— KEY —

WLHS / Chem / Monson

Name_____
Date_____Per_____

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

Moles to Mass	**Volume to # of particles**	**Mass to # of particles**
Moles to Volume	**Volume to Moles**	**Mass to Moles**
Moles to # of particles	**Volume to Mass**	**Mass to Volume**
# of particles to Volume	**# of particles to Moles**	**# of particles to Mass**

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?

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

B) 1.67×10^{26} molecules $NBr_3 \times \frac{1\ mol}{6.02 \times 10^{23}\ molecules}$ = 277 mol NBr_3

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

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

B) 17.7 mol $C_6H_{12}O_6 \times \frac{6.02 \times 10^{23}\ molecules}{1\ mol}$ = 1.07×10^{25} molecules $C_6H_{12}O_6$

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

A) barium sulfate, $BaSO_4$ = 233.4 g/mol

C) aluminum nitrate, $Al(NO_3)_3$ = 213.0 g/mol

E) strontium sulfide, SrS = 119.7 g/mol

B) iron(III) carbonate, $Fe_2(CO_3)_3$ = 291.6 g/mol

D) nitrogen trichloride, NCl_3 = 120.5 g/mol

F) phosphoric acid, H_3PO_4 = 98.0 g/mol

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

A) 15.5 g $SiO_2 \times \frac{1\ mol\ SiO_2}{60.1\ g}$ = 0.258 mol

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

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

D) 937 g $NH_4NO_2 \times \frac{1\ mol}{64.0\ g}$ = 14.6 mol

5) Find the mass of each of the following:

A) 1.50 mol C_5H_{12} $\times \frac{72\text{ g}}{1\text{ mol}} =$ 108.0 g

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

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

D) 0.00321 mol $NiSO_4$ $\times \frac{154.8\text{ g}}{1\text{ mol}} =$ 0.497 g

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

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

B) 0.00557 mol CO_2 gas $\times \frac{22.4\text{ L}}{1\text{ mol}} =$ 0.125 L

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

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

B) 135.7 L CO_2 gas $\times \frac{1\text{ mol}}{22.4\text{ L}} =$ 6.058 mol

8) How many **individual oxygen atoms** are in 17.3 g of cobalt(III) nitrate, $Co(NO_3)_3$?

$17.3\text{ g } Co(NO_3)_3 \times \frac{1\text{ mol}}{244.9\text{ g}} \times \frac{6.02\times10^{23}\text{ f.u.}}{1\text{ mol}} \times \frac{9.0\text{ atoms}}{1\text{ f.u.}} =$ 3.83×10^{23} O atoms

9) How many liters are occupied by:

A) 71.2 g of hydrogen gas (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 L H_2

B) 2.45×10^{24} carbon dioxide molecules (CO_2) at STP?

$2.45\times10^{24}\text{ molecules} \times \frac{1\text{ mol}}{(6.02\times10^{23}\text{ molecules})} \times \frac{22.4\text{ L}}{1\text{ mol}} =$ 91.2 L CO_2

10) What is the mass of:

A) 9.31×10^{23} molecules of CCl_4?

$9.31\times10^{23}\text{ molecules} \times \frac{1\text{ mol}}{(6.02\times10^{23}\text{ molecules})} \times \frac{154.0\text{ g}}{1\text{ mol}} =$ 238 g CCl_4

B) 6557 L methane gas (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 g CH_4

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

A) 422.6 g $Fe_2(CrO_4)_3$?

$422.6\text{ g} \times \frac{1\text{ mol}}{459.6\text{ g}} \times \frac{6.02\times10^{23}\text{ f.u.}}{1\text{ mol}} =$ 5.535×10^{23} f.u. $Fe_2(CrO_4)_3$

B) 0.887 L N_2O gas (at STP)?

$0.887\text{ L} \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol}} =$ 2.38×10^{22} 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?

$300.0\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{1\text{ mol}}{22.4\text{ L}} =$ .0134 mol

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

molar mass = g/mol $= \frac{1.447\text{ g}}{.0134\text{ mol}} = 108.0$ 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 g C = 5.96 mol C / .351 = 17
6.71 g H = 6.71 mol H / .351 = 19
4.91 g N = 0.351 mol N / .351 = 1
16.82 g O = 1.05 mol O / .351 = 3
$C_{17}H_{19}NO_3$

B) $C_{17}H_{19}NO_3$ = 285 g/mol
molecular = 285.33 g/mol
Molec. Form. = $C_{17}H_{19}NO_3$

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

A) K_2CO_3 = 138.2 g/mol
K = 56.6% K
C = 8.7% C
O = 34.7% O

B) $Ca(C_2H_3O_2)_2$ = 158.1 g/mol
Ca = 25.4% Ca H = 3.8% H
C = 30.4% C 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 K_2CO_3

g O = (.347)(124 g)
= 43.0 g O

B) 377 g $Ca(C_2H_3O_2)_2$

g O = (.405)(377 g)
= 152.7 g O

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

A) 82.0 g Kr_x $\frac{1\text{ mol}}{83.8\text{ g}} \times \frac{6.02\times10^{23}\text{ atoms}}{1\text{ mol}}$
= 5.89×10^{23} atoms

B) 0.842 mol C_2H_4 $\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol}} \times \frac{6\text{ atoms}}{1\text{ molecule}}$
= 3.04×10^{24} atoms

C) 36.0 g N_2 $\frac{1\text{ mol}}{28\text{ g}} \times \frac{6.02\times10^{23}}{1\text{ mol}} \rightarrow \frac{2\text{ N atoms}}{1\text{ molecule}}$
= 1.55×10^{24} atoms N

D) 15.7 L CO_2 gas (at STP) $\frac{1\text{ mol}}{22.4\text{ L}} \rightarrow \frac{6.02\times10^{23}\text{ molecules}}{1\text{ mol}} \times \frac{3\text{ atoms}}{1\text{ molecule}}$
= 1.27×10^{24} 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 g + 24 g = 40 g
O : (16/40) x 100 = 40% O
Mg : (24/40) x 100 = 60% 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 H_2O in the hydrated crystal?

32.5 g − 25.1 g = 7.4 g H_2O

% H_2O = $\frac{7.4\text{ g}}{32.5\text{ g}}$ x 100 = 22.8% H_2O

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

40.7 g C x $\frac{1\text{ mol}}{12\text{ g}}$ = 3.39 mol C / 3.39 = 1 x 2 = 2
54.2 g O x $\frac{1\text{ mol}}{16\text{ g}}$ = 3.39 mol O / 3.39 = 1 x 2 = 2
5.1 g H x $\frac{1\text{ mol}}{1\text{ g}}$ = 5.1 mol H / 3.39 = 1.5 x 2 = 3
$C_2H_3O_2$

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

$102.6\,g\,Ca \times \frac{1\,mol\,Ca}{40.1\,g} = 2.56\,mol\,Ca / 2.56 = 1$

$97.4\,g\,F \times \frac{1\,mol\,F}{19\,g} = 5.13\,mol\,F / 2.56 = 2$

CaF_2

21) What is the density (in grams per liter) at STP of the gas sulfur hexafluoride, SF_6? $SF_6 = 146.1\,g/mol$

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

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

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

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?

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

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

A) C_2H_5, 58 g/mol; $C_2H_5 = 29\,g/mol$; $\frac{58}{29} = 2$; C_4H_{10}

B) CH, 78 g/mol; $CH = 13\,g/mol$; $\frac{78}{13} = 6$; C_6H_6

C) HgCl, 236.1 g/mol; $HgCl = 236.1\,g/mol$; $HgCl$

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

	Type of Reaction:
$K_3PO_4 + Al(NO_3)_3 \rightarrow 3\,KNO_3 + AlPO_4$	D. R.
$2\,C_6H_{14} + 19\,O_2 \rightarrow 12\,CO_2 + 14\,H_2O$	Combust.
$Al_2O_3 + 3\,H_2O \rightarrow 2\,Al(OH)_3$	combination
$2\,Fe_2O_3 \rightarrow 4\,Fe + 3\,O_2$	de comp.
$Zn + SnCl_2 \rightarrow Sn + ZnCl_2$	S. R.
$Cu(NO_3)_2 + Na_2S \rightarrow CuS + 2\,NaNO_3$	D. R.
$2\,Al(OH)_3 + 3\,H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6\,H_2O$	D. R.
$SF_6 \rightarrow S + 3\,F_2$	de comp.
$N_2 + 3\,H_2 \rightarrow 2\,NH_3$	combination
$2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2$	de comp
$2\,NaCl + F_2 \rightarrow 2\,NaF + Cl_2$	S. R.