Description of the Mole Concept:

Suppose you were sent into the store to buy 36 eggs. When you picked them up you would get 3 boxes, each containing 12 eggs. You just used a mathematical device, called DOZEN, to simplify the process.

You might also be asked to obtain a GROSS of some item. This amount is known to contain 144 (12 dozen). Can you think of other terms that are used to help simplify amounts?

Chemist began to realize that numbers like 12 and 144 were much too small to use when working with individual parts of matter like atoms and molecules. They chose to use the term MOLE to represent amounts of matter that were applicable for them.

Keep in mind that this word MOLE is representative of an amount of something. Just as you can have a dozen eggs you can also have a dozen chairs, a dozen people, a dozen stars. So the scientist of the world can have a mole of water, a mole of sodium chloride, a mole of gold. <![endif]>

Now I need to show you the number associated with the mole:

602 000 000 000 000 000 000 000

Wow! That large a number is difficult to use in calculations so we must use another mathematical shorthand, scientific notation, to help us.

Lets rewrite that same number as: 6.02 E 23

Another name for this huge amount: Avogadro' Number.

As it turns out this number, named after Amadeo Avogadro, is used as a reference point for most calculations and equations found in chemistry.

The next section on the main menu deals with the 4 general rules associated with the MOLE concept. These rules allow us to compare mass with volume, mass with number of particles, and balance chemical equations. <![endif]>

Rules Utilized With MOLES

I. The chemical formula represents a mole of that substance.

II. The formula mass, expressed in grams, represents the mass of one mole of that substance.

III. One mole of any substance contains 6.02 E 23 particles.

IV. One mole of any gas, at STP conditions, occupies 22.4 liters of volume.

Now let me expand on each of these and include lots of examples. You are welcome to take notes!

Rule: The chemical formula represents a mole of that substance.

Remember that any number placed to the left of a chemical symbol or formula is called the COEFFICIENT. This number (integer, decimal, or in scientific notation) tells us the number of moles of that substance.

Examples:

Pb --> 1 mole of lead atoms (understood 1)

3 Pb --> 3 moles of lead atoms

4.5 Cl^{1-} --> 4.5 moles of chloride ions

2 CaCl --> 2 moles of calcium chloride

3.5 E-2 NaOH --> 3.5 E-2 moles of sodium hydroxide

Rule: The formula mass, in grams, represents the mass of that substance.

The formula mass of an element is its atomic mass (found on Periodic Table.) The formula mass of a compound is found by multiplying the number of `moles' of that element (see its subscript in the formula) by that atom's atomic mass. Then add masses of all elements and record in grams.

The following example is given to demonstrate how to find formula mass.

$CaCO_3$ (calcium carbonate)

Ca 1 x 40.1 = 40.1
C 1 x 12.0 = 12.0
O 3 x 16.0 = 48.0

100.1 grams = 100. g (3 sig figs)

If you need further help finding formula masses please see your teacher.

Now for some examples involving this rule:

2 Cu --> 2 moles of copper atoms --> 2 x 63.5 = 127

5.00 NaCl --> 5 moles sodium chloride --> 5.00 x 58.4 = 292 g

2.5 H_2SO_4 2.5 moles of sulfuric acid --> 2.5 x 98.1 = 245 g

Rule: One mole of any substance contains 6.02 E 23 particles.

Particles here might mean atoms, molecules, ions, electrons, or just about anything you might need to work with. Remember: just as there are 12 items in a dozen; 6.02 E 23 particles in a mole.

Examples:

HNO_3 --> 1 mole of nitric acid, 1.00 x 63.0 = 63.0 grams, 6.02 E 23 molecules of nitric acid

3.00 K --> 3.00 moles of potassium atoms , 3.00 x 39.1 = 117 grams, 3.00 x 6.02 E 23 =1.81 E 24 potassium atoms

Rule: One mole of any gas, at STP conditions, occupies 22.4 L of volume.

STP is a shorthand way of requiring the temperature to be at 0 degrees C and a standard pressure of 1 atm (101.3 kPa).

This rule is most commonly used when studying gas laws. Suppose you have 4 grams of helium gas. This represents 1 mole of helium (see 2nd rule). These 6.02 E 23 atoms of helium would take up 22.4 liters of volume. This large volume would be fully occupied if the temperature was 0 degrees Celsius and the pressure 1 atmosphere. A change in the temperature/pressure would, of course, change the volume occupied by the gas.

No problems are given for this rule at this time.

Sample Mole Calculations

The following problems will give you a chance to attempt working mole problems. The problem will be given on one screen and you will be allowed to work the problem on paper, using your calculator and the Periodic Table. The solution will be given on the following page.

You will be shown 6 problems. You may wish to ask your teacher for extra help.

Sample Mole Calculations: Formula to Number of Moles

Given: 4.50 Na_2CO_3 : how many moles of sodium carbonate are ther

Remember: The coefficient in front of an element or compound tells you the number of moles you have .

Of course you were dealing with 4.50 moles of sodium carbonate.

Remember that the coefficient can be a whole number, decimal, a number in scientific notation, and that the number of significant figures in that coefficient indicates the degree of precision needed in your final answer.

Sample Mole Calculations: Number of Moles to Formula

Given: 3.5 E-2 moles of strontium fluoride, correctly represent the coefficient and formula:

The answer would be 3.5 E-2 SrF_2

Sample Mole Calculations: Moles to Grams

Given: 2.00 moles of $Ca(OH)_2$ would represent ________ grams.

Remember that 1 mole of a compound is represented by the formula mass of that compound. Also, 1 mole of an element equals the atomic mass.

To solve this problem we must first calculate the formula mass and then multiply that number by the number of moles we have (in this case: 2.0)

To calculate formula mass, first list the elements in the formula along with the number of each (hint: use the subscripts). Then multiply that number by the atomic mass of that element. Add those masses and you have the formula mass. Remember to get your final answer you must multiply the formula mass by the number of moles. Try it on paper.

Calculate formula mass: Ca 1 x 40.1 = 40.1
O 2 x 16.0 = 32.0
H 2 x 1.01 = 2.02
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formula mass --> 74.1 g (rounded)

Calculate mass of 2.00 $Ca(OH)_2$

2.00 x 74.1 g = 148 g (again rounded to 3 significant figures

Sample Mole Calculations: Grams to Moles

Given: 48.5 grams of $CaCO_3$ = ___________ moles of calcium carbonate

Remember that you must first find the formula mass of the compound. Then we will use the factor label method to solve the problem.

Calculate formula mass: Ca 1 x 40.1 = 40.1
C 1 x 12.0 = 12.0
O 3 x 16.0 = 48.0
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formula mass -> 100. g (rounded)

Some of you will readily see that we have less than a full mole and simply divide 48.5/100. to get your answer. But we should know how to use the factor label method when we encounter more difficult problems.

Factor label method to solve mole problem:

$$\begin{array}{c|c} 48.5\text{ g }CaCO_3 & 1\text{ mol }CaCO_3 \\ \hline & 100.\text{ g }CaCO_3 \end{array} = 0.485\text{ mol }CaCO_3$$

The gram units will cancel leaving mole as the proper unit

Sample Mole Calculations: Moles to Particles (Atoms, molecules, ions,...)

Given: 4.20 moles of hydrogen fluoride = _______ molecules HF

Remember that 1 mole of any thing has 6.02 E 23 particles.

So to answer this problem we would just multiply 4.20 x 6.02 E 23 and get the answer 2.53 E 24 molecules.

Let me show you this same solution using the factor label set-up

$$\begin{array}{c|c} 4.20\text{ HF} & 6.02\text{ E }23\text{ mlcl} \\ \hline & 1\text{ mole HF} \end{array} = 2.53\text{ E }24\text{ mlcl HF}$$

The mole units cancel (the unit mole is implied in 4.20 HF)

Sample Mole Calculations: Grams to Particles

Given: 126 g of Lithium Sulfate = _______________ ion pairs Lithium Sulfate

Remember our motto: "Go To Moles" Since the unit of mole is not used directly in this problem we must use it indirectly. The factor label set-up will do this for us.

We will need to calculate formula mass for lithium sulfate. Do this off to the side of your work space. Did you get 110. grams? Also we will need to remember that 6.02 E 23 ion pairs of lithium sulfate equals 1 mole.

$$\begin{array}{c|c} 126\text{ g }Li_2SO_4 & 6.02\text{ E }23\text{ ion pr }Li_2SO_4 \\ \hline & 110.\text{ g }Li_2SO_4 \end{array} = 6.90\text{ E }23\text{ ion pr }Li_2SO_4$$

Wow! That last problem was complicated. To work the problem we had to use the transitive property from dear old math class. Since 6.02 E 23 ion pairs equals 1 mole and 110. g of lithium sulfate equals one mole they are equal to each other. When we place two items that are equal to each other in a ratio it is equal to 1.

Moles – Avogadro's Number

I. The chemical formula represents 1 mole of that substance.

II. The formula mass (expressed in grams) is the mass of 1 mole of that substance.

III. 1 mole of a substance contains 6.02 E 23 particles (atoms, mlcl, ions, electrons, etc.)

IV. 1 mole of any gas at STP (1 atmosphere of pressure and 0 °C) occupies 22.4 liters of volume.

Name	Formula	Formula mass	# of particles
Atomic nitrogen	N	14.0	6.02 E 23 atoms
Nitrogen gas	N_2	28.0	6.02 E 23 mlcl (1.20 E 24 atoms)
Silver ions	Ag^{+1}	108	6.02 E 23 ions
Sodium chloride	NaCl	58.5	6.02 E 23 ion pairs
Ammonium sulfate	$(NH_4)_2SO_4$	132	6.02 E 23 mlcl

Problems:

1 mole Mo = __________ g

1 mole Mo = __________ atoms

7 moles Mo = __________ g

7 moles Mo = __________ atoms

1 mol $Th_3(PO_4)_4$ = __________ mlcl = __________ g

0.5 mol CO_2 = _________g = ____________ mlcl

1.5 mol $MgCl_2$ = __________g = ____________ ion pairs

1 mol KNO_3 = __________ mol K, __________ mol N, _________mol O

1 mol KNO_3 = __________ g K, ___________g N, ____________ g O

10 g KNO_3 = ___________ mol KNO_3, ___________ g K, ____________ atoms O

2.2 mol of H_3PO_4 there are ____________ g H, ___________mol p, ___________atoms O

Molarity

Molarity: the ratio between the moles of dissolved substance (solute) and the volume of the solution (in liters or cubic decimeters)

Example: 1 M HNO_3 = 1 mole of HNO_3 in 1 L of solution

0.273 M $Ba(NO_3)_2$ contains 0.372 moles of barium nitrate in 1 L of solution

Sample Problem:

What is the molarity of a 250 mL solution containing 9,46 B CsBr?

Solution:

$$\frac{9.46 \text{ g CsBr}}{} \left| \frac{1 \text{ mole CsBr}}{213 \text{ g CsBr}} \right. = 0.0444 \text{ mol CsBr}$$

$$\frac{250 \text{ mL}}{} \left| \frac{1 \text{ L}}{1000 \text{ mL}} \right. = 0.250 \text{ L}$$

$$\text{molarity} = \frac{\text{mole}}{\text{liter}} = \frac{0.044\ 4 \text{ mol CsBr}}{0.250 \text{ L}} = 0.178 \text{ M CsBr}$$

Problems:

1. 145 g $(NH_4)_2C_4H_4O_6$ in 500 mL of solution
2. 13.2 g $MnSeO_4$ in 500 mL of solution
3. 45.1 g cobalt (II) sulfate in 250 mL of solution
4. 41.3 g iron (II) nitrate in 100 mL solution
5. 49.9 g $Pb(ClO_4)_2$ in 200 mL of solution
6. 35.0 g $MnSiF_6$ in 50.0 mL of solution

Sample test problems:

1. 7.25 E 4 grams of carbon (IV) tellurate contains ________grams of oxygen

2. 9.45 E – 15 moles of carbon (IV) tellurate contains _________ atoms of carbon

3. 5.50 E 16 atoms of zinc weighs _________ grams

4. 5.50 E 16 atoms of manganese is _________ moles of manganese

5. 8.35 moles of chromium (III) arsenate weighs __________ grams.

6. 8.35 moles of chromium (III) arsenate contains _________atoms of arsenic

PHYSICAL SCIENCE WORKSHEET -- ORANGE

1. 1 mole of iron weighs ____________________ grams.
2. 1 mole of iron contains __________________ atoms.
3. 7.4 moles of iron weighs _________________ grams.
4. 7.4 moles of iron contains _________________ atoms.
5. 1 gram of iron contains __________________ atoms.
6. 1 atom of iron weighs ____________________ grams.
7. 1.2 E 24 atoms of iron would be _________________ moles of iron.
8. 6.4 E 31 atoms of iron would be __________________ moles of iron.
9. 6.4 E 31 atoms of iron weighs ____________________ grams.
10. 140 grams of iron would be _______________________ atoms.

11. 1 mole of $Ca(OH)_2$ weighs _______________________ grams.
12. In one mole of $Ca(OH)_2$ there are __________________ ion pairs.
13. 4 moles of $Ca(OH)_2$ weighs ____________________ grams.
14. In 2.2 E - 3 moles of $Ca(OH)_2$ there are _________________ ion pairs.
15. The total number of atoms in one mole of $Ca(OH)_2$ would be _____________.
16. 2.2 E - 3 moles of $Ca(OH)_2$ weighs ________________ grams.
17. 1.6 E 4 grams of $Ca(OH)_2$ would would be ____________________ ion pairs.

18. A compound contains 29.1% sodium, 40.5% sulfur, and 30.4% oxygen.
    What would be the empirical formula for this compound? _______________

19. 3 grams of hydrogen combines with 42 grams of nitrogen and 144 grams of oxygen to form a new compound. What would be the empirical formula of this compound? ___________ How many moles of this compound would be created? _______.

20. Describe how you could make (exactly) 183 grams of $KClO_3$.

PHYSICAL SCIENCE WORKSHEET -- WHITE

1. 1 mole of CO_2 weighs ______________________ grams.
2. 3 moles of CO_2 contains ___________________ molecules of CO_2.
3. 3 molecules of CO_2 weighs _________________ grams.
4. 3 moles of CO_2 contains ___________________ atoms of carbon.
5. 3.1 moles of CO_2 contains _________________ molecules of CO_2.
6. 3.1 moles of CO_2 contains _________________ grams of CO_2.

7. 1 mole of $KClO_3$ weighs ____________________ grams.
8. 6 grams of $KClO_3$ would be _________________ moles.
9. 6 grams of $KClO_3$ if split up will produce ___________ grams of K, ____________ grams of Cl, and ___________ grams of O.

10. Find the percentage composition of each element in KNO_3.
    ______________% K, _____________% N, _____________% O
11. 1 mole of KNO_3 weighs ________ grams and contains ___________ ion pairs.
12. In 1 mole of KNO_3 there are ____________ moles of K, ____________ moles of N, and 3 moles of _________________.
13. In 0.25 moles of KNO_3 there are ___________ grams of K, ___________ grams of N, and ____________ grams of O.
14. 5 E 23 ion pairs of KNO_3 is ___________ moles and weighs _________ grams.
15. 10 grams of KNO_3 would be ____________ moles of KNO_3 and would be ________________ ion pairs.

16. In 2.2 moles of H_3PO_4 there are __________ grams of H, ___________ grams of P, and _____________ grams of O.
17. 2.1 E 24 molecules of H_3PO_4 would be ______________ moles and would weigh ____________ grams.
18. In 2.2 moles of H_3PO_4 there are _________________ molecules of H_3PO_4 and ________ atoms of H, _________ atoms of P, and _________ atoms of O

19. In 100 grams of H_3PO_4 there would be __________ grams of H, ___________ grams of P, and ___________ grams of O.

20. Find the percentage composition of each element in H_3PO_4

_____________% H, ______________% P, _______________% O