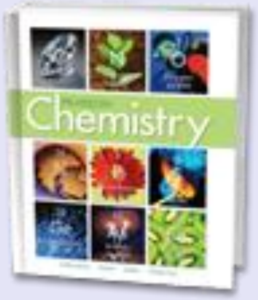
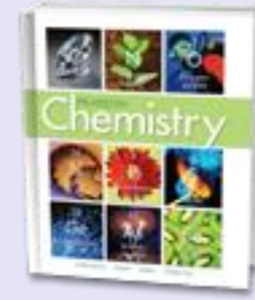


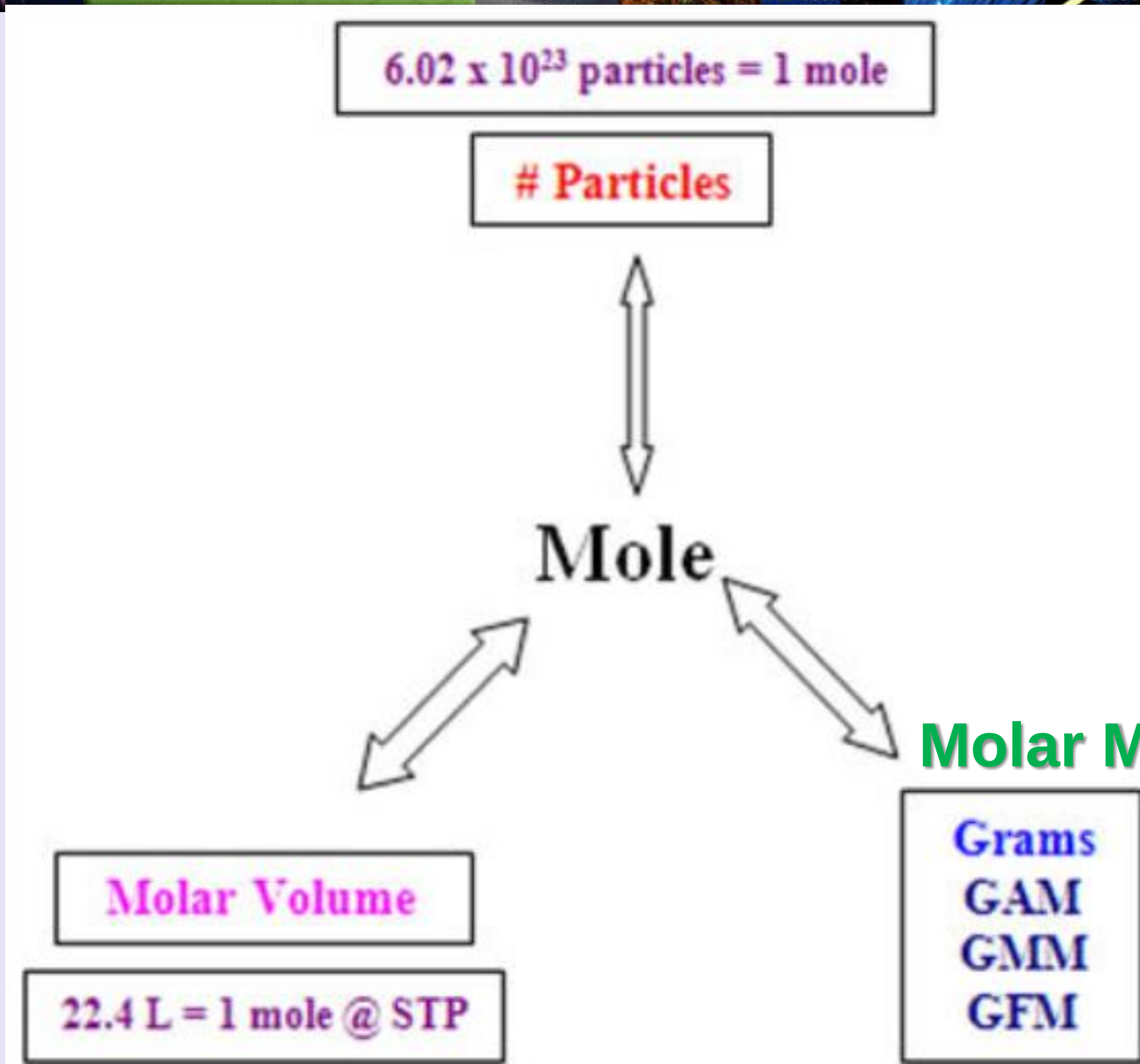
Chapter 10
Chemical Quantities

The Mole: A Measurement of Matter

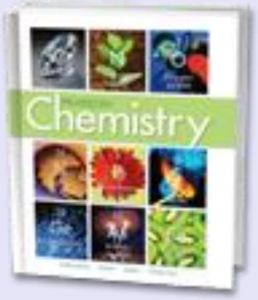
Mole-Mass and Mole-Volume Relationships

Percent Composition and Chemical Formulas





Molar Mass (g/mol)



Topics:

1. Molar Quantities

Objectives:

1. Understand and utilize the mole in mathematical computations according to the mole concept (Avogadro's Number).
2. Calculate Molar Mass of Elements and Compounds. Interconvert moles and mass.
3. Calculate Molar Volume at STP. Interconvert moles and liters, molar mass and density.

Name Examples of Standards in Real Life

Name Examples of Standards in Real Life

Safety standards

Quality standards

Standards of Use

Inclusion standards (who can use it)

Sustainability Standards

Privacy Standards

Electrical Standards

Boarding pass on an airline

Passport

Driver's license

Gas is sold by the gallon

Paying by credit card

Vehicle standards (mirrors, seat belts, lights, etc.)

How Are Scientists Able to Count the Number of Particles in Matter?

Avogadro's Number N_a

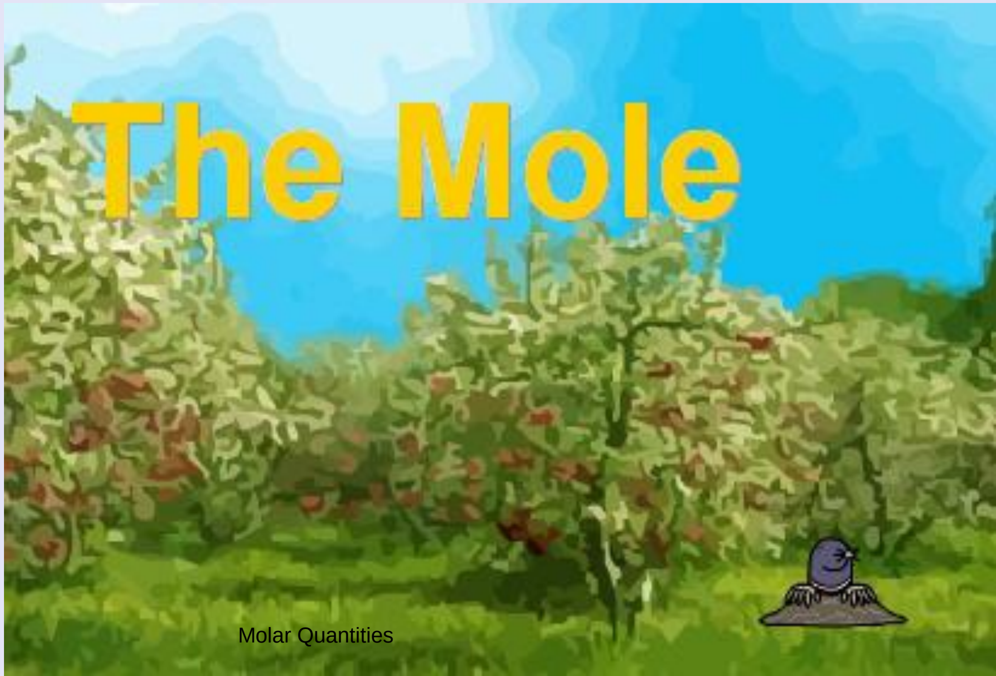
$= 6.02 \times 10^{23}$

GET YOUR CALCULATORS READY!!

Measuring Matter

Chemistry is both a **qualitative** and a **quantitative** science, meaning we **observe and describe matter**, and we **measure and quantify matter**.

To effectively measure and quantify matter, scientists use STANDARDS. Just as a "meter" is the standard unit of distance in the Metric system, scientists use the "MOLE" as a standard of chemical quantities.



Practical Example of Measuring Matter

STRATEGY

Apples can be measured in different ways.

At a fruit stand, they are often sold by **number**.

In a supermarket, you usually buy them by weight or **mass**.

At an orchard, you can buy apples by **volume**.

Using factor labeling we can interchange the various measurements.

Assume that 1 dozen apples = 2.0 kg = 0.20 bushels

Create conversion factors:

Practical Example of Measuring Matter

STRATEGY

Apples can be measured in different ways.

At a fruit stand, they are often sold by **number**.

In a supermarket, you usually buy them by weight or **mass**.

At an orchard, you can buy apples by **volume**.

Using factor labeling we can interchange the various measurements.

Assume that 1 dozen apples = 2.0 kg = 0.20 bushels

$$\frac{1\ \text{dozen apples}}{12\ \text{apples}} \qquad \frac{2.0\ \text{kg apples}}{1\ \text{dozen apples}} \qquad \frac{1\ \text{dozen apples}}{0.20\ \text{bushel apples}}$$

$$1\ \text{doz}/2.0\ \text{kg} = 2.0\ \text{kg}/1\ \text{doz} = 12\ \text{apples}/2.0\ \text{kg}$$

$$2.0\ \text{kg}/0.20\ \text{B} = 0.2\ \text{B}/1\ \text{doz} = 0.20\ \text{B}/2.0\ \text{kg}$$

Practical Example of Measuring Matter

From the conversion factors, one may determine **number**, **mass**, or **volume** depending on what is given.

Therefore, scientists need a STANDARD of comparison.

[e.g. just as the Spirit and the Bible are the standard for the universe.]

LESSON QUESTION

The Mole

The standard for mathematical (quantitative) measurement in chemical equations is the mole.

A **mole** (mol) of a substance is the SI unit for measuring the amount of a substance and is based on **Avogadro's number**.

The number of particles in a mole is

$$N_a = 6.022 \times 10^{23}$$

… *particles, atoms, molecules, you name it*

LESSON QUESTION

The Mole

Avogadro's number.

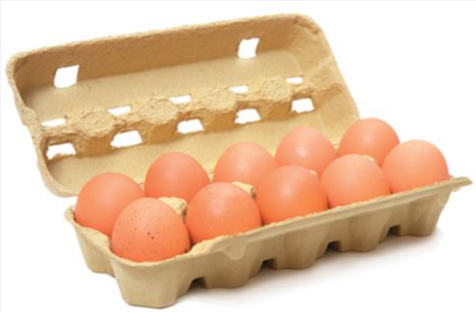
$$N_a = 6.022 \times 10^{23}$$

… particles, atoms, molecules, you name it

One mole of anything is N_a of that item.

A mole refers to a specific quantity (count / **number**, **mass** in grams, or **volume** in liters.

The mole concept is analogous to any set unit … e.g. a dozen (*12 of anything*)



Mole Song

Happy Mole Day! (October 23)

http://somup.com/cF6Qr8nnzh (1:58)

Simple Analogy

Fill in the table below:

TRY IT

1 Hamburger	2 Buns
	3 Strips of Bacon
	4 Pickles
10 Hamburgers	*Give the #*
	Buns
	Bacon
	Pickles
____Hamburgers	**40 Buns**
	Bacon
	Pickles
____Hamburgers	Buns
	18 Bacon
	Pickles
____Hamburgers	Buns
	Bacon
	12 Pickles
____Hamburgers	Buns
	Bacon
	Pickles

1 MiniVan	2 Headlights
	3 Seats
	4 Tires
	5 Doors
____ MiniVans	Headlights
	Seats
	Tires
	20 Doors
____ MiniVans	Headlights
	Seats
	12 Tires
	Doors
____ MiniVans	Headlights
	18 Seats
	Tires
	Doors
____ MiniVans	**20 Headlights**
	Seats
	Tires
	Doors

Simple Analogy
Fill in the table below:

TRY IT

1 Hamburger	2 Buns
	3 Strips of Bacon
	4 Pickles
10 Hamburgers	*Give the #*
	20 Buns
	30 Bacon
	40 Pickles
20 Hamburgers	**40 Buns**
	60 Bacon
	80 Pickles
6 Hamburgers	12 Buns
	18 Bacon
	24 Pickles
3 Hamburgers	6 Buns
	9 Bacon
	12 Pickles
____Hamburgers	Buns
	Bacon
	Pickles

1 MiniVan	2 Headlights
	3 Seats
	4 Tires
	5 Doors
4 MiniVans	8 Headlights
	12 Seats
	16 Tires
	20 Doors
3 MiniVans	6 Headlights
	9 Seats
	12 Tires
	15 Doors
6 MiniVans	12 Headlights
	18 Seats
	24 Tires
	30 Doors
10 MiniVans	**20 Headlights**
	30 Seats
	40 Tires
	50 Doors

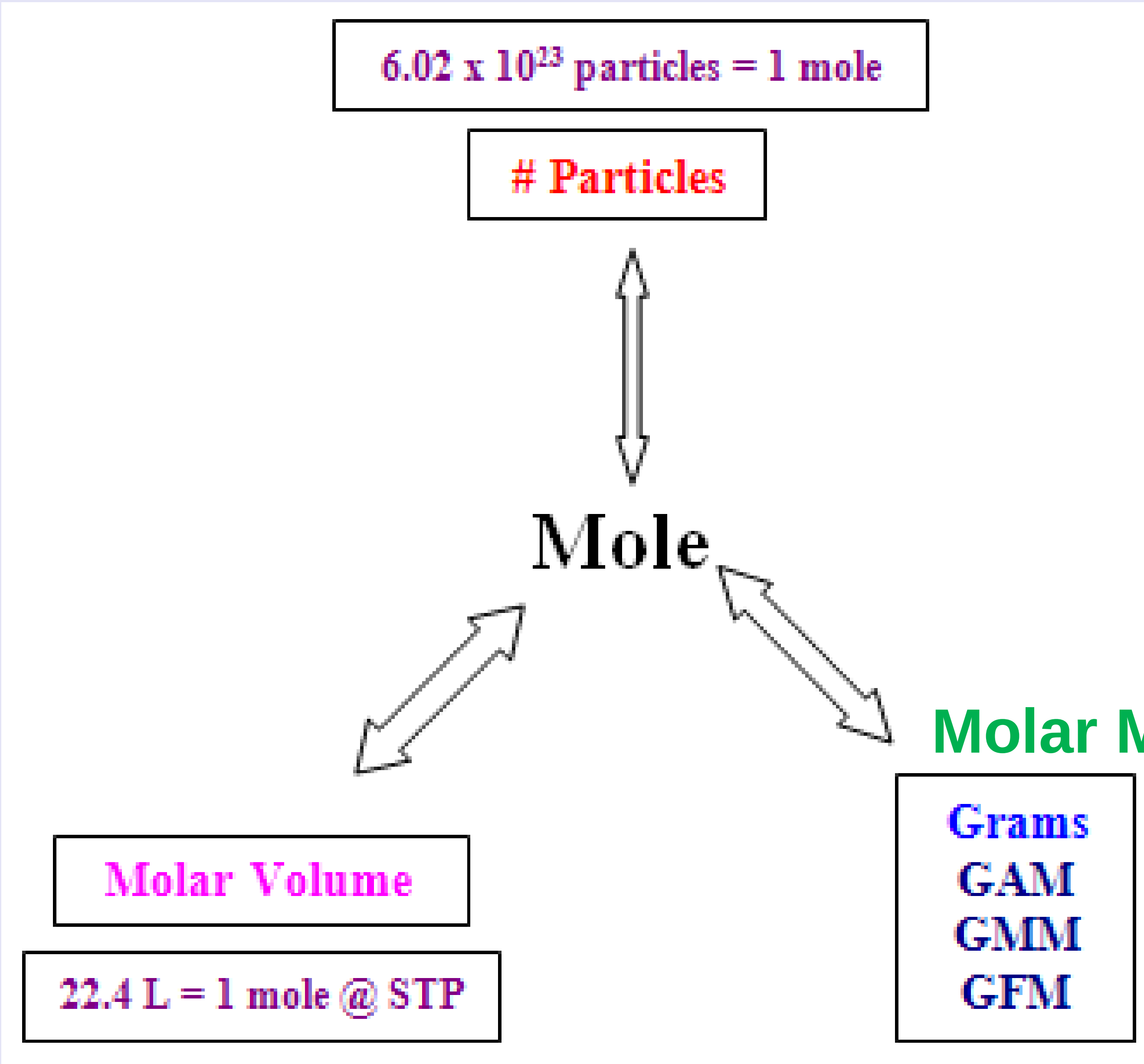
NOTE:

The number of hamburgers & minivans were the **STANDARD**s of comparison.

It works the same way using “Moles”.

This is why we use **COEFFICIENTS** in chemical equations.

The Mole Concept



A mole refers to a specific quantity:

number, **mass**, **volume**.

Molar Mass (g/mol)

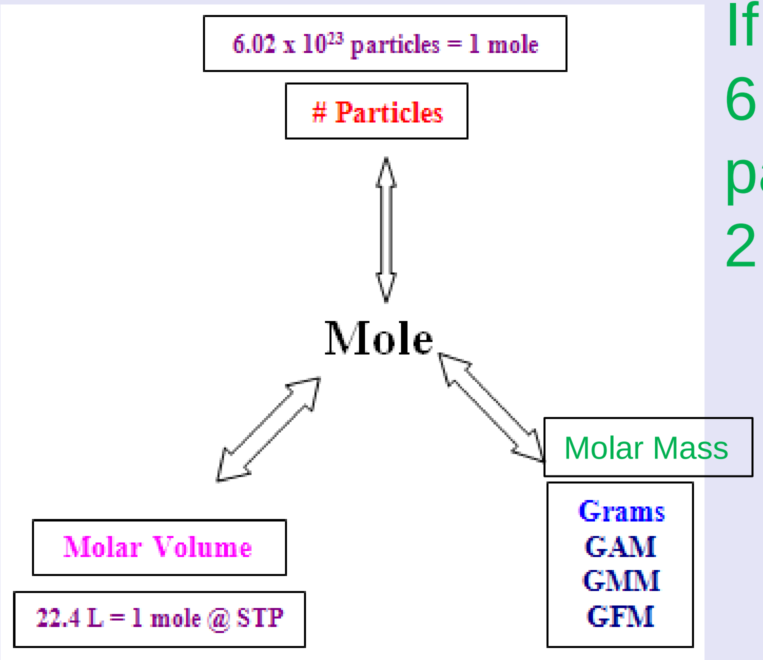
GAM (gram atomic mass)

GMM (gram molecular mass) (covalent)

GFM = (gram formula mass) (ionic)

The Mole Concept

QUICK CHECK

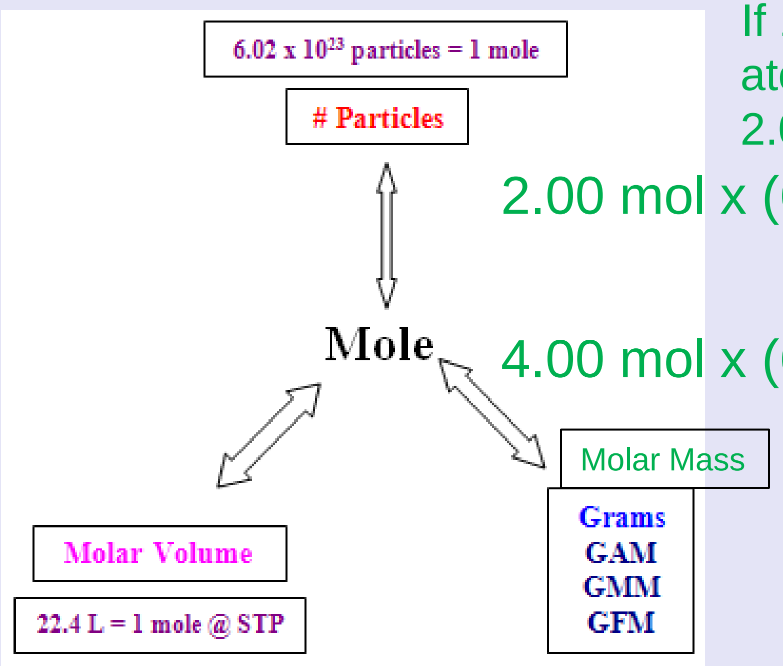


If 1.00 mole of mercury has 6.02×10^{23} atoms (or particles). How many will be in 2.00 moles? 4.00 moles?

If 22.4 L is 1.00 mole of a gas, how many liters are in 5.00 moles? 10.0 moles?

How many grams are in 1.00 mole of Copper? (*Use Periodic Table*) 3.00 moles? 6.00 moles?

The Mole Concept



QUICK CHECK

If 1 mole of mercury has 6.02×10^{23} atoms (or particles). How many will be in 2.00 moles? 4.00 moles?

2.00 mol x (6.02×10^{23} atoms/mol) = 12.04×10^{23} atoms

1.20×10^{24} atoms

4.00 mol x (6.02×10^{23} atoms/mol) = 24.08×10^{23} atoms

2.41×10^{24} atoms

number, volume, mass

If 22.4 L is 1.00 mole of a gas, how many liters are in 5.00 moles? 10.0 moles?

5.00 mol x 22.4 L/mol = 112 liters

10.0 mol x 22.4 L/mol = 224 liters

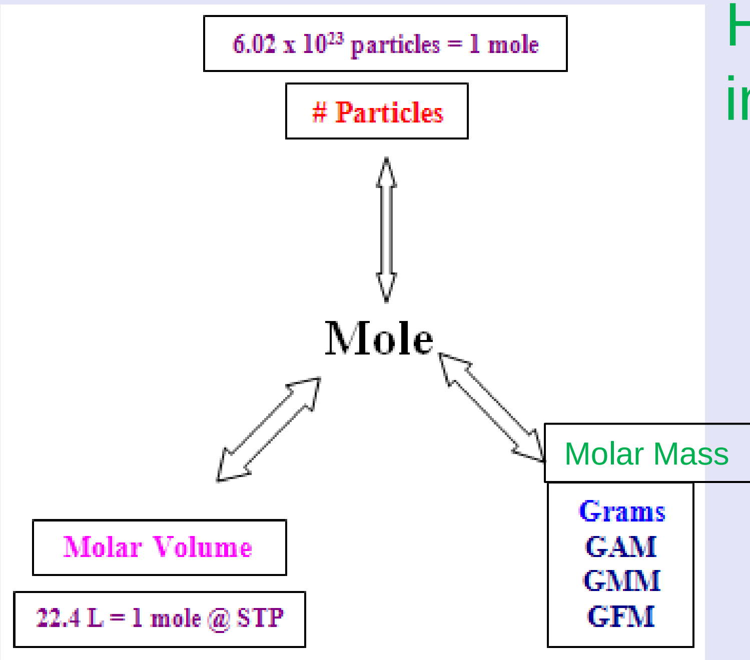
How many grams are in 1.00 mole of Copper? (Use Periodic Table) 3.00 moles? 6.00 moles?

1.00 mol Cu = 63.5 g

3.00 mol x 63.5 g/mol = 191 g

6.00 mol x 63.5 g/mol = 381 g

The Mole Concept



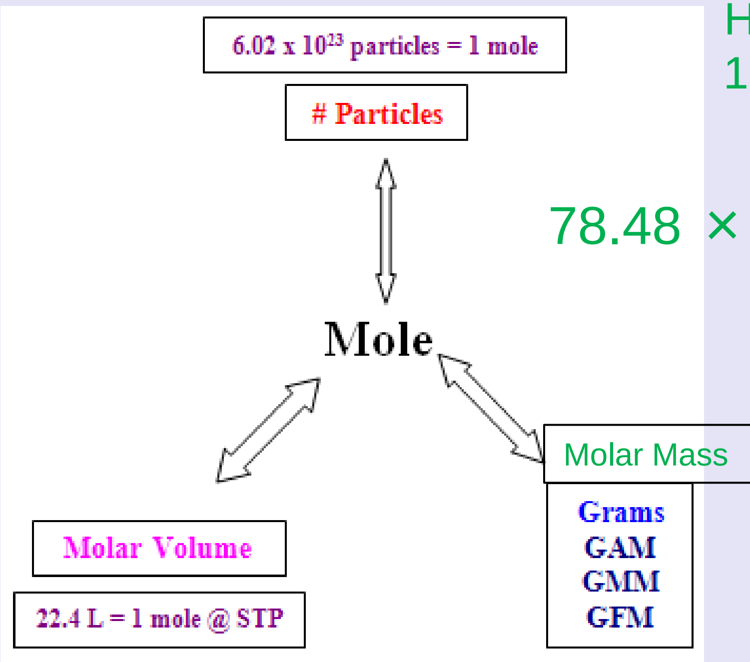
How many moles of NaCl are in 78.48×10^{23} particles?

How many moles of $CO_{2\,(g)}$ are in 356 Liters?

How many moles of calcium are there if one has 242 g?

The Mole Concept

QUICK CHECK



How many moles of NaCl are in 78.48×10^{23} particles?

78.48×10^{23} particles x 1 mol / 6.022×10^{23} particles)

= 13.04 moles

number, volume, mass

How many moles of $CO_{2\,(g)}$ are in 356 Liters?

356 L x 1 mol/22.4 L = 15.9 moles

How many moles of calcium are there if one has 242 g?

242 g Ca x 1 mol/40.08 g =

= 6.04 moles

The Chemist's Dozen

mole (mol): the SI unit for the amount of a substance; a mole is defined as the number of atoms in 12 g of C-12, or 6.02×10^{23}

GAM

1 mole Mg

? g

? atoms

? L if a gas

GMM

1 mole H_2O

? g

? molecules

? L if a gas

GFM

1 mole NaCl

? g

? formula units

? L if a gas

The Chemist’s Dozen

mole (mol): the SI unit for the amount of a substance; a mole is defined as the number of atoms in 12 g of C-12, or 6.02×10^{23}

GAM

1 mole Mg

Periodic Table → 24.31 g

6.02×10^{23} atoms

22.4 L if a gas

GMM

1 mole H_2O

2(1.008) + 16.00 = 18.01 g

6.02×10^{23} molecules

22.4 L if a gas

GFM

1 mole NaCl

22.99 + 35.45 = 58.44 g

6.02×10^{23} formula units

22.4 L if a gas

Calculating Avogadro's Number

One atom of carbon-12 has a mass of 12.00 amu. How many atoms of carbon-12 are in 12.00 g? [1.66×10^{-24} g = 1 amu]

- Set up calculation:
- Cancel units and solve:

Calculating Avogadro's Number

Enrichment

One atom of carbon-12 has a mass of 12.00 amu. How many atoms of carbon-12 are in 12.00 g?

- Set up calculation (use AGES & factor label):

$$12.00 \text{ g C-12} \times \frac{1 \text{ amu}}{1.66 \times 10^{-24} \text{ g}} \times \frac{1 \text{ atom C-12}}{12.00 \text{ amu}}$$

- Cancel units and solve:

$$12.00 \cancel{\text{g}} \text{ C-12} \times \frac{1 \cancel{\text{amu}}}{1.66 \times 10^{-24} \cancel{\text{g}}} \times \frac{1 \text{ atom C-12}}{12.00 \cancel{\text{amu}}} = 6.02 \times 10^{23} \text{ atoms C-12}$$

TRY IT

How many moles of the element magnesium is equal to 1.25×10^{23} atoms of magnesium? How many grams does this represent?

Determining Moles using Number

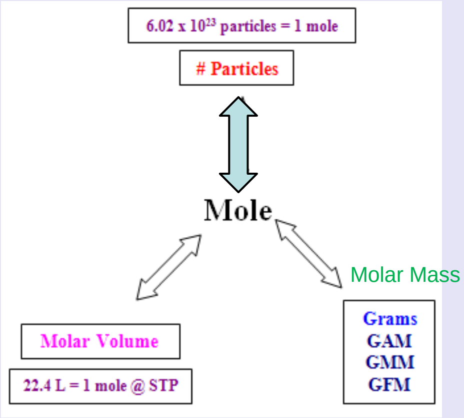
How many moles of the element magnesium is equal to 1.25×10^{23} atoms of magnesium? How many grams does this represent?

Multiply the number of atoms of Mg by the conversion factor.

$$1.25 \times 10^{23} \text{ ~~atoms Mg~~} \times \frac{1 \text{ mol Mg}}{6.02 \times 10^{23} \text{ ~~atoms Mg~~}} = 0.208 \text{ mol Mg}$$

Multiply the number of moles of Mg by GAM.

$$0.208 \text{ mol Mg} \times 24.305 \text{ g/mol} = 5.06 \text{ g}$$



Converting Moles to Number of Atoms

Propane is a gas used for cooking and heating. How many atoms are in 2.12 moles of propane (C_3H_8)?

Converting Moles to Number of Atoms

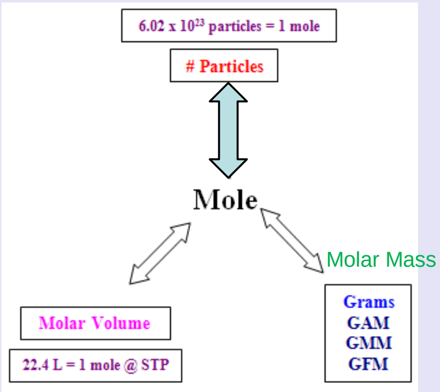
Propane is a gas used for cooking and heating. How many atoms are in 2.12 moles of propane (C_3H_8)? There are **11 atoms/molecule** of propane and 6.022×10^{23} molecules in a mole:

Multiply the number of molecules of propane conversion factor.

$$2.12 \text{ mol } C_3H_8 \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol } C_3H_8} = 12.77 \times 10^{23} \text{ molecules}$$

Multiply the number of atoms / molecule conversion factor.

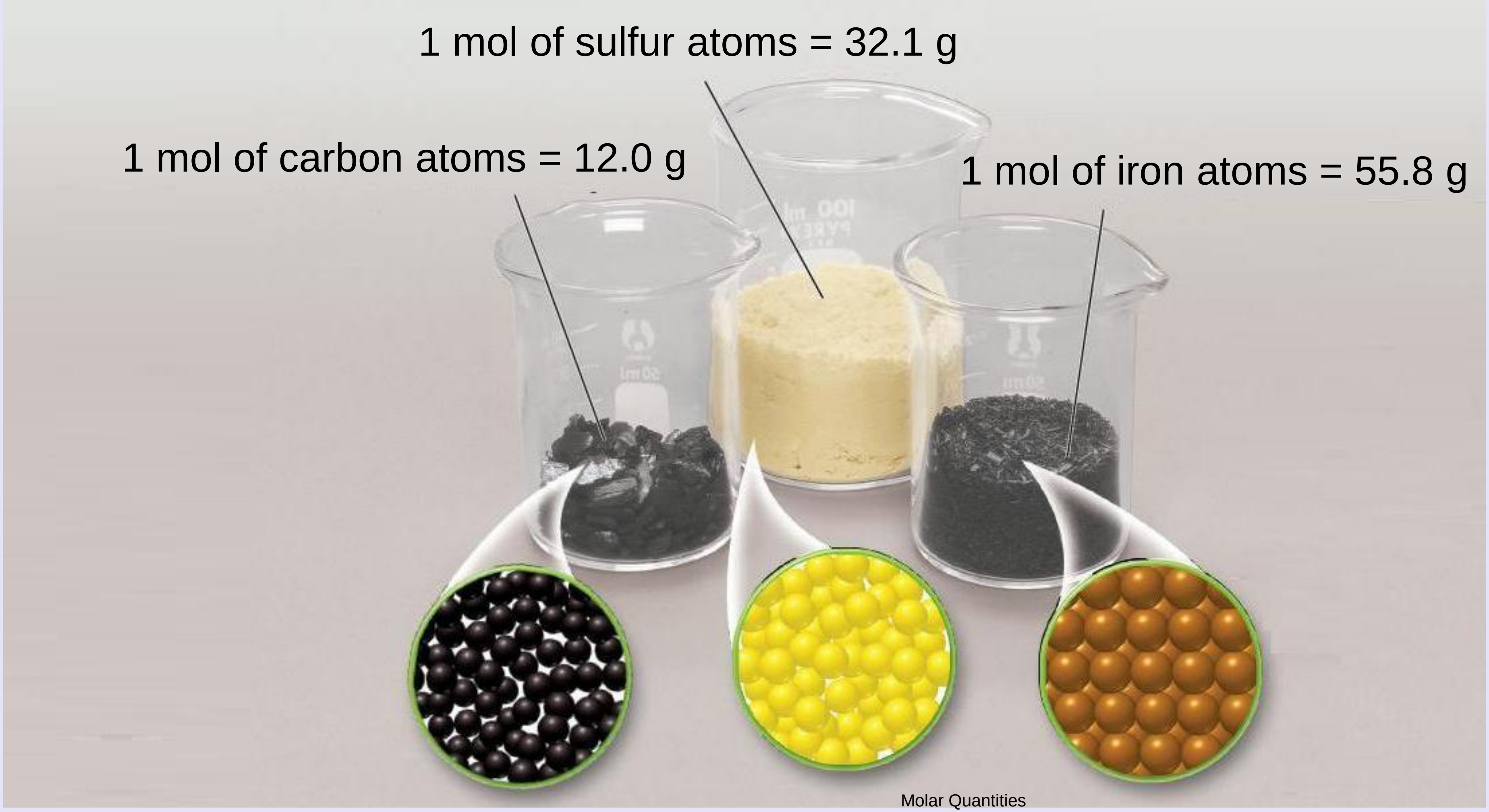
$$12.77 \times 10^{23} \text{ molecules } C_3H_8 \times \frac{11 \text{ atoms}}{1 \text{ molecule } C_3H_8} = 140.4 \times 10^{23} \text{ atoms}$$



$$= 1.40 \times 10^{25} \text{ atoms}$$

Molar Mass

Molar mass (g/mol) is when there is 1 mol or 6.02 x 10^{23} atoms/units of a particular element or compound.



Molar Quantities

Molar Mass

GAM (Gram Atomic Mass)

The molar mass of an element, in grams per mole, has the same value as the average atomic mass of the element in amu's.

E.g. $_{34}Se^{79}$ atomic mass =

Similarly, _____ is the molar mass of magnesium, meaning that 1 mol (*or 6.02 x 10^{23} atoms of magnesium*) has a mass of ? g.

What are the molar mass (GAM) of the following elements?

1 mole of potassium atoms (K) = ?

1 mole of aluminum atoms (Al) = ?

1 mole of oxygen molecules (O_2) = ?

Remember Professor HOFBrINCl? (diatomic elements)

Molar Mass

GAM (Gram Atomic Mass)

The molar mass of an element, in grams per mole, has the same value as the average atomic mass of the element in amu's.

E.g. $_{34}Se^{79}$ atomic mass = 79.0 amu GAM = 79.0 g/mol

Similarly, 24.3 g/mol is the molar mass of magnesium, meaning that 1 mol (*or 6.02 x 10^{23} atoms of magnesium*) has a mass of 24.3 g.

What are the molar mass (GAM) of the following elements?

1 mole of potassium atoms (K) = 39.1 g/mol

1 mole of aluminum atoms (Al) = 27.0 g/mol

1 mole of oxygen molecules (O_2) = 16.0 x 2 = 32.0 g/mol

Remember Professor HOFBrINCl? (diatomic elements)

The Mass of a Mole of a Compound

Molar Mass

To find the molar mass of a compound, add the atomic masses of the atoms that make up the molecule.

A molecule of H_3PO_4 is composed of three Hydrogen atoms, one Phosphorus atom, and four of oxygen atoms (*round masses*).

H_3PO_4					
Atom	# atoms in Formula		Atomic Mass		Total Mass of Element
H					
P		X		=	
O					

The Mass of a Mole of a Compound

Molar Mass

To find the molar mass of a compound, add the atomic masses of the atoms that make up the molecule.

A molecule of H_3PO_4 is composed of three Hydrogen atoms, one Phosphorus atom, and four of oxygen atoms (*round masses*).

H_3PO_4					
Atom	# atoms in Formula		Atomic Mass		Total Mass of Element
H	3	x	1	=	3
P	1		31		31
O	4		16		64
					98 amu

1 mol of H_3PO_4 has a mass of 98 g.

This is the mass of 6.02×10^{23} molecules of H_3PO_4 .

Molar Mass of a Compound

TRY IT

Determine the molar masses of table salt and carbon dioxide.

1 compound NaCl =

1 molecule CO_2 =

Molar Mass of a Compound

TRY IT

Determine the molar masses of table salt and carbon dioxide.

1 compound NaCl = (1 x 23 amu) + (1 x 35 amu) = 58 amu

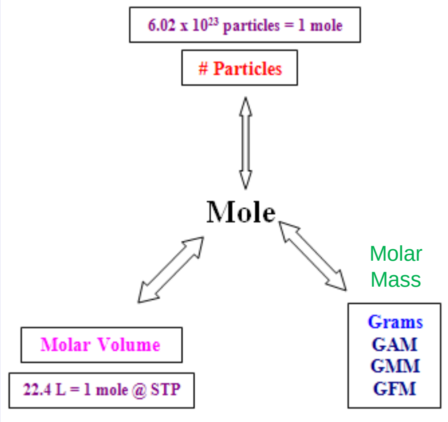
1 mol of NaCl = 6.02 x 10^{23} NaCl cmpds = 58 grams → "**GFM**"

Na	1 x 23 g/mol
Cl	1 x 35 g/mol
	58 g/mol

1 molecule CO_2 = (1 x 12 amu) + (2 x 16 amu) = 44 amu

1 mole CO_2 = 6.02 x 10^{23} CO_2 molecules = 44 grams → "**GMM**"

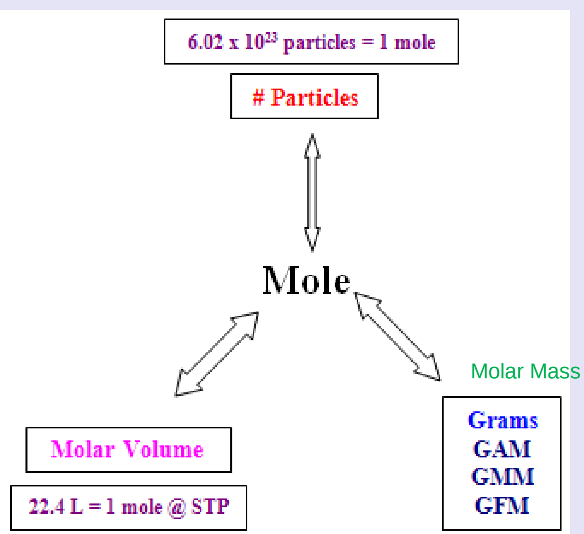
C	1 x 12 g = 12 g/mol
O	2 x 16 g = 32 g/mol
	44 grams/mol



TRY IT

Molar Mass of a Compound

Determine the molar mass of 1 mol of glucose ($C_6H_{12}O_6$) molecules (blood sugar).



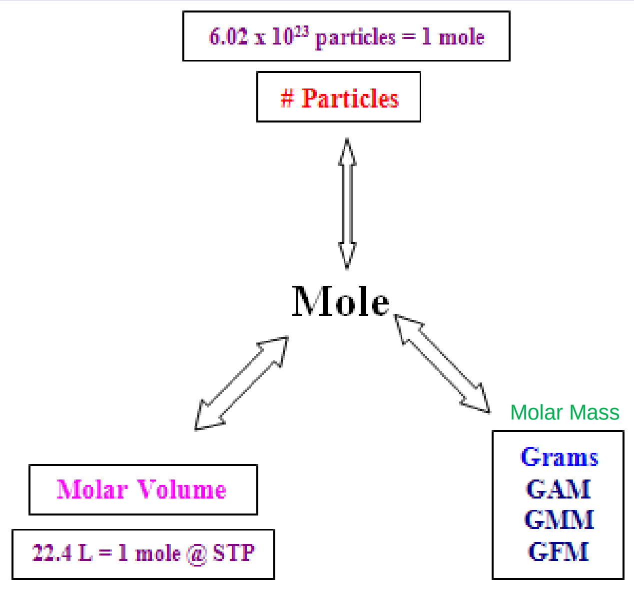
The molar mass of an element, in grams per mole, has the same value as the average atomic mass of the element in amu's.

TRY IT

Molar Mass of a Compound

Determine the molar mass of 1 mol of glucose ($C_6H_{12}O_6$) molecules (blood sugar).

C	6 x 12 g/mol	=	72 g/mol
H	12 x 1 g/mol	=	12 g/mol
O	6 x 16 g/mol	=	96 g/mol
			180 g/mol $C_6H_{12}O_6$



The molar mass of an element, in grams per mole, has the same value as the average atomic mass of the element in amu's.

EXAMPLE

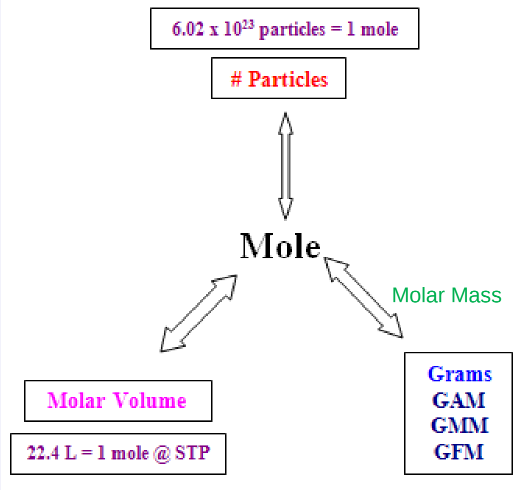
Converting Moles to Mass

What is the mass, in grams, of 9.45 mol of aluminum oxide, (Al_2O_3)?

Converting Moles to Mass

What is the mass, in grams, of 9.45 mol of aluminum oxide, (Al_2O_3)? First determine the mass of 1 mol of Al_2O_3:

Al	2 x 27.0 g/mol	=	54.0 g/mol
O	3 x 16.0 g/mol	=	48.0 g/mol
			102.0 g/mol Al_2O_3



Multiply the given number of moles by the conversion factor.

$$9.45 \text{ mol } Al_2O_3 \times \frac{102.0 \text{ g } Al_2O_3}{1 \text{ mol } Al_2O_3}$$

$$= 964 \text{ g } Al_2O_3$$

Converting Mass to Moles

Rust is iron(III) oxide (Fe_2O_3). How many moles of iron(III) oxide are contained in 92.2 g of pure Fe_2O_3?

Converting Mass to Moles

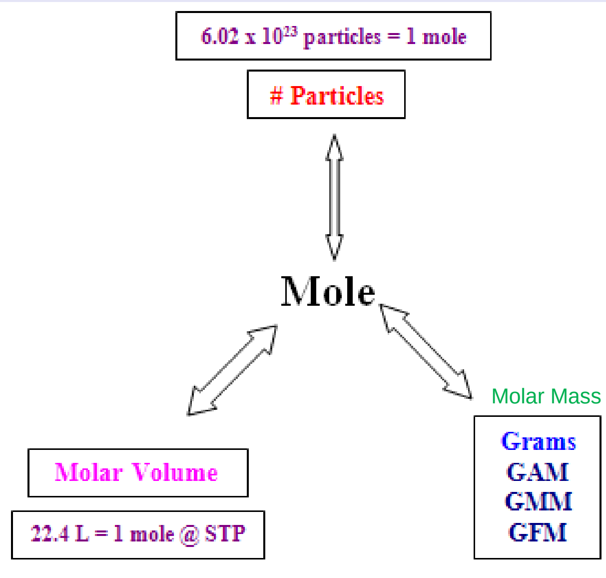
Rust is iron(III) oxide (Fe_2O_3). How many moles of iron(III) oxide are contained in 92.2 g of pure Fe_2O_3?

Fe	2 x 55.8 g/mol	=	111.6 g/mol
O	3 x 16.0 g/mol	=	48.0 g/mol
			159.6 g/mol Fe_2O_3

Multiply the given mass by the conversion factor.

$$92.2 \text{ g } Fe_2O_3 \times \frac{1 \text{ mol } Fe_2O_3}{159.6 \text{ g } Fe_2O_3}$$

$$= 0.578 \text{ mol } Fe_2O_3$$



Molar Volume

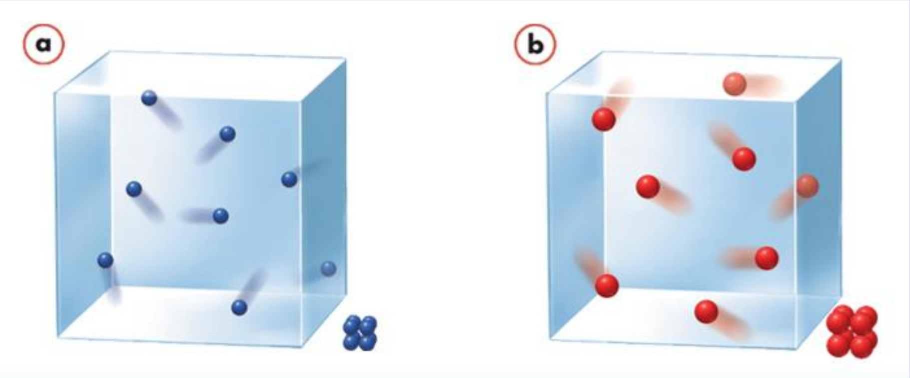
Avogadro's hypothesis

Equal volumes of gases at the same temperature and pressure contain equal numbers of particles.

Standard temperature and pressure (STP) means a temperature of 0 ºC (273 K) and a pressure of 101.3 kPa, or 1 atm.

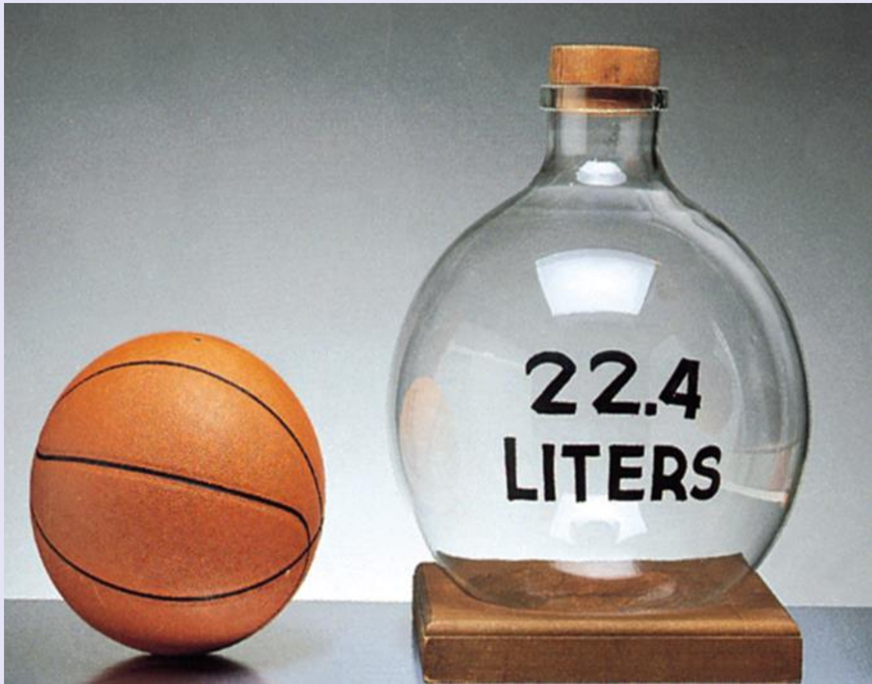
At STP, 1 mol, or 6.02×10^{23} particles, of any gas occupies a volume of 22.4 L.

The quantity, 22.4 L, is called the **molar volume** of a gas.



Molar Volume

Sulfur dioxide (SO_2) gas is an air pollutant produced by burning coal. Determine the volume, in liters, of 0.60 mol SO_2 gas at STP.



Molar Volume

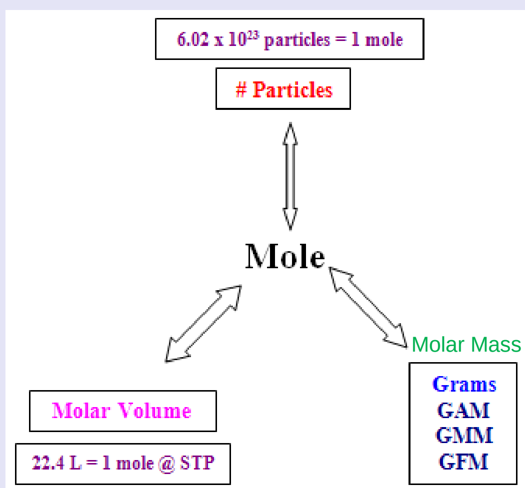
Sulfur dioxide (SO_2) gas is an air pollutant produced by burning coal. Determine the volume, in liters, of 0.60 mol SO_2 gas at STP.

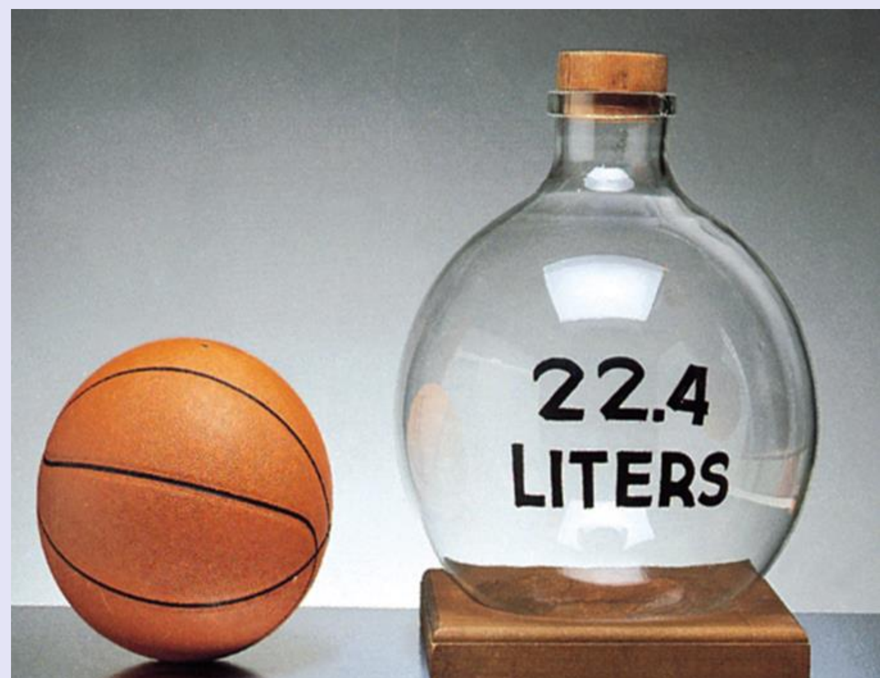
$$1 \text{ mol gas @ STP} = 22.4 \text{ L} \rightarrow \frac{22.4 \text{ L}}{1 \text{ mol}} \text{ and } \frac{1 \text{ mol}}{22.4 \text{ L}}$$

Multiply the given number of moles by the conversion factor.

$$0.60 \text{ mol } SO_2 \times \frac{22.4 \text{ L } SO_2}{1 \text{ mol } SO_2}$$

$$= 13 \text{ L } SO_2$$





Calculating Molar Mass and Density

Using factor labelling, one can interconvert density & molecular mass. Usually the density of a gas is measured in grams per liter (g/L) and at a specific temperature.

The density of a gaseous compound containing carbon and oxygen is found to be 1.964 g/L at STP. What is the molar mass of the compound?

Calculating Molar Mass and Density

Using factor labelling, one can interconvert density & molecular mass. Usually the density of a gas is measured in grams per liter (g/L) and at a specific temperature.

The density of a gaseous compound containing carbon and oxygen is found to be 1.964 g/L at STP. What is the molar mass of the compound?

Set it up to find molar mass → g/mol

$$1.964\ g/L \qquad = \ ?\ g/mol$$

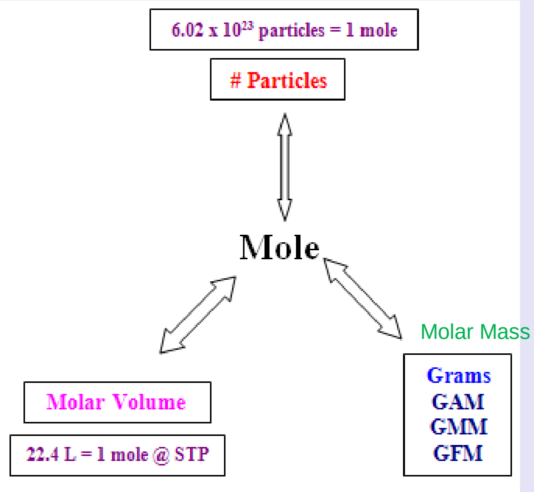
Calculating Molar Mass and Density

Using factor labelling, one can interconvert density & molecular mass. Usually the density of a gas is measured in grams per liter (g/L) and at a specific temperature.

The density of a gaseous compound containing carbon and oxygen is found to be 1.964 g/L at STP. What is the molar mass of the compound?

Since density is g/L, we know that liters and moles are related.

Factor label the given density by the molar volume conversion factor.



$$\frac{1.964\ g}{1\ \cancel{L}} \times \frac{22.4\ \cancel{L}}{1\ mol} = 44.0\ g/mol$$

Molar Quantities

Calculating Molar Mass and Density

200 ml of a gas (@STP) has a mass of 0.396 g. What is the molecular mass of this gas?

Calculating Molar Mass and Density

200 ml of a gas (@STP) has a mass of 0.396 g. What is the molecular mass of this gas?

Set it up to find molar mass → g/mol

Put mass over volume (density):

0.396 **g** / 200 mL = ? **g/mol**

0.396 **g** / 200 mL x 1000 ml / 1 L x 22.4 L/**mol** = 44.4 **g/mol**

OR

Next slide …

Calculating Molar Mass and Density

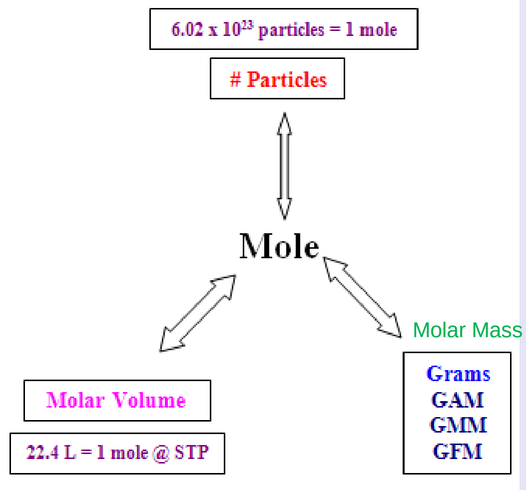
200 ml of a gas (@STP) has a mass of 0.396 g. What is the molecular mass of this gas?

Since mass and volume are given, determine the density of the gas [hint: set up units to solve for molar mass → g/mol]

D = M/V   D = 0.396 g / 200 ml x 1000 ml / 1 L = 1.98 g/L

Factor label the density into molecular mass

1.98 g/L x 22.4 L / mol @ STP = **44.4 g/mol**



Molar Quantities

Calculating Molar Mass and Density

Determine the density of SO_2 *gas @ STP.*

Calculating Molar Mass and Density

Determine the density of SO_2 gas @ STP.

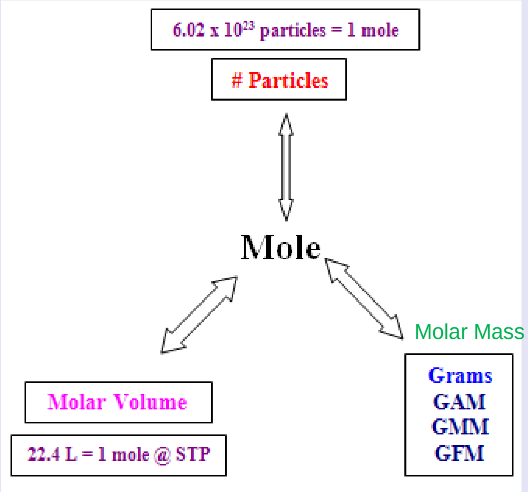
Since the molecular formula is given, determine the molecular mass of the gas

S	1 x 32.1 g/mol	=	32.1 g/mol
O	2 x 16.0 g/mol	=	32.0 g/mol
			64.1 g/mol SO_2 *gas*

Convert molecular mass into density @ STP (**factor label the UNITS**)

64.1 g/mole x 1 mol / 22.4 L @ STP = 2.9 g / L

Confirm your answer by checking Reference Table C



QUICK CHECK

Review

Determine the number of moles in 56.0 g of magnesium phosphate ($Mg_3(PO_4)_2$):

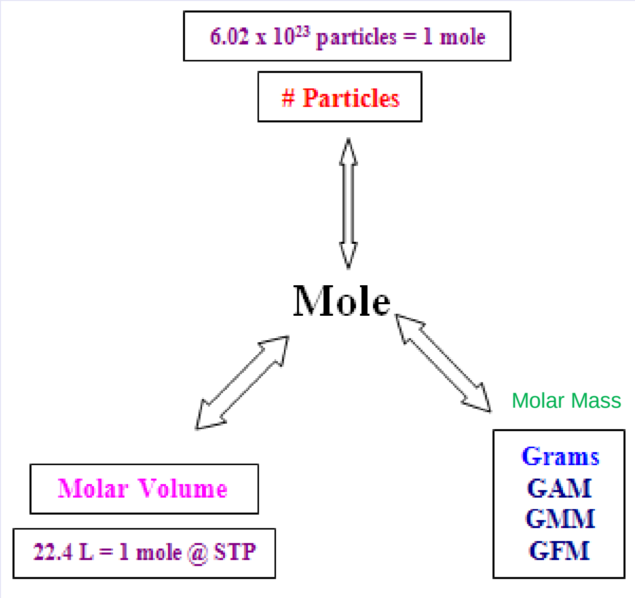
QUICK CHECK

Review

Determine the number of moles in 56.0 g of magnesium phosphate ($Mg_3(PO_4)_2$):

Mg	3 x 24.3 g/mol =	72.9 g/mol
P	2 x 31.0 g/mol =	62.0 g/mol
O	8 x 16.0 g/mol =	128.0 g/mol
		262.9 g/mol $Mg_3(PO_4)_2$

$$56.0 \text{ g} \times \frac{1 \text{ mol}}{262.9 \text{ g}} = 0.213 \text{ mol } Mg_3(PO_4)_2$$



Review

The molar mass of water (H_2O) is 18.00 g/mol. What is the mass of 8.21×10^{25} molecules of water?

QUICK CHECK

The molar mass of water (H_2O) is 18.00 g/mol. What is the mass of 8.21×10^{25} molecules of water?

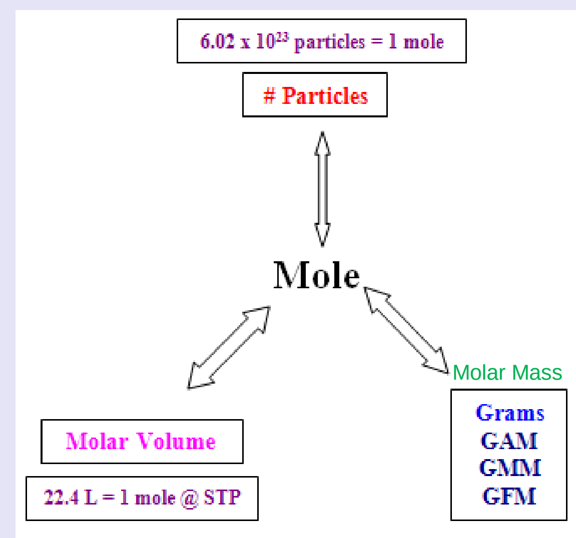
QUICK CHECK

Go to the STANDARD first (moles)

$$8.21 \times 10^{25} \cancel{\text{molecules } H_2O} \times \frac{1 \text{ mol Mg}}{6.02 \times 10^{23} \cancel{\text{molecules } H_2O}} = 1.36 \times 10^{2} \text{ mol } H_2O$$

Convert moles to grams

$$1.36 \times 10^{2} \text{ mol } H_2O \times 18.00 \text{ g/mol} = 2.45 \times 10^{3} \text{ g } H_2O$$



Calculate Molar Mass

Give the molar mass of each element.

Use the Periodic Table

Potassium (K):

Osmium (Os):

Manganese (Mn):

The isotope lead-208 (^{208}Pb):

The isotope strontium-87 (^{87}Sr):

Calculate the molar mass of each compound.

Ammonia (NH_3):

Lead(II) chloride ($PbCl_2$):

Acetic acid (CH_3COOH):

Magnesium hydroxide ($Mg(OH)_2$):

Iron(III) oxide (Fe_2O_3):

Calculate Molar Mass

Give the molar mass of each of the following elements.

Use the Periodic Table

Potassium (K):

39.1 g/mol

Osmium (Os):

190. g/mol

Manganese (Mn):

54.9 g/mol

The isotope lead-208 (^{208}Pb):

208 g/mol

The isotope strontium-87 (^{87}Sr):

87.6 g/mol

Calculate the molar mass of each compound.

Ammonia (NH_3):

N	1 x 14.0 g/mol	= 14.0 g/mol
H	3 x 1.00 g/mol	= 3.00 g/mol
		= 17.0 g/mol

Lead(II) chloride ($PbCl_2$):

Pb	1 x 207.2 g/mol	= 207.2 g/mol
Cl	2 x 35.5 g/mol	= 71.0 g/mol
		= 278 g/mol

Acetic acid (CH_3COOH):

C	2 x 12.0 g/mol	= 24.0 g/mol
H	4 x 1.0 g/mol	= 4.0 g/mol
O	2 x 16.0 g/mol	= 32.0 g/mol
		= 60.0 g/mol

Magnesium hydroxide ($Mg(OH)_2$):

Mg	1 x 24.3 g/mol	= 24.3 g/mol
H	2 x 1.00 g/mol	= 2.00 g/mol
O	2 x 16.0 g/mol	= 32.0 g/mol
		= 58.3 g/mol

Iron(III) oxide (Fe_2O_3):

Fe	2 x 55.8 g/mol	= 111.6 g/mol
O	3 x 16.0 g/mol	= 48.0 g/mol
		= 160. g/mol

Convert between Mass, Particles, & Volume

How many atoms of phosphorus (P) are in a sample that has a mass of 172.90 g?

Determine the mass of the sample described below.

8.32×10^{20} formula units $CaBr_2$

A gas cylinder contains 9.03×10^{24} molecules of oxygen gas (O_2). How many liters of oxygen are in the cylinder?

Convert between Mass, Particles, & Volume

How many atoms of phosphorus (P) are in a sample that has a mass of 172.9 g?

172.9 g x 1 mol/30.97 g P = 5.583 mol

5.583 mol x 6.022 × 10^{23} atoms/mol =

= 3.362 × 10^{24} atoms

A gas cylinder contains 9.03 × 10^{24} molecules of oxygen gas (O_2). How many liters of oxygen are in the cylinder?

9.03 × 10^{24} molecules x 1 mol/6.02 × 10^{23} molecules

= 15.0 moles

15.0 mol x 22.4 L/mol = 336 L O_2

Determine the mass of the sample described below.

8.32 × 10^{20} formula units $CaBr_2$

8.32 × 10^{20} f units x 1 mol/6.02 × 10^{23} f. units

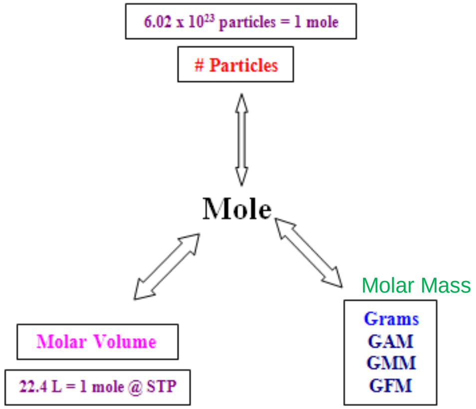
= 1.38 x 10^{-3} moles

Ca 1 x 40.1 g/mol= 40.1 g/mol

Br 2 x 79.9 g/mol= <u>159.8 g/mol</u>

= 199.9 g/mol $CaBr_2$

1.38 x 10^{-3} mol x 199.9 g/mol = 0.276 g $CaBr_2$



s-block

Period	1 IA
1	1.00794 +1 −1 **H** 1 $1s^1$

KEY

Atomic Mass → 12.0111
Selected Oxidation States → −4 +2 +4
Symbol → **C**
Atomic Number → 6
Electron Configuration → $1s^2 2s^2 2p^2$

Relative atomic masses are based on ^{12}C = 12.00000

New Designation
Former Designation (prior to 1984 IUPAC decision)

d-block

Transition Elements

Period	*s*-block GROUP 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 (VIII)	9 (VIII)	10 (VIII)	
2	6.941 +1 **Li** 3 $1s^2 2s^1$	9.01218 +2 **Be** 4 $1s^2 2s^2$									
3	22.98977 +1 **Na** 11 $[Ne]3s^1$	24.305 +2 **Mg** 12 $[Ne]3s^2$									
4	39.0983 +1 **K** 19 $[Ar]4s^1$	40.08 +2 **Ca** 20 $[Ar]4s^2$	44.9559 +3 **Sc** 21 $[Ar]3d^1 4s^2$	47.88 +2 +3 +4 **Ti** 22 $[Ar]3d^2 4s^2$	50.9415 +2 +3 +4 +5 **V** 23 $[Ar]3d^3 4s^2$	51.996 +2 +3 +6 **Cr** 24 $[Ar]3d^5 4s^1$	54.9380 +2 +3 +4 +7 **Mn** 25 $[Ar]3d^5 4s^2$	55.847 +2 +3 **Fe** 26 $[Ar]3d^6 4s^2$	58.9332 +2 +3 **Co** 27 $[Ar]3d^7 4s^2$	58.69 +2 +3 **Ni** 28 $[Ar]3d^8 4s^2$	63.54 29 [Ar]3d
5	85.4678 +1 **Rb** 37 $[Kr]5s^1$	87.62 +2 **Sr** 38 $[Kr]5s^2$	88.9059 +3 **Y** 39 $[Kr]4d^1 5s^2$	91.224 +4 **Zr** 40 $[Kr]4d^2 5s^2$	92.9064 +3 +5 **Nb** 41 $[Kr]4d^4 5s^1$	95.94 +3 +6 **Mo** 42 $[Kr]4d^5 5s^1$	(98) +4 +6 +7 **Tc** 43 $[Kr]4d^6 5s^1$	101.07 +3 **Ru** 44 $[Kr]4d^7 5s^1$	102.906 +3 **Rh** 45 $[Kr]4d^8 5s^1$	106.42 +2 +4 **Pd** 46 $[Kr]4d^{10} 5s^0$	107.86 47 [Kr]4d
6	132.905 +1 **Cs** 55 $[Xe]6s^1$	137.33 +2 **Ba** 56 $[Xe]6s^2$	**La-Lu** 57 71	178.49 +4 **Hf** 72 $[Xe]4f^{14} 5d^2 6s^2$	180.948 +5 **Ta** 73 $[Xe]4f^{14} 5d^3 6s^2$	183.85 +6 **W** 74 $[Xe]4f^{14} 5d^4 6s^2$	186.207 +4 +6 +7 **Re** 75 $[Xe]4f^{14} 5d^5 6s^2$	190.2 +3 +4 **Os** 76 $[Xe]4f^{14} 5d^6 6s^2$	192.22 +3 +4 **Ir** 77 $[Xe]4f^{14} 5d^7 6s^2$	195.08 +2 +4 **Pt** 78 $[Xe]4f^{14} 5d^9 6s^1$	196.96 79 [Xe]4f
7	(223) +1 **Fr** 87 $[Rn]7s^1$	226.025 +2 **Ra** 88 $[Rn]7s^2$	**Ac-Lr** 89 103	(261) **Unq*** 104	(262) **Unp** 105	(263) **Unh** 106	(262) **Uns** 107	**Uno** 108	**Une** 109		

* The sys
103 wil

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2.00000

lation States

s-block

18

O

18 O
4.00260 **He** 2 — 0 — $1s^2$

p-block

GROUP

	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 O
Period 2				10.81 **B** 5 — +3 — $1s^2 2s^2 2p^1$	12.0111 **C** 6 — −4, +2, +4 — $1s^2 2s^2 2p^2$	14.0067 **N** 7 — −3, −2, −1, +1, +2, +3, +4, +5 — $1s^2 2s^2 2p^3$	15.9994 **O** 8 — −2 — $1s^2 2s^2 2p^4$	18.998403 **F** 9 — −1 — $1s^2 2s^2 2p^5$	20.179 **Ne** 10 — 0 — $1s^2 2s^2 2p^6$
Period 3				26.98154 **Al** 13 — +3 — $[Ne]3s^2 3p^1$	28.0855 **Si** 14 — −4, +2, +4 — $[Ne]3s^2 3p^2$	30.97376 **P** 15 — −3, +3, +5 — $[Ne]3s^2 3p^3$	32.06 **S** 16 — −2, +4, +6 — $[Ne]3s^2 3p^4$	35.453 **Cl** 17 — −1, +1, +3, +5, +7 — $[Ne]3s^2 3p^5$	39.948 **Ar** 18 — 0 — $[Ne]3s^2 3p^6$
Period 4	58.69 **Ni** 28 — +2, +3 — $[Ar]3d^8 4s^2$	63.546 **Cu** 29 — +1, +2 — $[Ar]3d^{10} 4s^1$	65.39 **Zn** 30 — +2 — $[Ar]3d^{10} 4s^2$	69.72 **Ga** 31 — +3 — $[Ar]3d^{10} 4s^2 4p^1$	72.59 **Ge** 32 — −4, +2, +4 — $[Ar]3d^{10} 4s^2 4p^2$	74.9216 **As** 33 — −3, +3, +5 — $[Ar]3d^{10} 4s^2 4p^3$	78.96 **Se** 34 — −2, +4, +6 — $[Ar]3d^{10} 4s^2 4p^4$	79.904 **Br** 35 — −1, +1, +5 — $[Ar]3d^{10} 4s^2 4p^5$	83.80 **Kr** 36 — 0, +2 — $[Ar]3d^{10} 4s^2 4p^6$
Period 5	106.42 **Pd** 46 — +2, +4 — $[Kr]4d^{10} 5s^0$	107.868 **Ag** 47 — +1 — $[Kr]4d^{10} 5s^1$	112.41 **Cd** 48 — +2 — $[Kr]4d^{10} 5s^2$	114.82 **In** 49 — +3 — $[Kr]4d^{10} 5s^2 5p^1$	118.71 **Sn** 50 — +2, +4 — $[Kr]4d^{10} 5s^2 5p^2$	121.75 **Sb** 51 — −3, +3, +5 — $[Kr]4d^{10} 5s^2 5p^3$	127.60 **Te** 52 — −2, +4, +6 — $[Kr]4d^{10} 5s^2 5p^4$	126.905 **I** 53 — −1, +1, +5, +7 — $[Kr]4d^{10} 5s^2 5p^5$	131.29 **Xe** 54 — 0, +2, +4, +6 — $[Kr]4d^{10} 5s^2 5p^6$
Period 6	195.08 **Pt** 78 — +2, +4 — $[Xe]4f^{14} 5d^9 6s^1$	196.967 **Au** 79 — +1, +3 — $[Xe]4f^{14} 5d^{10} 6s^1$	200.59 **Hg** 80 — +1, +2 — $[Xe]4f^{14} 5d^{10} 6s^2$	204.383 **Tl** 81 — +1, +3 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^1$	207.2 **Pb** 82 — +2, +4 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^2$	208.980 **Bi** 83 — +3, +5 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^3$	(209) **Po** 84 — +2, +4 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^4$	(210) **At** 85 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^5$	(222) **Rn** 86 — 0 — $[Xe]4f^{14} 5d^{10} 6s^2 6p^6$

IONIZATION ENERGIES AND ELECTRONEGATIVITIES

Upper number: First Ionization Energy (kcal/mol of atoms)
Lower number: Electronegativity*

1	2	13	14	15	16	17	18
H 313 / 2.2							He 567
Li 125 / 1.0	Be 215 / 1.5	B 191 / 2.0	C 260 / 2.6	N 336 / 3.1	O 314 / 3.5	F 402 / 4.0	Ne 497
Na 119 / 0.9	Mg 176 / 1.2	Al 138 / 1.5	Si 188 / 1.9	P 242 / 2.2	S 239 / 2.6	Cl 300 / 3.2	Ar 363
K 100 / 0.8	Ca 141 / 1.0	Ga 138 / 1.6	Ge 182 / 1.9	As 226 / 2.0	Se 225 / 2.5	Br 273 / 2.9	Kr 323
Rb 96 / 0.8	Sr 131 / 1.0	In 133 / 1.7	Sn 169 / 1.8	Sb 199 / 2.1	Te 208 / 2.3	I 241 / 2.7	Xe 280
Cs 90 / 0.7	Ba 120 / 0.9	Tl 141 / 1.8	Pb 171 / 1.8	Bi 168 / 1.9	Po 194 / 2.0	At — / 2.2	Rn 248
Fr — / 0.7	Ra 122 / 0.9						

* Arbitrary scale based on fluorine = 4.0

Polyatomic Ions

Name	Formula	Name	Formula
perPhosphate	$(PO_5)^{-3}$	perCarbonate	$(CO_4)^{-2}$
Phosphate	$(PO_4)^{-3}$	**Carbonate**	$(CO_3)^{-2}$
Phosphite	$(PO_3)^{-3}$	Carbonite	$(CO_2)^{-2}$
hypoPhosphite	$(PO_2)^{-3}$	hypocarbonite	$(CO)^{-2}$
perChlorate	$(ClO_4)^{-1}$	perNitrate	$(NO_4)^{-}$
Chlorate	$(ClO_3)^{-1}$	**Nitrate**	$(NO_3)^{-}$
Chlorite	$(ClO_2)^{-1}$	Nitrite	$(NO_2)^{-}$
hypoChlorite	$(ClO)^{-1}$	Hyponitrite	$(NO)^{-}$
perSulfate	$(SO_5)^{-2}$	perChromate	$(CrO_5)^{-2}$
Sulfate	$(SO_4)^{-2}$	**Chromate**	$(CrO_4)^{-2}$
Sulfite	$(SO_3)^{-2}$	Chromite	$(CrO_3)^{-2}$
hyposulfite	$(SO_2^{-2}$	Hypochromite	$(CrO_2)^{-2}$
Acetate	$(C_2H_3O_2)^{-1}$	**Cyanide**	$(CN)^{-1}$
Hydroxide	$(OH)^{-1}$	**Manganate**	$(MnO_4)^{-2}$

Ammonium
$(NH_4)^{+1}$