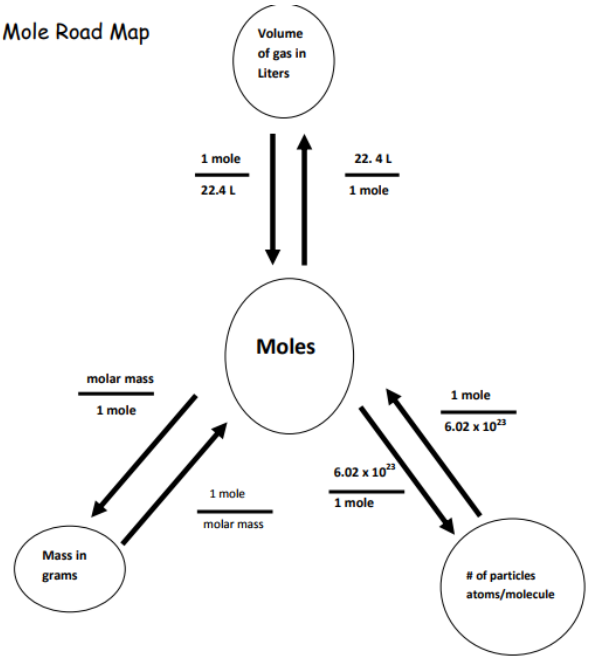
The Mole **Honors Chemistry**

What is a mole?

- the amount of a substance that contains as many particles as there are atoms in exactly 12g of carbon-12
- A mole is a counting unit just like a dozen

Avogadro's Number:

- Constant
- the number of particles in exactly one mole of a pure substance
- 1 mol = 6.02 X10^{23} of anything. But most often the mole is used with atoms, ions, formula units or molecules
- 1mol cars=
- 1 mole Al=
- 1 mol H_2O=



There are three mole equalities. They are:

1 mol = 6.02 x 10^{23} particles
1 mol = (Molar mass of the substance)
1 mol = 22.4 L for a gas at STP
Molar Mass is the mass present in 1 mole of a substance

Mole Conversions:

Mole- Particle conversions:

1. How many moles of calcium is 3.01 x 10^{22} atoms of calcium?

2. How many molecules are there in 5.00 moles of glucose, $C_6H_{12}O_6$?

3. How many moles are 1.20 x 10^{25} atoms of sulphur?

4. How many molecules are in 0.750 moles of carbon dioxide?

Mole-Volume Conversions

5. Determine the volume, in liters, occupied by 0.080 moles of a oxygen gas at STP.

6. How many moles of helium atoms are present in 11.2 L of Helium gas at STP?

7. What is the volume of 0.05 mol of neon gas at STP?

8. What is the volume of 5.2 moles of water vapor at STP?

Find the molar mass of the following compounds

9. KOH

10. H_3PO_4

11. $BeCl_2$

12. $(NH_4)_2SO_4$

13. $Mg(OH)_2$

14. CH_3COOH

Mole-Mass Conversions

15. How many moles in 28 grams of CO_2?

16. You are massing a 24 K gold chain, and find that it weighs 50.00 grams. Determine how many moles of gold atoms you have.

17. Fructose (fruit sugar) is a ketohexose (a six-carbon ketonic sugar), which occurs in sweet fruits and **honey**. Glucose and fructose have the same molecular **formula**, $C_6H_{12}O_6$. Calculate the mass of 3.56 moles of honey

18. Find the number of moles of argon in 452 g of argon.

19. Find the grams in 3.26×10^{-4} mol of $HC_2H_3O_2$

20. Find the mass in 2.6 mol of Potassium carbonate.

Mixed Mole Conversions

Given unit → Moles → Desired unit

21. Find the mass in grams of 2.00×10^{23} molecules of F_2.

22. Find the mass, in grams, of 2.00×10^{23} molecules of chlorine gas.

23. How many particles are there in 1.43 g of a molecular compound with a molar mass of 233 g?

24. You have 8.50 moles of Silver (Ag). How many grams is this?

25. The head of a match contains 1.6 grams of Sulphur, S. How many atoms of S does a match contain?

26. While cleaning a cut, you spill a bottle of Iodine. The label says that the bottle holds 300 grams of Iodine. How many moles of Iodine are there?

27. Your silver bracelet masses out at 126 g. How many moles of Ag do you have?

28. How many oxygen atoms are in 43.15 g of Iron (III) sulfate?

29. 1.7 x 10^{24} atoms of hydrogen to L of hydrogen gas

30. 2.40 X 10^{23} molecules of PCl_5 to the total number of atoms

31. Water has a molar mass of 18 grams. Let's say you drink a 1.5 liters of water every day. The density of water is 1g/1ml. How many molecules of water do you consume a day?

32. Most of the toothpastes probably contains around 62 g of fluorine per tube. How many moles are in one tube of toothpaste?

33. Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed by G.D. Searle as *Nutra Sweet*. The molecular formula of aspartame is $C_{14}H_{18}N_2O_5$

    a) Calculate the molar mass of aspartame.

    b) How many moles of molecules are in 20 g of aspartame?

    c) What is the mass in grams of 6.56 moles of aspartame?

    d) How many molecules are in 5 mg of aspartame?

    e) How many atoms of nitrogen are in 1.2 grams of aspartame?

Answers: **1)5.00X10^{-2}mols** **2) 3.01X10^{24} molecules** **3) 1.99X10^{1} mols** **4) 4.52 X 10^{23} molecules**
5)1.8L **6)5.00X 10-1 mols** **7) 1L** **8)120L**
9) 56.11g **10) 98g** **11) 79.912g** **12)132.16g**
13) 58.33 g **14) 60.05g** **15) 6.4 X 10-1** **16) 2.538 X 10-1mol**
17) 6.41 X10^{2} g **18) 11.3 mol** **19) 1.96 X 10^{-6} g** **20) 3.6 X 10^{2} g**
21) 1.26 X 10^{1} g **22) 2.36 X 10^{1}g** **23) 3.69X 10^{2}** **24) 9.17 X 10^{2} g**
25)3.0 X 10^{22} **26) 1 mol I_2** **27) 1.17 mols** **28)7.795X 10^{23} atoms**
29) 32L **30) 1.44 X 10 24** **31) 8.3 X 10^{1} mols** **32) 1.6 moles**
33) a) 294.34 g **b) 0.07 mols** **c) 1930g** **d) 1X 10^{19} molecules**
e) 4.9 X 10^{21}

Empirical Formula

Empirical formula of a substance is the simplest formula which gives the lowest whole-number ratio between the number of atoms of different elements present in the substance.

Significance

An empirical formula provides the following information.

(i) Empirical formula of a compound gives us the names of all the elements present in the compound.

(ii) Empirical formula of a compound gives the simplest whole-number ratio between the numbers of atoms of all the elements present in the compound. It does not give the actual number of atoms present in that compound. Besides, any two compounds can have the same empirical formula.

(iii) Elemental analysis of an unknown sample.

Steps for solving an Empirical Formula Problem

- If given percent data, assume 100g of sample. If given grams, then use grams and proceed to the next step
- Convert grams to moles for each element in the compound
- Divide each of these mole amounts by smallest mole amount calculated. Then, If one of the ratios does not turn out to be a whole number (generally within about 0.05), they must all be multiplied by the same number so that the ratios are all whole numbers. Below are some decimal places that may result when calculating the ratios and by what factor the ratios should be multiplied by in order to obtain a whole number.

Decimal Place	Multiply by
.25	4
.33	3
.5	2
.67	3
.75	4

To determine actual molecular formula and when molar mass is given

- Calculate the Molar Mass of the Empirical Formula you determined in step 4.
- Divide Actual Given Molar Mass by Empirical Formula Molar Mass. This will be a WHOLE #
- Multiply all Subscripts in Empirical Formula by this whole number.
- Write ACTUAL Molecular Formula

Examples:

1. Qualitative analysis shows that a compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. Find the empirical formula of the compound.

2. Find the empirical formula of a compound found to contain 26.56% potassium, 35.41% chromium and the remainder oxygen

3. A 60.00g sample of tetraethyl lead, a gasoline additive, is found to contain 38.43g lead, 17.83g carbon, and 3.74g hydrogen. Find its empirical formula

4. If 4.04g of N combine with 11.46g O to produce a compound with a molar mass of 108.0 g/mol, what is the molecular formula of this compound?

5. A compound having an approximate molar mass of 165-170 g has the following percentage composition by mass: carbon, 42.87%; hydrogen, 3.598%; oxygen, 28.55%; nitrogen, 25.00%. Determine the empirical and molecular formulas of the compound.

6. Caffeine, a stimulant found in coffee, tea, and chocolate, contains 49.48% carbon, 5.15% hydrogen, 28.87% nitrogen, and 16.49% oxygen by mass, and has a molecular mass of 194.2 g/mol. Determine the molecular formula of caffeine.

7. If a compound decomposes into 44.8L of oxygen gas and 4.0g of hydrogen gas, what is the compounds empirical formula?

8. A new substance is created in the lab from the synthesis of 11.68 g of C, 2.928 x 10^{23} molecules of oxygen, and 21.8 L of hydrogen. What is the percent compostion? What is it's molecular formula if it's gram formula mass is 360g?

Answers: 1. **Na_2SO_4 2. $K_2Cr_2O_7$ 3. PbC_8H_{20} 4. N_2O_5 5. C_2H_2ON, $C_6H_6O_3N_3$ 6. $C_4H_5N_2O$, $C_8H_{10}N_4O_2$**

7. HO 8. 40.01% C, 53.31% O, 6.68%H, $C_{12}H_{24}O_{12}$