100\ \text{cm}}\right) = \boxed{0.0872\ \text{m}}$$

Again, the units must cancel.

Ex// Convert 41.2 cm^2 to m^2.

$$X\ m^2 = 41.2\ \text{cm·cm}\left(\frac{1\ m}{100\ cm}\right)\left(\frac{1\ m}{100\ cm}\right)$$

$$= \boxed{0.00412\ m^2}$$

$$X\ m^2 = 41.2\ cm^2\left(\frac{1\ m}{100\ cm}\right)^2 = \boxed{0.00412\ m^2}$$

Ex// Convert 2 atm to pressure uints **Pa, and mm of Hg,**?

$$\frac{1\ atm}{101325\ pa} \quad \text{or} \quad \frac{101325\ pa}{1\ atm}$$

Unit conversation

$$X\ pa = 8.72\ atm\left(\frac{101325\ pa}{1\ atm}\right) = \boxed{202650\ pa}$$

$$X\ mm\ of\ Hg = 8.72\ atm\left(\frac{760\ mm}{1\ atm}\right) = \boxed{1520\ mm}$$

Converting Units of Temperature

Ex// A child has a body temperature of 38.7°C, and normal body temperature is 98.6°F. Does the child have a fever? What is the child’s temperature in kelvins?

SOLUTION:

Converting from °C to °F $\quad \frac{9}{5}(38.7\ °C) + 32 = \mathbf{101.7\ °F}$

Yes, the child has a fever.

Converting from °C to K $\quad 38.7\ °C + 273.15 = \mathbf{311.8\ K}$

EX// change 806 mmHg to (a) torr (b) atmosphere (c) kilopascals.

Home work) convert

1- 1.49x10^{3} mg to gm

2- 4.6 cm^{3} to m^{3}

3- 1.07 bar to torr

Unit analysis

Unit analysis is also a useful guard against algebraic mistakes. An error in setting up an algebraic solution often changes the units of the answer, and check of the answer's units will show the mistake.

PROBLEM Unit analysis and recognition of a reasonable value can prevent errors such as those that resulted in the following answers. Identify the problem with these results for the requested quantity:

Quantity	Wrong answer
the density of NaCl(*s*)	$1.3 \cdot 10^{-24}$ g cm^{-3}
the density of NaCl(*s*)	$3.3 \cdot 10^{7}$ g cm^{-1}
bond length of CsI	12.3 m
speed of a molecule	$4.55 \cdot 10^{11}$ m s^{-1}
momentum of electron	$5 \cdot 10^{-10}$ m s^{-1}

SOLUTION Each of those examples gives an answer of entirely the wrong magnitude (which could arise from using the wrong conversion factor, the wrong units, or both).

Quantity	Wrong answer	Why unreasonable
the density of NaCl(*s*)	$1.3 \cdot 10^{-24}$ g cm^{-3}	too small
the density of NaCl(*s*)	$3.3 \cdot 10^{7}$ g cm^{-1}	wrong units
bond length of CsI	12.3 m	too big
speed of a molecule	$4.55 \cdot 10^{11}$ m s^{-1}	too big (greater than speed of light)
momentum of electron	$5 \cdot 10^{-10}$ m s^{-1}	wrong units