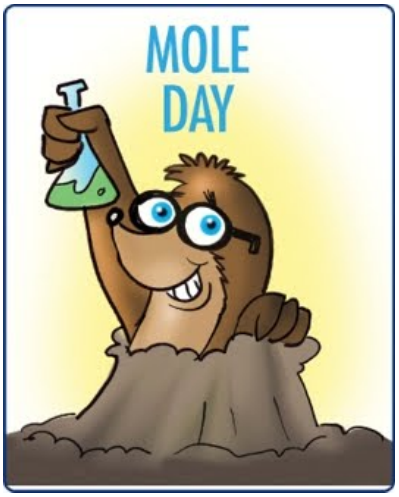
Chemistry II

INTRODUCTION TO UNIT TWO

THE MOLE

TODAY IS A VERY SPECIAL DAY IN CHEMISTRY!



October 23

Celebrated by chemists annually from 6.02 am to 6.02 pm on October 23rd, Mole Day commemorates Avogadro's number ($6.022140857 \times 10^{23}$), which is the number of atoms in exactly 12 grams of carbon-12 (one mole). This was founded by the National Mole Day Foundation on May 15th 1991.

What is a dozen?

Consider this: the mass of 12 donuts does not equal the mass of 12 timbits
OR: If you are offered 1500 g donuts vs. 1500 g timbits (for free!), which would you take? *You will need a lot more timbits to reach 1500 g than donuts.*

Definition of the mole:

the number of particles in exactly 12 g of the isotope Carbon -12.

OR

The number of carbon-12 atoms in 12 grams of unbound carbon in the ground state.
That number to 3 significant figures is 6.02×10^{23}
(This is the number that represents one mole, and it is called **"Avogadro's number")**

The History of the Term "Mole"

The Avogadro constant is named after the early nineteenth century Italian scientist Amedeo Avogadro, who is credited (in 1811) with being the first to realize that the volume of a gas (strictly, of an ideal gas) is proportional to the number of atoms or molecules. The French chemist Jean Baptiste Perrin in 1909 proposed naming the constant, 6.02×10^{23}, in honor of Avogadro.

Lorenzo Romano Amedeo Carlo Avogadro di Quaregna e di Cerreto
9 August 1776, Turin – 9 July 1856

PUTTING AVOGADRO's "mole" into the context of the periodic table:

example: B^5 (atomic number 5) The mass of one Boron atom is 10.8 ***amu***

amu stands for "atomic mass units"

This mass is compared to the Carbon-12 isotope.

amu is our standard to compare to! It is 1/12 of the C-12 atom. This is equivalent to 1.66×10^{-27} kg.

6.02×10^{23} atoms (one mole) of Boron will have a mass of 10.8 g.
We say that the atomic mass is 10.8 g / mole.
(g / mole is a much more use-able unit to use than "amu", especially when we have to do unit cancelling calculations)

Another example: The ionic compound, Calcium Sulphide. Chemical Formula CaS.
If we wanted to talk about one molecule of calcium sulphide, we would say
1 Ca atom = 40.1 amu and 1 sulphur atom = 32.1 amu
BUT, it is much more practical to talk about ***1 mole of CaS molecules***
1 mole calcium = 40.1 g 1 mole sulphur = 32.1 g
That's 6.02×10^{23} calcium atoms and 6.02×10^{23} sulphur atoms, making 6.02×10^{23} CaS molecules) with a total mass of 72.1 g.
So we would say that the ***molar mass*** of CaS is 72.1 g/mole.

molar mass can also stated as ***molecular mass***.

Real World Moles

Given that the volume of a grain of sand is approximately 10^{-12} m^3, and given that the area of the United States is about $10^{13} m^2$, it therefore follows that a mole of sand grains would cover the United States in approximately one centimeter of sand.

A human body contains very roughly one hundred trillion cells; there are roughly six billion people on Earth; so the total number of human cells on the planet is approximately $100\times10^{12}*6\times10^{9}=6\times10^{23}$, which is very close to one mole.

Since the Earth has a radius of about 6400 km, its volume is approximately 10^{21} m^3. Since about 500 large grapefruit will fit in one cubic meter, it therefore follows that a mole of grapefruit would have approximately the same volume as the Earth.

If you had a mole of pennies, you could give out enough money to everyone in the world so that they could spend a million dollars every hour, day and night, for the rest of their lives.

ONE DOZEN can be:	**Similarily, ONE MOLE Can be:**
12 dinner rolls	6.02×10^{23} atoms
12 eggs	6.02×10^{23} molecules
12 roses	6.02×10^{23} protons
12 blood cells (microscopic things too!)	6.02×10^{23} ions
12 of anything!!!!!	*6.02×10^{23} of anything!!!!*

DO YOU THINK YOU HAVE A GRASP OF WHAT 'the mole" is?

COUNTING ATOMS

Complete the following table.

Molecular formula	***Name***	***# of Molecules indicated***	***# of each atom in the given molecular formula***
H_2O	**water**	***1***	***2H 1O***
	Silver carbonate	***1***	***2Ag 1C 3O***
$CuSO_4$		***1***	
	Copper (II) nitrate	***1***	
	Ammonium sulphide	***1***	
	chlorine gas	***4***	
	liquid nitrogen	***3***	
	solid iodine	***2***	
	Zinc acetate	***1***	
	Magnesium Phosphate	***2***	
7 LiH_2PO_4			
$K_4P_2O_7 \bullet 3\ H_2O$	***Potassium Pyrophosphate trihydrate***		
	Aluminum Oxide Dihydrate	***1***	
6 $SnCl_2 \bullet 5\ H_2O$			

Determine the molar mass of each of the following:
(note that we can also call it atomic mass or molecular mass, depending on whether we are talking specifically about an atom or a molecule)

SUBSTANCE	MOLAR MASS
Cu	63.546 g / mole
Sn	
H_2O	
Copper (II) sulphate	

1 mole Cu, 1 mole S, 4 moles O, but only 1 mole CuSO4 !!!

Oxygen gas	
Bromine liquid	
Solid Phosphorus crystals	
Copper (I) phosphide	
potassium chromate	
ammonium oxalite	
Copper (II) nitrate	
Aluminum Oxide Dihydrate	

COUNTING ATOMS ANSWER KEY

Molecular formula	*Name*	*# of Molecules*	*# of each atom*
H_2O	**water**	*1*	*2H 1 O*
Ag_2CO_3	***Silver carbonate***	*1*	*2Ag 1C 3 O*
$CuSO_4$	Copper (II) sulphate	*1*	*I Cu 1S 4 O*
$Cu(NO_3)_2$	Copper (II) nitrate	*1*	*I Cu 2N 6 O*
$(NH_4)_2S$	Ammonium sulphide	*1*	*2N 8H 1S*
4 $Cl_{2\ (g)}$	chlorine (is a gas at room temp)	*4*	*8 Cl*
3 $N_{2\ (l)}$	nitrogen (is a liquid at - 210°C, and a gas at temps above -196°C)	*3*	*6 N*
2 $I_{2\ (s)}$	solid iodine	*2*	*4 I*
$Zn(CH_3COO)_2$	Zinc acetate	*1*	*1 Zn 4 C* *6 H 4 O*
2 $Mg_3(PO_4)_2$	Magnesium Phosphate	*2*	*6 Mg 4 P* *16 O*
7 LiH_2PO_4	Lithium dihydrogen phosphate	*7*	*7 Li 14 H* *7 P 28 O*
$K_4P_2O_7 \bullet 3\ H_2O$	***Potassium Pyrophosphate trihydrate***	*1*	*4 K 2 P* *ten O* *6 H*
$Al_2O_3 \bullet 2\ H_2O$	Aluminum Oxide Dihydrate	*1*	*2 Al 5 O* *4 H*
6 $SnCl_2 \bullet 5\ H_2O$	***Tin (II) chloride pentahydrate***	*6*	*6 Sn 12 Cl* *60 H 30 O*

Determine the molar mass of each of the following:

SUBSTANCE		**MOLAR MASS**
Cu		**63.546 g / mole**
Sn		**118.711 g / mole**
H_2O		**18.015 g / mole**
Copper (II) sulphate		**159.608 g / mole**

1 mole Cu, 1 mole S, 4 moles O, but only 1 mole CuSO4 !!!

Oxygen gas	O_2	**31.998 g / mole**
Bromine liquid	Br_2	**159.808 g / mole**
Solid Phosphorus crystals	P_4	**123.896 g / mole**
Copper (I) phosphide	Cu_3P	**221.612 g/ mole**
potassium chromate K_2CrO_4		**194.188 g / mole**
ammonium oxal***ite*** $(NH_4)_2C_2O_3$		**108.097 g/ mole**
Copper (II) nitrate $Cu(NO_3)_2$		**187.553 g / mole**
Aluminum Oxide Dihydrate $Al_2O_3 \bullet 2\ H_2O$		**137.991 g / mole**