

# - KEY -

## UNIT 5 STUDY GUIDE: Moles / Balancing Equations / Types of Reactions (CH 10-11)

For the test, you should be able to:

- 1) Define: **Avogadro's Number**      **Mole**      **Molar Mass**      **Molar Volume**      **STP**
- 2) List the conditions for STP (temperature & pressure)
- 3) Describe the molar volume of a gas (1 mole of any gas at STP = \_\_\_\_\_ L)
- 4) Distinguish between the empirical formula and the molecular formula of a compound.
- 5) Calculate the molar mass of a substance (element or compound) using the Periodic Table.
- 6) Calculate the number of representative particles in a given amount of a substance.
- 7) Perform the following conversions and calculations
 

|                                 |                                 |                               |
|---------------------------------|---------------------------------|-------------------------------|
| <b>Moles to Mass</b>            | <b>Volume to # of particles</b> | <b>Mass to # of particles</b> |
| <b>Moles to Volume</b>          | <b>Volume to Moles</b>          | <b>Mass to Moles</b>          |
| <b>Moles to # of particles</b>  | <b>Volume to Mass</b>           | <b>Mass to Volume</b>         |
| <b># of particles to Volume</b> | <b># of particles to Moles</b>  | <b># of particles to Mass</b> |
- 8) Calculate the percent composition of a compound (given a specific amount in grams of a compound, or given the formula of a known compound)
- 9) Calculate the empirical and/or the molecular formula of a compound, given its percent composition or other data.

**Problems: Show your work and include correct units in your answers!**


1) How many moles is each of the following?

$$\text{A) } 5.55 \times 10^{19} \text{ atoms Cu} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}} = 9.22 \times 10^{-5} \text{ mol Cu}$$

$$\text{B) } 1.67 \times 10^{26} \text{ molecules NBr}_3 \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} = 277 \text{ mol NBr}_3$$

2) How many molecules (or formula units for ionic compounds) are in each of the following?

$$\text{A) } 0.000558 \text{ mol NaCl} \times \frac{6.02 \times 10^{23} \text{ f.u.}}{1 \text{ mol}} = 3.36 \times 10^{20} \text{ f.u. NaCl}$$

$$\text{B) } 17.7 \text{ mol C}_6\text{H}_{12}\text{O}_6 \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 1.07 \times 10^{25} \text{ molecules C}_6\text{H}_{12}\text{O}_6$$

3) Determine the molar mass (g/mol) of:

 A) barium sulfate, BaSO<sub>4</sub>

$$= 233.4 \text{ g/mol}$$

 C) aluminum nitrate, Al(NO<sub>3</sub>)<sub>3</sub>

$$= 213.0 \text{ g/mol}$$

E) strontium sulfide, SrS

$$= 119.7 \text{ g/mol}$$

 B) iron(III) carbonate, Fe<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>

$$= 291.6 \text{ g/mol}$$

 D) nitrogen trichloride, NCl<sub>3</sub>

$$= 120.5 \text{ g/mol}$$

 F) phosphoric acid, H<sub>3</sub>PO<sub>4</sub>

$$= 98.0 \text{ g/mol}$$

4) Convert the following masses to moles for each substance.

$$\text{A) } 15.5 \text{ g SiO}_2 \times \frac{1 \text{ mol SiO}_2}{60.1 \text{ g}} = 0.258 \text{ mol}$$

$$\text{C) } 5.96 \text{ g KOH} \times \frac{1 \text{ mol}}{56.1 \text{ g}} = 0.106 \text{ mol KOH}$$

$$\text{B) } 0.088 \text{ g AgCl} \times \frac{1 \text{ mol}}{143.4 \text{ g}} = 0.00061 \text{ mol AgCl}$$

$$\text{D) } 937 \text{ g NH}_4\text{NO}_3 \times \frac{1 \text{ mol}}{64.0 \text{ g}} = 14.6 \text{ mol}$$

5) Find the mass of each of the following:

$$\text{A) } 1.50 \text{ mol C}_5\text{H}_{12} \times \frac{72 \text{ g}}{1 \text{ mol}} = 108.0 \text{ g}$$

$$\text{C) } 0.770 \text{ mol Ca(CN)}_2 \times \frac{92.1 \text{ g}}{1 \text{ mol}} = 70.9 \text{ g}$$

$$\text{B) } 5.60 \text{ mol NaOH} \times \frac{40.0 \text{ g}}{1 \text{ mol}} = 224 \text{ g}$$

$$\text{D) } 0.00321 \text{ mol NiSO}_4 \times \frac{154.8 \text{ g}}{1 \text{ mol}} = 0.497 \text{ g}$$

6) Find the volume (L) of each of the following (assume STP for all gases):

$$\text{A) } 7.22 \text{ mol He gas} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 162 \text{ L}$$

$$\text{B) } 0.00557 \text{ mol CO}_2 \text{ gas} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 0.125 \text{ L}$$

7) How many moles are in each of the following?

$$\text{A) } 10.5 \text{ L Ne gas} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.469 \text{ mol}$$

$$\text{B) } 135.7 \text{ L CO}_2 \text{ gas} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 6.058 \text{ mol}$$

8) How many individual oxygen atoms are in 17.3 g of cobalt(III) nitrate,  $\text{Co(NO}_3)_3$ ?

$$17.3 \text{ g Co(NO}_3)_3 \times \frac{1 \text{ mol}}{244.9 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ f.u.}}{1 \text{ mol}} \times \frac{9 \text{ O atoms}}{1 \text{ f.u.}} = 3.83 \times 10^{23} \text{ O atoms}$$

9) How many liters are occupied by:

A) 71.2 g of hydrogen gas ( $\text{H}_2$ ) at STP?

$$71.2 \text{ g H}_2 \times \frac{1 \text{ mol}}{2.0 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 797 \text{ L H}_2$$

B)  $2.45 \times 10^{24}$  carbon dioxide molecules ( $\text{CO}_2$ ) at STP?

$$2.45 \times 10^{24} \text{ molecules} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 91.2 \text{ L CO}_2$$

10) What is the mass of:

A)  $9.31 \times 10^{23}$  molecules of  $\text{CCl}_4$ ?

$$9.31 \times 10^{23} \text{ molecules} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} \times \frac{154.0 \text{ g}}{1 \text{ mol}} = 238 \text{ g CCl}_4$$

B) 6557 L methane gas ( $\text{CH}_4$ ) at STP?

$$6557 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{16.0 \text{ g}}{1 \text{ mol}} = 4684 \text{ g CH}_4$$

11) How many representative particles are in each of the following?

A) 422.6 g  $\text{Fe}_2(\text{CrO}_4)_3$ ?

$$422.6 \text{ g} \times \frac{1 \text{ mol}}{459.6 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ f.u.}}{1 \text{ mol}} = 5.535 \times 10^{23} \text{ f.u. Fe}_2(\text{CrO}_4)_3$$

B) 0.887 L  $\text{N}_2\text{O}$  gas (at STP)?

$$0.887 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 2.38 \times 10^{22} \text{ molecules}$$

12) A gas at STP has a volume of 300.0 mL and a mass of 1.447 g. What is the molar mass of the gas?

$$\frac{1.447 \text{ g}}{0.300 \text{ L}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 108.0 \text{ g/mol}$$

$$300.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.0134 \text{ mol}$$

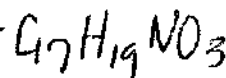
$$\text{molar mass} = \frac{1.447 \text{ g}}{0.0134 \text{ mol}} = 108.0 \text{ g/mol}$$

13) Morphine contains 71.56% carbon, 6.71% hydrogen, 4.91% nitrogen and 16.82% oxygen. It has a molar mass of 285.33 g/mol

A) Determine the empirical formula for morphine.

B) Determine the molecular formula for morphine.

A)  $71.56 \text{ g C} = 5.96 \text{ mol C} / 1.351 = 17$   
 $6.71 \text{ g H} = 6.71 \text{ mol H} / 1.351 = 19$   
 $4.91 \text{ g N} = 0.351 \text{ mol N} / 1.351 = 1$   
 $16.82 \text{ g O} = 1.05 \text{ mol O} / 1.351 = 3$



B)  $\text{C}_{17}\text{H}_{19}\text{NO}_3 = 285.33 \text{ g/mol}$

molecular = 285.33 g/mol

Molec. Form. =  $\text{C}_{17}\text{H}_{19}\text{NO}_3$

14) Calculate the percent composition of each element in the following compounds:

A)  $\text{K}_2\text{CO}_3 = 138.2 \text{ g/mol}$

K =  $56.6\%$  K

C =  $8.7\%$  C

O =  $34.7\%$  O

B)  $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 = 158.1 \text{ g/mol}$

Ca =  $25.4\%$  Ca H =  $3.8\%$  H

C =  $30.4\%$  O =  $40.5\%$  O

15) Using the results from the previous question, calculate the mass (grams) of oxygen present in the following amounts of the above compounds:

A) 124 g  $\text{K}_2\text{CO}_3$

g O =  $(.347)(124 \text{ g})$   
 =  $43.0 \text{ g O}$

B) 377 g  $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$

g O =  $(.405)(377 \text{ g})$   
 =  $152.7 \text{ g O}$

16) Which of the following contains the largest number of INDIVIDUAL ATOMS?

A)  $82.0 \text{ g Kr} \times \frac{1 \text{ mol}}{83.8 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 5.89 \times 10^{23} \text{ atoms}$

C)  $36.0 \text{ g N}_2 \times \frac{1 \text{ mol}}{28 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \times \frac{2 \text{ N atoms}}{1 \text{ molecule}} = 1.55 \times 10^{24} \text{ atoms N}$

B)  $0.842 \text{ mol C}_2\text{H}_4 \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \times \frac{6 \text{ atoms}}{1 \text{ molecule}} = 3.04 \times 10^{24} \text{ atoms}$

D)  $15.7 \text{ L CO}_2 \text{ gas (at STP)} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} \times \frac{3 \text{ atoms}}{1 \text{ molecule}} = 1.27 \times 10^{24} \text{ atoms}$

17) If a reaction is run using 16 grams of oxygen and 24 grams of magnesium, what is the percent composition of oxygen and magnesium in this experiment?

total mass =  $16 \text{ g} + 24 \text{ g} = 40 \text{ g}$

O :  $(16/40) \times 100 = 40\% \text{ O}$

Mg :  $(24/40) \times 100 = 60\% \text{ Mg}$

18) A hydrated crystal had an original mass of 32.5 grams. After heating, the anhydrous crystal had a mass of 25.1 grams. What was the percent composition of  $\text{H}_2\text{O}$  in the hydrated crystal?

$32.5 \text{ g} - 25.1 \text{ g} = 7.4 \text{ g H}_2\text{O}$

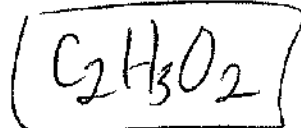
%  $\text{H}_2\text{O} = \frac{7.4 \text{ g}}{32.5 \text{ g}} \times 100 = 22.8\% \text{ H}_2\text{O}$

19) What is the empirical formula of a compound that is 40.7% carbon, 54.2% oxygen, and 5.1% hydrogen?

$40.7 \text{ g C} \times \frac{1 \text{ mol}}{12 \text{ g}} = 3.39 \text{ mol C} / 3.39 = 1 \times 2 = 2$

$54.2 \text{ g O} \times \frac{1 \text{ mol}}{16 \text{ g}} = 3.39 \text{ mol O} / 3.39 = 1 \times 2 = 2$

$5.1 \text{ g H} \times \frac{1 \text{ mol}}{1 \text{ g}} = 5.1 \text{ mol H} / 3.39 = 1.5 \times 2 = 3$



20) What is the empirical formula of a compound formed by the reaction of 102.6 grams of Ca and 97.4 grams of F?

$$102.6 \text{ g Ca} \times \frac{1 \text{ mol Ca}}{40.1 \text{ g}} = 2.56 \text{ mol Ca} \quad 97.4 \text{ g F} \times \frac{1 \text{ mol F}}{19 \text{ g}} = 5.13 \text{ mol F}$$

$$\frac{2.56 \text{ mol Ca}}{2.56} = 1 \quad \frac{5.13 \text{ mol F}}{2.56} = 2$$

$$\boxed{\text{CaF}_2}$$

21) What is the density (in grams per liter) at STP of the gas sulfur hexafluoride,  $\text{SF}_6$ ?  $\text{SF}_6 = 146.1 \text{ g/mol}$

$$\frac{146.1 \text{ g}}{\text{mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = \boxed{6.52 \text{ g/L}}$$

22) The molar mass of a certain gas is 49 g/mol. What is the density of the gas in g/L at STP?

$$\frac{49 \text{ g}}{\text{mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = \boxed{2.19 \text{ g/L}}$$

23) If the density of an unknown gas Z is 4.50 g/L at STP, what is the molar mass (g/mol) at STP?

$$\frac{4.50 \text{ g}}{\text{L}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = \boxed{100.8 \text{ g/mol}}$$

24) Calculate the **molecular formulas** of the compounds with the following empirical formulas and molecular masses:

A)  $\text{C}_2\text{H}_5$ , 58 g/mol;

$$\text{C}_2\text{H}_5 = 29 \text{ g/mol}$$

$$\frac{58}{29} = 2 \quad \boxed{\text{C}_4\text{H}_{10}}$$

B)  $\text{CH}$ , 78 g/mol;

$$\text{CH} = 13 \text{ g/mol}$$

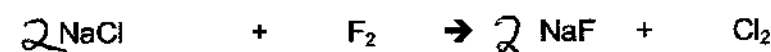
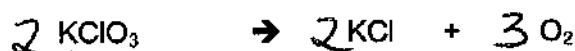
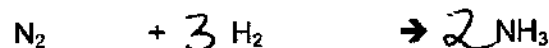
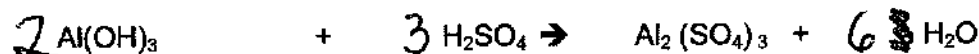
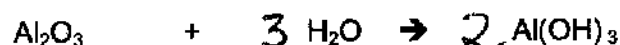
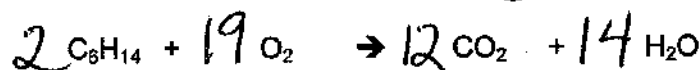
$$\frac{78}{13} = 6 \quad \boxed{\text{C}_6\text{H}_6}$$

C)  $\text{HgCl}$ , 236.1 g/mol

$$\text{HgCl} = 236.1 \text{ g/mol}$$

$$\boxed{\text{HgCl}}$$

25) Balance the following chemical equations & indicate which type of reaction each one is:



Type of Reaction:

D.R.

Combust.

combination

decomp

S.R.

D.R.

D.R.

decomp

combination

decomp

S.R.