Unit 3 – Moles & Stoichiometry

At the end of this unit, you'll know…

- ✓ A compound is a substance composed of two or more different elements that are chemically combined in a fixed proportion. A chemical compound can only be broken down by chemical means.
- ✓ Chemical compounds can be represented by a specific formula and assigned a name based on the IUPAC system.
- ✓ Types of chemical formulas include empirical, molecular, and structural.
- ✓ Empirical formulas show elements in their simplest whole number ratios. This may or may not be the same as the molecular formula.
- ✓ Molecular formulas show the actual number of atoms per element in a single molecule.
- ✓ Structural formulas show the number of each type of atom as well as their physical arrangement.
- ✓ All chemical reactions show a conservation of mass, energy and charge.
- ✓ A balanced chemical equation represents conservation of atoms.
- ✓ The coefficients in a balanced chemical equation can be used to determine mole ratios in the reaction.
- ✓ The formula mass of a substance is the sum of the atomic masses of its atoms. The molar mass (gram formula mass) equals the mass of one mole of that substance.
- ✓ The percent composition by mass of each element in a compound can be calculated mathematically.
- ✓ Types of chemical reactions include synthesis, decomposition single replacement, and double replacement.

Term	Definition
Balanced equation	a chemical equation in which the number of moles of each element on the reactants side is equal to the number of moles of each element on the products side
Coefficient	the integer that appears in front of an element, molecule, or compound indicating the number of moles present
Decomposition reaction	a chemical reaction in which a compound is broken down into simpler substance Ex: AB à A + B
Double-replacement reaction	a chemical reaction in which a metal replaces a metal AND a nonmetal replaces a nonmetal within two compounds; two compounds “trade” elements Ex: AB + XY à AY + XB
Empirical formula	formula for a compound which provides the simplest ratio of the elements present Ex: The empirical formula for the molecule C6H12O6 is CH2O
Formula mass (FM)	the sum of the atomic masses of a substance in a.m.u.
Gram formula mass (GFM)	the sum of the atomic masses of a substance in grams
Law of conservation of energy	in any chemical reaction, energy can neither be created nor destroyed; the energy of the reactants must be equal to the energy of the products
Law of conservation of mass	in any chemical reaction, mass can neither be created nor destroyed; the mass of the reactants must be equal to the mass of the products
Mole	a quantity of 6.02 x 1023 units of a substance; the amount of a substance equal to the sum of the atomic masses in grams; Avogadro’s number
Molecular formula	formula for a compound which provides the number and identity of the atoms of each element present Ex: C6H12O6
Percent mass	mass of part/mass of whole x 100%
Single-replacement reaction	a chemical reaction in which a metal replaces a metal OR a nonmetal replaces a nonmetal within a compound Ex: A + BC à AC + B
Species	the individual products and reactants in a chemical reaction
Subscript	the integer to the lower right of an element which indicates the number of atoms present in the compound
Synthesis reaction	a chemical reaction in which two or more substances combine to form a compound Ex: A + B à AB

Name____________________________ Date ________________

Period ________________

Elements and Compounds

_____1) **Which of the following CAN be decomposed by chemical change?**

a) SO_2 b) N_2 c) Ne d) Al

_____2) **Which of the following fictitious element symbols are legitimate?**

a) Cn b) HB c) zL d) r

_____3) **Which of the following substances can not be decomposed by chemical change?**

a) Na b) HNO_3 c) $ZnCl_2$ d) $C_6H_{12}O_6$

_____4) **You have discovered a new element and name it. Which one of the following symbols may be used for your new element?**

a) U b) DG c) nD d) Sd

_____5) **Which of the following substances can be decomposed by chemical change?**

a) Na b) Cl c) NaCl d) K

_____6) **Which of the following represents a homogeneous mixture?**

a) NaCl (s) b) NaCl (l) c) NaCl (aq) d) NaCl (g)

_____7) **Which of the following represents a heterogeneous mixture?**

a) air b) soil c) salt water d) sugar

8) Draw a particle diagram of a compound of $CaCl_2$, using black solid circles to represent the Ca and empty circles to represent the Cl. Draw at least five molecules of $CaCl_2$ in the box below:

Name______________________________ Date _________________

Period _________________

Elements and Compounds

9 Which substance can be decomposed by chemical means?

(1) ammonia (3) phosphorus
(2) oxygen (4) silicon

10 Which substance can be decomposed by chemical means?

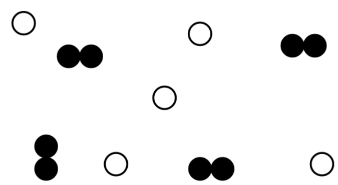
(1) tungsten (3) krypton
(2) antimony (4) methane

11 Bronze contains 90 to 95 percent copper and 5 to 10 percent tin. Because these percentages can vary, bronze is classified as

(1) a compound (3) a mixture
(2) an element (4) a substance

Label each of the following as Element, Compound, Mixture of elements, mixture of compounds, or mixture of both (elements and compounds.).

12 ____________________



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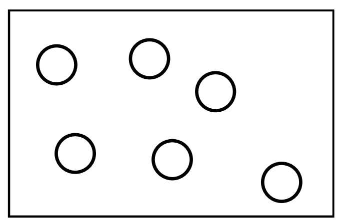

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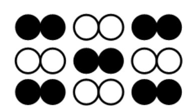

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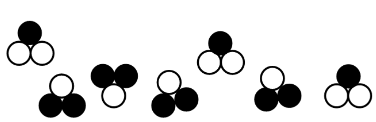

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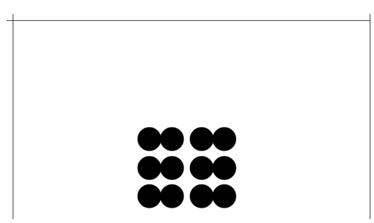

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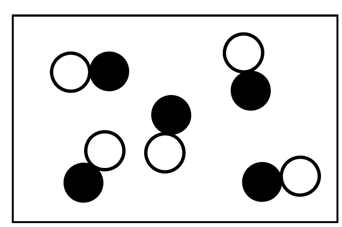

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Name ______________________________ Date ________________

Period ______________________________

Naming Compounds

M-NM

1. $NaBr$ ______________________________
2. CaO ______________________________
3. Li_2S ______________________________
4. $MgBr_2$ ______________________________
5. $Be(OH)_2$ ______________________________
6. NH_4Cl ______________________________
7. $Fe(NO_3)_3$ ______________________________
8. $TiBr_3$ ______________________________
9. Cu_3P ______________________________
10. $SnSe_2$ ______________________________
11. $GaAs$ ______________________________
12. $Pb(SO_4)_2$ ______________________________
13. $Be(HCO_3)_2$ ______________________________
14. $Mn_2(SO_3)_3$ ______________________________
15. $Al(CN)_3$ ______________________________

NM-NM

16. SO_3 ______________________________
17. N_2S ______________________________
18. PH_3 ______________________________
19. BF_3 ______________________________
20. P_2Br_4 ______________________________
21. CO ______________________________
22. SiO_2 ______________________________
23. SF_6 ______________________________
24. NH_3 ______________________________
25. NO_2 ______________________________

Mixed

26. $Fe(CN)_3$ ______________________________
27. Mg_3N_2 ______________________________
28. N_2O ______________________________
29. H_2O ______________________________
30. Na_2CO_3 ______________________________
31. P_2O_5 ______________________________
32. NH_3 ______________________________
33. $FeSO_4$ ______________________________
34. SiO_2 ______________________________
35. $GaCl_3$ ______________________________
36. $CoBr_2$ ______________________________
37. B_2H_4 ______________________________

Name ______________________________________ Date _________________

Period ______________________________________

Molecular Formula from Name

1. magnesium acetate ____________________
2. boron carbide ____________________
3. calcium carbonate ____________________
4. aluminum carbonate ____________________
5. aluminum chloride ____________________
6. calcium chloride ____________________
7. ammonium chloride ____________________
8. sodium cyanide ____________________
9. sulfur dibromide ____________________
10. oxygen difluoride ____________________
11. carbon disulfide ____________________
12. magnesium hydroxide ____________________
13. potassium iodide ____________________
14. nitrogen monoxide ____________________
15. sodium nitrate ____________________
16. magnesium oxide ____________________
17. aluminum oxide ____________________
18. phosphorus pentafluoride ____________________
19. sodium phosphate ____________________
20. beryllium phosphide ____________________
21. lithium sulfate ____________________
22. diboron tetrahydride ____________________
23. nitrogen trichloride ____________________
24. dinitrogen trioxide ____________________

Name ____ Date __________________

Period ____

25. iron (III) sulfite ______________________
26. chromium (III) sulfide ______________________
27. calcium carbonate ________________________
28. sodium acetate ________________________
29. cobalt (II) fluoride ________________________
30. sodium phosphide ________________________
31. tin (IV) oxide ________________________
32. gold (III) bromide ________________________
33. copper (II) iodide ________________________
34. strontium chloride ________________________
35. lithium acetate ________________________
36. magnesium hydroxide _______________________
37. nickel (II) nitrate ________________________
38. chromium (III) sulfite _______________________
39. copper (II) sulfide ________________________
40. iron (III) bromide ________________________
41. aluminum nitride ________________________
42. calcium sulfate ________________________
43. sodium phosphate ________________________
44. iron (III) nitrate ________________________
45. ammonium carbonate ________________________
46. sulfur tetrafluoride ________________________
47. xenon tetrafluoride ________________________
48. dihydrogen monoxide ________________________

Name ________________________________ Date _________________
Period _____________

Writing Ionic Formulas

Use the crisscross method to predict the simplest possible formula

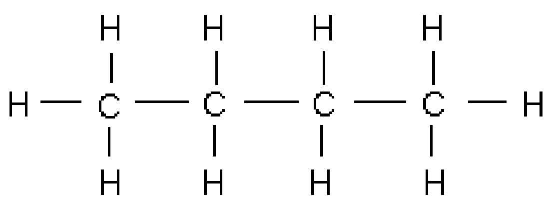
	Cl^{-}	OH^{-}	CO_3^{2-}	SO_4^{2-}	PO_4^{3-}
Na^{+}					
NH_4^{+}					
K^{+}					
Ca^{2+}					
Mg^{2+}					
Fe^{3+}					
Al^{3+}					
Co^{3+}					
Fe^{2+}					
H^{+}					

Name ____ Date __________________

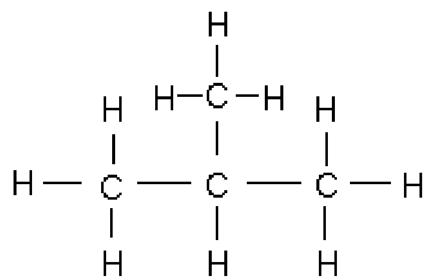
Period ____

Formulas

1. Explain the difference between a molecular formula and an empirical formula. ______________________
____
____
2. Write the empirical formula for each of the following:
   a. $C_6H_{12}O_6$ ______________________
   b. O_2F_2 ______________________
   c. P_4O_6 ______________________
   d. $C_2H_6O_2$ ______________________
   e. $C_2H_4O_2$ ______________________
   f. $C_7H_{15}COOH$ ______________________



butane



methylpropane

3. Write the molecular formula for butane. ___________________________
4. Write the molecular formula for methylpropane. ___________________________
5. Compound X has been found to contain twice as many hydrogen atoms as carbon atoms ond no other elements.
   a. Write the empirical formula for compound X. _____________________________
   b. Of the molecular formulas in the box below, which ones could possibly represent compound X?
   ____
6. Compound Y has been found to contain elements in the following ratio: 3 carbon atoms : 6 hydrogen atoms : 1 oxygen atoms.
   a. Write the empirical formula for compound Y. _____________________________
   b. Of the molecular formulas in the box below, which ones could possibly represent compound Y?
   ____

CH_3	C_5H_{10}	$C_6H_{12}O_2$	
$C_{12}H_{26}$	$C_{11}H_{22}$	C_2H_4	
$C_{10}H_{20}O_3$	CH_4	C_4H_6	CH_2

Name ____ Date __________________

Period ____

Identifying Reaction Types

Determine if the following are synthesis (S), decomposition (D), single replacement (SR), or double replacement (DR) reactions.

______1. $2NaClO_3 \rightarrow 2NaCl + 3O_2$

______2. $2AgNO_3 + Ni \rightarrow Ni(NO_3)_2 + 2Ag$

______3. $H_2CO_3 \rightarrow H_2O + CO_2$

______4. $BaCO_3 \rightarrow BaO + CO_2$

______5. $4Cr + 3\ O_2 \rightarrow 2\ Cr_2O_3$

______6. $Ca + 2HCl \rightarrow CaCl_2 + H_2$

______7. $Ca(C_2H_3O_2)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaC_2H_3O_2$

______8. $Cu(OH)_2 + 2HC_2H_3O_2 \rightarrow Cu(C_2H_3O_2)_2 + 2H_2O$

______9. $8Cu + S_8 \rightarrow 8CuS$

______10. $P_4 + 5\ O_2 \rightarrow 2\ P_2O_5$

______11. $2K + 2H_2O \rightarrow 2KOH + H_2$

______12. $3AgNO_3 + K_3PO_4 \rightarrow Ag_3PO_4 + 3KNO_3$

______13. $H_2 + Cl_2 \rightarrow 2HCl$

______14. $NaOH + HCl \rightarrow NaCl + H_2O$

______15. $Fe_2O_3 + H_2O \rightarrow 2FeO + OH$

______16. $2NH_3 \rightarrow N_2 + 3H_2$

______17. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

______18. $F_2 + 2HBr \rightarrow Br_2 + 2HF$

______19. $Zn(NO_3)2 + CaCO_3 \rightarrow Ca(NO_3)_2 + ZnCO_3$

______20. $4Al + 3O_2 \rightarrow 2Al_2O_3$

Name ____ Date __________________

Period ____

______21. $CuSO_4 \bullet 5H_2O \rightarrow CuO + H_2SO_4 + 4H_2O$

______22. $SiF_6 + 6Xe \rightarrow SiXe_6 + 3F_2$

______23. $H_2 + Cl_2 \rightarrow 2HCl$

______24. $NaOH + HCl \rightarrow NaCl + H_2O$

______25. $2NH_3 \rightarrow N_2 + 3H_2$

______26. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

______27. $Zn(NO_3)_2 + CaCO_3 \rightarrow Ca(NO_3)_2 + ZnCO_3$

______28. $4Al + 3O_2 \rightarrow 2Al_2O_3$

______29. $CuSO_4 \bullet 5H_2O \rightarrow CuO + H_2SO_4 + 4H_2O$

______30. $SiF_6 + 6Xe \rightarrow SiXe_6 + 3F_2$

______31. $2\ NaClO_3 \rightarrow 2\ NaCl + 3\ O_2$

______32. $2\ AgNO_3 + Ni \rightarrow Ni(NO_3)_2 + 2\ Ag$

______33. $H_2CO_3 \rightarrow H_2O + CO_2$

______34. $BaCO_3 \rightarrow BaO + CO_2$

______35. $4\ Cr + 3\ O_2 \rightarrow 2\ Cr_2O_3$

______36. $Ca + 2\ HCl \rightarrow CaCl_2 + H_2$

______37. $Ca(C_2H_3O_2)2 + Na_2CO_3 \rightarrow CaCO_3 + 2\ NaC_2H_3O_2$

______38. $Cu(OH)_2 + 2\ HC_2H_3O_2 \rightarrow Cu(C_2H_3O_2)_2 + 2\ H_2O$

______39. $P_4 + 5\ O_2 \rightarrow 2\ P_2O_5$

______40. $2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$

______41. $3\ AgNO_3 + K_3PO_4 \rightarrow Ag_3PO_4 + 3\ KNO_3$

Name ______________________________________ Date __________________

Period ______________________________________

Balancing Equations

1) ___ $C_2H_4O_2$ + ___ O_2 → ___ CO_2 + ___ H_2O

2) ___ AgI + ___ $Fe_2(CO_3)_3$ → ___ FeI_3 + ___ Ag_2CO_3

3) ___ V_2O_5 + ___ CaS → ___ CaO + ___ V_2S_5

4) ___ $NaNO_3$ + ___ PbO → ___ $Pb(NO_3)_2$ + ___ Na_2O

5) ___ AgBr + ___ $GaPO_4$ → ___ Ag_3PO_4 + ___ $GaBr_3$

6) ___ H_2SO_4 + ___ $B(OH)_3$ → __ $B_2(SO4)_3$ + ___ H_2O

Name ______________________________________ Date __________________

Period ______________________________________

7) ___ S_8 + ___ O_2 → ___ SO_2

8) ___ Fe + ___ $AgNO_3$ → ___ $Fe(NO_3)_2$ + ___ Ag

9) ___ Fe_2O_3 + ___ H_2 → ___ Fe + ___ H_2O

10) ___ Li + ___ N_2 → ___ Li_3N

11) ___ Zn + ___ HCl → ___ $ZnCl_2$ + ___ H_2

12) ___ Mg + ___ N_2 → ___ Mg_3N_2

Name ______________________________________ Date __________________

Period ______________________________________

13) ___ Ca_3P_2 → ___ Ca + ___ P

14) ___ HCl + ___ F_2 → ___ HF + ___ Cl_2

15) ___ NaCl → ___ Na + ___ Cl2

16) ___ H_2O → ___ H_2 + ___ O_2

17) ___ N_2 + ___ H_2 → ___ NH_3

18) ___ Ag + ___ $AuCl_3$ → ___ AgCl + ___ Au

Name ______________________________________ Date _________________

Period ______________________________________

19) ___ $Pb(NO_3)_2$ + ___ $NaCl$ → ___ $PbCl_2$ + ___ $NaNO_3$

20) ___ Na_3PO_4 + ___ $AgNO_3$ → ___ Ag3PO_4 + ___ $NaNO_3$

21) ___ C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O

22) ___ CH_4 + ___ O_2 → ___ CO_2 + ___ H_2O

23) ___ H_2 + ___ Cl_2 → ___ HCl

24) ___ Na + ___ H_2O → ___ $NaOH$ + ___ H_2

Name ________________________________ Date ________________
Period ________________

Identifying Reaction Types

Identify the reaction type and balance the following:

Reaction	Reaction Type
1. $\_\_N_2 + \_\_H_2 \rightarrow \_\_NH_3$	
2. $\_\_KClO_3 \rightarrow \_\_KCl + \_\_O_2$	
3. $\_\_Zn + \_\_HCl \rightarrow \_\_ZnCl_2 + \_\_H_2$	
4. $\_\_C_3H_8 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$	
5. $\_\_NaCl + \_\_F_2 \rightarrow \_\_NaF + \_\_Cl_2$	
6. $\_\_K_3PO_4 + \_\_Al(NO_3)_3 \rightarrow \_\_KNO_3 + \_\_AlPO_4$	
7. $\_\_H_2 + \_\_O_2 \rightarrow \_\_H_2O$	
8. $\_\_AgNO_3 + \_\_MgCl_2 \rightarrow \_\_AgCl + \_\_Mg(NO_3)_2$	

9. ___CH_4 + ___O_2 → ___CO_2 + ___H_2O	
10. ___$AlBr_3$ + ___K_2SO_4 → ___KBr + ___$Al_2(SO_4)_3$	
11. ___$FeCl_3$ + ___$NaOH$ → ___$Fe(OH)_3$ + ___$NaCl$	
12. ___P + ___O_2 → ___P_2O_5	
13. ___C_3H_8 + ___O_2 → ___CO_2 + ___H_2O	
14. ___S_8 + ___O_2 → ___SO_3	
15. ___K + ___$MgBr_2$ → ___KBr + ___Mg	
16. ____Na_2CO_3 + ____$Ca(OH)_2$ → ____$NaOH$ + ____$CaCO_3$	

Name ______________________________________ Date __________________

Period ______________________________________

Formula Mass

Calculate the formula mass for the following:

1) Br_2

2) $CsOH$

3) $BaCl_2$

4) FeF_3

5) $AlCl_3$

6) Al_2O_3

7) SO_3

8) HNO_3

9) $(NH_4)_2CO_3$

10) $Mg_3(PO_4)_2$

11) $Pb(CH_3COO)_2$

Name ______________________________________ Date __________________
Period ______________________________________

Molar Mass – GFM

Find the gfm of the following compounds.

1) NaBr

2) $PbSO_4$

3) $Ca(OH)_2$

4) Na_3PO_4

5) $(NH_4)_2CO_3$

6) $C_6H_{12}O_6$

7) $Fe_3(PO_4)_2$

8) $(NH_4)_2S$

9) $Zn(C_2H_3O_2)_2$

10) AgF

11) H_2SO_4

12) NH_4OH

13) $Al_2(SO_4)_3$

14) O_2

Name ____ Date ___________________
Period ____

Convert the following from grams to moles:

1) 15.0 g $C_6H_{12}O_6$

2) 25.0 g NaOH

3) 54.0 g HCl

4) 13.0 g H_2O

5) 23.0 g $Ca(NO_3)_2$

6) 1.00 g H_2SO_4

7) 0.105 g O_2

Convert the following from moles to grams:

1) 0.500 moles LiF

2) 0.1188 moles NaOH

3) 4.00 moles KCl

4) 10.0 moles H_2O_2

5) 13.0 moles Na_2CO_3

6) 28.0 moles H_2O

7) 0.800 moles NH_3

Name ____ Date ___________________
Period ____

Grams, Molecules, and Moles Worksheet

1) How many molecules are there in 32.0 grams of FeF_3? **Molecules:** __________

2) How many molecules are there in 250. grams of Na_2SO_4? **Molecules:** __________

3) How many grams are there in 4.60×10^{24} atoms of silver? **Grams:** ____________

4) How many grams are there in 4.70×10^{23} molecules of $AgNO_3$? **Grams:** ____________

5) How many grams are there in 5.70×10^{23} molecules of H_2SO_4? **Grams:** ____________

6) How many molecules are there in 221 grams of $Cu(NO_3)_2$? **Molecules:** __________

Name ______________________________________ Date __________________
Period ______________________________________

7) How many grams are there in 4.90×10^{25} molecules of H_2? **Molecules:** __________

8) How many molecules are there 230. grams of $CoCl_2$? **Molecules:** ___________

9) How many molecules are there in 3.20 grams of NH_4SO_2? **Molecules:** ___________

10) How many grams are there in 4.40×10^{23} molecules of N_2I_6? **Grams:** _____________

11) How many molecules are there in 120.0 grams of CCl_4? **Molecules:** ___________

12) How many molecules are there 4.39 grams of LiCl? **Molecules:** ____________

Name ____ Date ___________________
Period ____

Solutions to the Molar Mass Practice Worksheet:

Important note to students: The 'mole' is a unit commonly used to indicate a number of things about the amount of material present. I will be introducing it this week. All of the units given here are "grams per mole", which may be abbreviated as "g/mol", "grams/mol", or "$g \cdot mol^{-1}$", depending on how your teacher likes to see it written. They all mean the same thing, but it's probably a good idea to use whatever your teacher showed you in class. Also, remember that if you don't use units in your answer, the answer is *wrong!*

All answers are rounded to the nearest 0.1 grams.

1) 102.9 g/mol
2) 303.3 g/mol
3) 74.1 g/mol
4) 164.0 g/mol
5) 96.0 g/mol
6) 180.0 g/mol
7) 357.4 g/mol
8) 68.1 g/mol
9) 183.4 g/mol
10) 126.9 g/mol

Name ______________________________________ Date _________________
Period ______________________________________

Empirical Formula Worksheet

Molecular formula from empirical formula and molecular mass.

Step 1 – Write the empirical formula.
Step 2 – Calculate the empirical formula mass.
Step 3 – Write the molar mass.
Step 4 – Divide the empirical mass by the molar mass – this is your multiplier.
Step 5 – Multiply empirical subscripts by your multiplier – this is your molecular formula.

Empirical Formula	Empirical Formula Mass	Molar Mass	Multiplier	Molecular Formula

1. A compound has an empirical formula of NO_2 and a molecular mass of 92. What is the molecular formula?

2. A compound with an empirical formula of CH_2 has a molecular mass of 70. What is the molecular formula?

3. A compound has an empirical formula of CH_2 and a molecular mass of 42. What is the molecular formula?

Name ______________________________________ Date _________________
Period ______________________________________

4. A compound has an empirical formula of CH_4N and a molar mass of 120. What is the molecular formula?

5. A compound has an empirical formula of NS and a molecular mass of 138. What is the molecular formula?

6. A compound has a molecular mass of 168 and an empirical formula of C_3H_4O. What is the molecular formula?

7. A compound has a molecular mass of 189 and an empirical formula of $C_2H_7O_2$. What is the molecular formula?

Name ______________________________________ Date _________________
Period ______________________________________

8. A compound has a molecular mass of 222 and an empirical formula of $Mn(C_2H_4)_2$. What is the molecular formula?

9. A compound has a molecular mass of 180 and an empirical formula of CH_2O. What is the molecular formula?

10. A compound has a molecular mass of 78 and an empirical formula of CH. What is the molecular formula?

11. A compound has a molecular mass of 70 and an empirical formula of CH_2. What is the molecular formula?

Name ______________________________________ Date _________________
Period ______________________________________

Percent Composition

Compound	GFM	% comp	% comp	% comp
H_2SO_4		% H	% S	% O
$CaCl_2$		% Ca	% Cl	
H_2O		% H	% O	
$CuCO_3$		% Cu	% C	% O
NaCl		% Na	% Cl	
$Al_2(PO_4)_3$		% Al	% P	% O
KOH		% K	% O	% H

Name ______________________________________ Date _________________
Period ______________________________________

Compound	GFM	% comp	% comp	% comp
C_2H_6		% C	% H	
ZnI_2		% Zn	% I	
CO_2		% C	% O	
CaO		% Ca	% O	
NO		% N	% O	
Fe_2O_3		% Fe	% O	
H_2O_2		% H	% O	
$CuSO_4 \cdot 5H_2O$		% Cu	% $CuSO_4$	% H_2O

Name ______________________________________ Date _________________
Period ______________________________________

Empirical Formula From Percent Composition

Determine the empirical formula for each of the following:

1. 92.24% C; 7.76% H

2. 36.48% Na; 25.44% S; 38.08% O

3. 49.99% C; 5.61% H; 44.40% O

4. 38.76% Ca; 19.97% P; 41.27% O

5. A compound composed of 0.556g carbon and 0.0933g hydrogen.

Name ______________________________________ Date _________________
Period ______________________________________

Molecular Formula from Empirical Formula and Percent Composition

1. Calculate the molecular formula for the following:
   a. empirical formula CH, molar mass = 78 g/mol

   b. empirical formula NO2, molar mass = 46.01 g/mol

   c. caffeine, 49.5% C, 5.15% H, 28.9% N, 16.5% O by mass, molar mass = 195 g

   d. A compound analyzes as 79.08% C; 5.54% H and 15.38% N. What isthe molecular formula if the molar mass is 273.36 g/mol?

Name ____ Date __________________

Period ____

Crystal Hydrates

1. Base your answer to the following question on A hydrate is a compound with water molecules incorporated into its crystal structure. In an experiment to find the percent by mass of water in a hydrated compound, the following data were recorded:

Mass of crucible + hydrated crystals before heating	7.50 grams
Mass of crucible	6.80 grams
Mass of crucible + anhydrous crystals after heating	7.20 grams

What is the percent by mass of water in the hydrate?

A) 72. % B) 50. % C) 96. % D) 8.0 %

---

2. The percent by mass of water in the hydrate $Na_2SO_4 \bullet 10H_2O$ is closest to

A) 18% B) 44% C) 76% D) 56%

3. What is the percent by mass of water present in 1.0 mole of $CaSO_4 \bullet 2H_2O$?

A) 79% B) 10.% C) 12% D) 21%

4. A student obtained the following data to determine the percent by mass of water in a hydrate.

Mass of empty crucible + cover	11.70 g
Mass of crucible + cover + hydrated salt before heating	14.90 g
Mass of crucible + cover + anhydrous salt after thorough heating	14.53 g

What is the approximate percent by mass of the water in the hydrated salt?

A) 12% B) 88% C) 98% D) 2.5%

5. A 4.4 gram sample of a hydrate was heated until the water of hydration was driven off. The anhydrous compound remaining had a mass of 3.3 grams. What is the percentage by mass of water in the hydrate?

A) 25% B) 33% C) 67% D) 75%

6. A 20. gram sample of a hydrate is heated until all the water of hydration is driven off. The mass of the anhydrous compound remaining is 15 grams. What is the percent by mass of water in the hydrate?

A) 75% B) 15% C) 25% D) 33%

7. Which species contains the greatest percent by mass of hydrogen?

A) H_3O^+ B) H_2O_2
C) H_2O D) OH^-

8. A 1.20-gram sample of a hydrated salt is heated to a constant mass of 0.80 gram. What was the percent by mass of water contained in the original sample?

A) 20. B) 33 C) 50. D) 67

9. A student determining the percent by mass of water in a hydrated crystal obtained the following data.
Mass of crystal before heating..................5.0 g
Mass of crystal after 1st heating...............4.0 g
Mass of crystal after 2nd heating..............4.0 g
What is the percent by mass of water in the hydrate?

A) 0.80% B) 0.20%
C) 80.% D) 20.%

10. The percent by mass of water in $BaCl_2 \cdot 2\,H_2O$ (formula mass = 243) is equal to

A) $\frac{18}{243} \times 100$ B) $\frac{243}{18} \times 100$
C) $\frac{243}{36} \times 100$ D) $\frac{36}{243} \times 100$

Name ______________________________________ Date __________________

Period ______________________________________

11. A 10.0 gram sample of a hydrate was heated until all the water of hydration was driven off. The mass of anhydrous product remaining was 8.00 grams. What is the percent of water in the hydrate?

A) 25.0% B) 12.5%
C) 80.0% D) 20.0%

12. A 60. gram sample of $LiCl \bullet H_2O$ is heated in an open crucible until all of the water has been driven off. What is the total mass of LiCl remaining in the crucible?

A) 42 g B) 24 g C) 18 g D) 60 g

13. A student determining the percent by mass of water in a hydrated sample of salt obtained the following data:
Mass of hydrate 6.25 g
Mass of sample after 1st heating 5.12 g
Mass of sample after 2nd heating 5.12 g

The correct expression for obtaining the percent by mass of water in the sample is

A) $\frac{6.25\text{ g}}{1.13\text{ g}} \times 100$ B) $\frac{5.12\text{ g}}{6.25\text{ g}} \times 100$
C) $\frac{6.25\text{ g}}{5.12\text{ g}} \times 100$ D) $\frac{1.13\text{ g}}{6.25\text{ g}} \times 100$

14. An 8.24-gram sample of a hydrated salt is heated until it has a constant mass of 6.20 grams. What was the percent by mass of water contained in the original sample?

A) 75.2% B) 14.1%
C) 24.8% D) 32.9%

Base your answers to questions **15** and **16** on the table below shows the data collected during the heating of a 5.0 gram sample of a hydrated salt.

Mass of Salt (g)	Heating Time (min)
5.0	0.0
4.1	5.0
3.1	10.
3.0	15.
3.0	30.
3.0	60.

15. What is the percent of water in the original sample?

A) 82.% B) 40.%
C) 60.% D) 30.%

16. After 60. minutes, how many grams of water appear to remain in the salt?

A) 0.00 B) 2.0 C) 1.9 D) 0.90

Name ____ Date ___________________
Period ____

Mole Ratio Worksheet

1) Given this equation: $N_2 + 3\ H_2$ ---> $2\ NH_3$, write the following molar ratios:
a) N_2 / H_2

b) N_2 / NH_3

c) H_2 / NH_3

2) Given the following equation: $8\ H_2 + S_8$ ---> $8\ H_2S$, write the following molar ratios:
a) H_2 / H_2S

b) H_2 / S_8

c) H_2S / S_8

3) Answer the following questions for this equation: $2\ H_2 + O_2$ ---> $2\ H_2O$
a) What is the H_2 / H_2O molar ratio?

b) Suppose you had 20 moles of H_2 on hand and plenty of O_2, how many moles of H_2O could you make?

c) What is the O_2 / H_2O molar ratio?

d) Suppose you had 20 moles of O_2 and enough H_2, how many moles of H_2O could you make?

4) Use this equation: $N_2 + 3\ H_2$ ---> $2\ NH_3$, for the following problems
a) If you used 1 mole of N_2, how many moles of NH_3 could be produced?

b) If 10 moles of NH_3 were produced, how many moles of N_2 would be required?

c) If 3.00 moles of H_2 were used, how many moles of NH_3 would be made?

d) If 0.600 moles of NH_3 were produced, how many moles of H_2 are required?

Name ______________________________________ Date _________________
Period ______________________________________

Mole/Mole Ratio Problems

1. ___N_2 + ___H_2 → ___NH_3

a. How many moles of hydrogen are needed to completely react with two moles of nitrogen?

b. How many moles of nitrogen trihydride can be produced with 5 moles of nitrogen?

c. How many moles of nitrogen are needed to produce .5 moles of nitrogen trihydride?

d. How many liters of nitrogen trihydride can be produced from 24 liters of nitrogen gas?

2. ___$KClO_3$ → ___KCl + ___O_2

a. How many moles of oxygen are produced by the decomposition of six moles of potassium chlorate?

b. How many moles of potassium chloride are produced by the decomposition of .75 moles of potassium chlorate?

c. How many moles of potassium chlorate are needed to produce 100 moles of oxygen?

d. How many liters of oxygen will the decomposition of 100 liters of potassium chlorate produce?

Name ____ Date __________________
Period ____

3. __Zn + __HCl → __$ZnCl_2$ + __H_2

a. How many moles of hydrogen are produced from the reaction of three moles of zinc?

b. How many moles zinc are needed to produce 3.5 moles of zinc chloride?

c. How many moles of hydrogen can 15 moles hydrogen chloride produce?

d. How many liters hydrogen chloride are needed react with 11 liters of zinc?

4. __C_3H_8 + __O_2 → __CO_2 + __H_2O

a. How many moles of oxygen are necessary to react completely with fours moles of Propane (C_3H_8)?

b. How many moles of Propane (C_3H_8) are needed to produce 25 moles of carbon dioxide?

c. How many moles of water will 3 moles of propane (C_3H_8) produce?

d. How many liters of Propane (C_3H_8) are needed to react with 75 liters of oxygen?

5. __$NaCl$ + __F_2 → __NaF + __Cl_2

a. How many moles of fluorine are needed to produce 3.2 moles of sodium chloride?

b. How many moles of chlorine can me produced by using a total of 3 moles of sodium chloride?

c. How many moles of sodium fluoride can five moles of fluorine produce?

Name____________________________ Date ________________

Period ________________

Math of Chemistry Review

34 What is the gram-formula mass of $Ca_3(PO_4)_2$?

(1) 248 g/mol (3) 279 g/mol
(2) 263 g/mol (4) 310. g/mol

17 What is the total number of different elements present in NH_4NO_3?

(1) 7 (3) 3
(2) 9 (4) 4

Base your answers to questions 77 through 79 on the information below.

Some dry chemicals can be used to put out forest fires. One of these chemicals is $NaHCO_3$. When $NaHCO_3(s)$ is heated, one of the products is $CO_2(g)$, as shown in the balanced equation below.

$$2NaHCO_3(s) + heat \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

77 In the space *in your answer booklet*, show a correct numerical setup for calculating the percent composition by mass of carbon in the product Na_2CO_3. [1]

78 Identify the type of chemical reaction represented by this equation. [1]

79 Determine the total number of moles of $CO_2(g)$ produced when 7.0 moles of $NaHCO_3(s)$ is completely reacted. [1]

10 Given the balanced equation representing a reaction:

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

What is the mole ratio of CO(g) to $CO_2(g)$ in this reaction?

(1) 1:1 (3) 2:1
(2) 1:2 (4) 3:2

12 Which polyatomic ion contains the greatest number of oxygen atoms?

(1) acetate (3) hydroxide
(2) carbonate (4) peroxide

51 What is the oxidation number of nitrogen in NO(g)? [1]

51 ___________________

35 A compound has a molar mass of 90. grams per mole and the empirical formula CH_2O. What is the molecular formula of this compound?

(1) CH_2O (3) $C_3H_6O_3$
(2) $C_2H_4O_2$ (4) $C_4H_8O_4$

9 What is the name of the polyatomic ion in the compound Na_2O_2?

(1) hydroxide (3) oxide
(2) oxalate (4) peroxide

Name____________________________ Date ________________

Period ________________

9 What is the name of the polyatomic ion in the compound Na_2O_2?

(1) hydroxide (3) oxide
(2) oxalate (4) peroxide

36 Which formula represents lead(II) chromate?

(1) $PbCrO_4$ (3) Pb_2CrO_4
(2) $Pb(CrO_4)_2$ (4) $Pb_2(CrO_4)_3$

36 Given the balanced equation representing a reaction:

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

What is the *minimum* number of moles of O_2 that are needed to completely react with 16 moles of NH_3?

(1) 16 mol (3) 64 mol
(2) 20. mol (4) 80. mol

18 Bronze contains 90 to 95 percent copper and 5 to 10 percent tin. Because these percentages can vary, bronze is classified as

(1) a compound (3) a mixture
(2) an element (4) a substance

38 Which pair consists of a molecular formula and its corresponding empirical formula?

(1) C_2H_2 and CH_3CH_3 (3) P_4O_{10} and P_2O_5
(2) C_6H_6 and C_2H_2 (4) SO_2 and SO_3

10 Given the balanced equation representing the reaction between propane and oxygen:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

According to this equation, which ratio of oxygen to propane is correct?

(1) $\frac{5 \text{ grams } O_2}{1 \text{ gram } C_3H_8}$ (3) $\frac{10 \text{ grams } O_2}{11 \text{ grams } C_3H_8}$

(2) $\frac{5 \text{ moles } O_2}{1 \text{ mole } C_3H_8}$ (4) $\frac{10 \text{ moles } O_2}{11 \text{ moles } C_3H_8}$

17 Which substance can be decomposed by chemical means?

(1) tungsten (3) krypton
(2) antimony (4) methane

55 Determine the percent composition by mass of oxygen in the compound $C_6H_{12}O_6$. [1]

55 ______________ %

54 A hydrated compound contains water molecules within its crystal structure. The percent composition by mass of water in the hydrated compound $CaSO_4 \bullet 2H_2O$ has an accepted value of 20.9%. A student did an experiment and determined that the percent composition by mass of water in $CaSO_4 \bullet 2H_2O$ was 21.4%.

In the space *in your answer booklet*, calculate the percent error of the student's experimental result. Your response must include *both* a correct numerical setup and the calculated result. [2]

54

______________ %

Name______________________________ Date ________________

Period ________________

6 A compound is made up of iron and oxygen, only. The ratio of iron ions to oxide ions is 2:3 in this compound. The IUPAC name for this compound is

(1) triiron dioxide
(2) iron(II) oxide
(3) iron(III) oxide
(4) iron trioxide

37 The percent composition by mass of magnesium in $MgBr_2$ (gram-formula mass = 184 grams/mole) is equal to

(1) $\frac{24}{184} \times 100$
(2) $\frac{160.}{184} \times 100$
(3) $\frac{184}{24} \times 100$
(4) $\frac{184}{160.} \times 100$

9 What is the total number of pairs of electrons shared in a molecule of N_2?

(1) one pair
(2) two pairs
(3) three pairs
(4) four pairs

38 Given the balanced equation:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(\ell) + CO_2(g)$$

What is the total number of moles of CO_2 formed when 20. moles of HCl is completely consumed?

(1) 5.0 mol
(2) 10. mol
(3) 20. mol
(4) 40. mol

51 In the space *in your answer booklet,* draw a Lewis electron-dot diagram for a sulfur atom in the ground state. [1]

51

6 What is the IUPAC name for the compound FeS?

(1) iron(II) sulfate
(2) iron(III) sulfate
(3) iron(II) sulfide
(4) iron(III) sulfide

35 In which compound is the percent composition by mass of chlorine equal to 42%?

(1) HClO (gram-formula mass = 52 g/mol)
(2) $HClO_2$ (gram-formula mass = 68 g/mol)
(3) $HClO_3$ (gram-formula mass = 84 g/mol)
(4) $HClO_4$ (gram-formula mass = 100. g/mol)

33 A substance has an empirical formula of CH_2 and a molar mass of 56 grams per mole. The molecular formula for this compound is

(1) CH_2
(2) C_4H_6
(3) C_4H_8
(4) C_8H_4

36 Given the balanced equation:

$$2C + 3H_2 \rightarrow C_2H_6$$

What is the total number of moles of C that must completely react to produce 2.0 moles of C_2H_6?

(1) 1.0 mol
(2) 2.0 mol
(3) 3.0 mol
(4) 4.0 mol

7 Given the balanced equation representing a reaction:

$$F_2(g) + H_2(g) \rightarrow 2HF(g)$$

What is the mole ratio of $H_2(g)$ to HF(g) in this reaction?

(1) 1:1
(2) 1:2
(3) 2:1
(4) 2:3

8 What is the chemical formula for sodium sulfate?

(1) Na_2SO_3
(2) Na_2SO_4
(3) $NaSO_3$
(4) $NaSO_4$

10 Which chemical equation is correctly balanced?

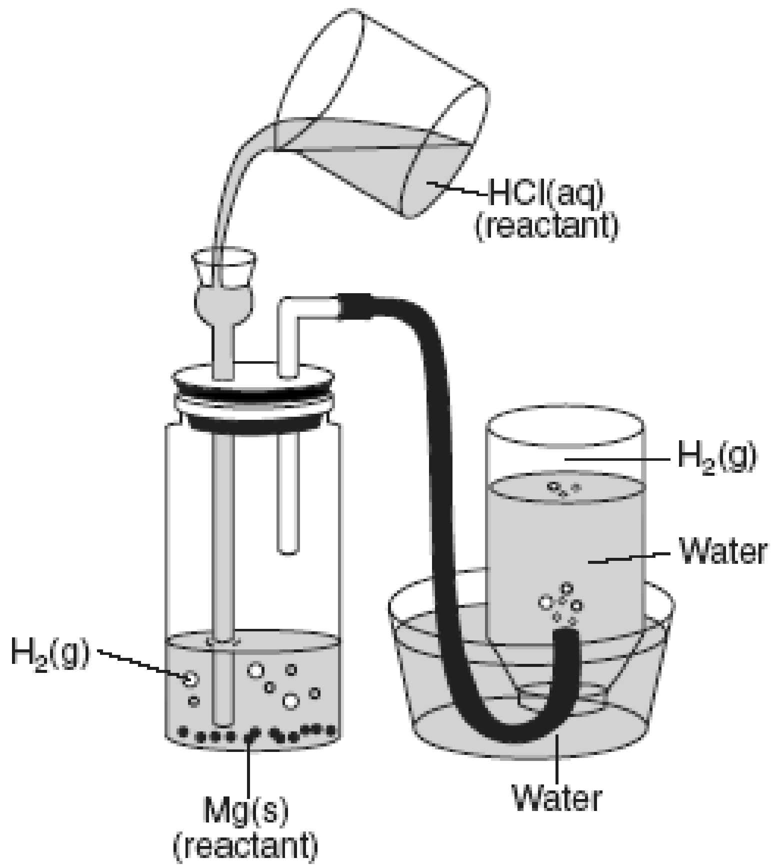
(1) $H_2(g) + O_2(g) \rightarrow H_2O(g)$
(2) $N_2(g) + H_2(g) \rightarrow NH_3(g)$
(3) $2NaCl(s) \rightarrow Na(s) + Cl_2(g)$
(4) $2KCl(s) \rightarrow 2K(s) + Cl_2(g)$

Name____________________________ Date ________________

Period ________________

Base your answers to questions 82 through 85 on the information below.

A student places a 2.50-gram sample of magnesium metal in a bottle and fits the bottle with a 2-hole stopper as shown in the diagram. Hydrochloric acid is added to the bottle, causing a reaction. As the reaction proceeds, hydrogen gas travels through the tubing to an inverted bottle filled with water, displacing some of the water in the bottle.



82 Balance the equation *in your answer booklet* for the reaction of magnesium and hydrochloric acid, using the smallest whole-number coefficients. [1]

83 Identify the type of chemical reaction that occurs when magnesium reacts with hydrochloric acid. [1]

84 In the space *in your answer booklet*, show a correct numerical setup for calculating the number of moles of magnesium used in the experiment. [1]

85 Based on Reference Table *J*, explain why Ag(s) will *not* react with HCl(aq) to generate $H_2(g)$. [1]

Name_____________________________ Date ________________

Period ________________

82 ________ $Mg(s)$ + ________ $HCl(aq) \rightarrow$ ________ $MgCl_2(aq)$ + ________ $H_2(g)$

83 ____

84

85 ____

____

____

33 What is the percent composition by mass of nitrogen in NH_4NO_3 (gram-formula mass = 80.0 grams/mole)?

(1) 17.5%
(2) 35.0%
(3) 52.5%
(4) 60.0%

31 The percentage by mass of Br in the compound $AlBr_3$ is closest to

(1) 10.%
(2) 25%
(3) 75%
(4) 90.%

9 The correct chemical formula for iron(II) sulfide is

(1) FeS
(2) Fe_2S_3
(3) $FeSO_4$
(4) $Fe_2(SO_4)_3$

48 Given the incomplete equation:

$$4Fe + 3O_2 \rightarrow 2X$$

Which compound is represented by X?

(1) FeO
(2) Fe_2O_3
(3) Fe_3O_2
(4) Fe_3O_4

REGENTS CHEMISTRY **Moles & Stoich Practice Test** **Name** ________________________

Mr. Dolgos **Period** ____

1) How many oxygen atoms are represented in the formula $Al_2(CO_3)_3$?

a) 3 b) 9 c) 10 d) 6

2) What is the total number of atoms present in 1 mole of $Ca_3(PO_4)_2$?

a) 8 b) 5 c) 10 d) 13

3) What is the total mass of iron in 1.0 mole of Fe_2O_3?

a) 72 g b) 112 g c) 56 g d) 160 g

4) What is the gram formula mass of Li_2SO_4?

a) 206 g b) 55 g c) 110 g d) 54 g

5) What is the percent composition by mass of sulfur in H_2SO_4? [formula mass = 98]

a) 98% b) 16% c) 65% d) 33%

6) A hydrate is a compound with water molecules incorporated into its crystal structure. In an experiment to find the percent by mass of water in a hydrated compound, the following data were recorded:

Mass of test tube + hydrate crystals before heating	25.3 grams
Mass of test tube	21.3 grams
Mass of test tube + anhydrate crystals after heating	22.3 grams

What is the percent by mass of water in the hydrate?

a) 75% b) 50% c) 8.0% d) 95%

7) Which of the following statements explains why mass is lost when a student heats a sample of $BaCl_2 \cdot 2H_2O$ crystals?

a) water is given off as a gas
b) the crystals sublime
c) chlorine is given off as a gas
d) the crystals fuse (melt)

8) When the equation $H_2S + O_2 \rightarrow H_2O + SO_2$ is completely balanced using the *smallest* whole numbers, the sum of all the coefficients is

a) 9 b) 11 c) 7 d) 5

9) What is the percent by mass of water in the hydrate $Na_2CO_3 \bullet 10H_2O$ [formula mass = 286]?

a) 26.1% b) 62.9% c) 6.89% d) 214.5%

10) How many grams are there in 2.5 moles of C_2H_5OH?

a) 18 b) 115 c) 46 d) 0.05

11) Which quantity is equivalent to 146 grams of NaCl?

a) 1.0 mole b) 2.5 moles c) 2.0 moles d) 1.5 moles

12) The equation below is best classified as which type of chemical reaction?

$$H_2 + Fe_3O_4 \dashrightarrow Fe + H_2O$$

a) Synthesis
b) Combustion
c) Single replacement
d) Double replacement

13) When the equation $NaBr + H_3PO_4 \rightarrow Na_3PO_4 + HBr$ is balanced using the smallest whole numbers, the sum of the coefficients will be

a) 6 b) 8 c) 5 d) 4

14) The equation below is best classified as which type of chemical reaction?

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$

a) Synthesis
b) Combustion
c) Single replacement
d) Double replacement

15) Given the reaction: $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

What is the ratio of moles of CO_2 produced to moles of C_2H_6 consumed?

a) 7 to 2 b) 2 to 1 c) 1 to 1 d) 3 to 2

16) Which represents the greatest mass of chlorine?

a) 1 atom of chlorine
b) 1 molecule of chlorine
c) 1 mole of chlorine
d) 1 gram of chlorine

17) Given the reaction: $2Na + 2H_2O \rightarrow 2NaOH + H_2$, what is the total number of moles of hydrogen produced when 4 moles of sodium react completely?

a) 1 b) 2 c) 3 d) 4

18) What type of reaction best describes the following chemical reaction?

$$Zn + CuSO_4 \dashrightarrow ZnSO_4 + Cu$$

a) single replacement
b) double replacement
c) decomposition
d) synthesis

19) Which chemical equation best represent a decomposition reaction?

a) $Cl_2 + 2KI \rightarrow 2KCl + I_2$
b) $2Al + 3Cl_2 \rightarrow 2AlCl_3$
c) $H_2CO_3 \rightarrow H_2O + CO_2$
d) $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$

20) What is the molecular formula of a compound that has a molecular mass of 54 and an empirical formula of C_2H_3?

a) C_8H_{12} b) C_6H_9 c) C_4H_6 d) C_2H_3

21) What is the empirical formula of the compound whose molecular formula is P_4O_{10}?

a) P_8O_{20} b) PO_2 c) P_2O_5 d) PO

22) Which of the following is an empirical formula?

a) H_2O_2 b) H_2O c) C_2H_2 d) C_4H_8

23) Which represents *both* an empirical and molecular formula?

a) P_2O_5 b) C_3H_6 c) N_2O_4 d) $C_6H_{12}O_6$

Constructed Response Questions

For questions 24 and 25, show all work and express your answer in the appropriate units.

24) Calculate the gram formula mass of $ZnSO_4$. (3 pts)

25) Use your answer from 23 to calculate the percent by mass of zinc in $ZnSO_4$. (3 pts)

26) Balance the following reaction and reduce to the *lowest* whole number coefficients: (1 pt)

_____ H_2SO_4 + _____ $B(OH)_3$ $\rightarrow$ _____ $B_2(SO_4)_3$ + _____ H_2O

27) Li and KNO3 according to the following equation:

$$Li + KNO_3 \rightarrow LiNO_3 + X$$

Write the formula for the missing product X. (1 pt)

Use the chemical equation below to answer questions 28-30.

$$\_\_\_ N_2 + \_\_\_ H_2 \rightarrow \_\_\_ NH_3$$

28) Balance the equation above using the lowest whole number coefficients.

29) How many moles of H_2 are required to produce 6.5 moles of NH_3? Show all work and make sure your answer has the correct number of significant figures and proper units.

30) How many grams of NH_3 are produced if 50.0 grams of N_2 are consumed? Show all work and make sure your answer has the correct number of significant figures and proper units.

For question 31, show all work and make sure your answer has the correct number of significant figures and proper units.

31) A compound consists of 85% silver and 15% fluorine by mass.

a) What is the empirical formula for this compound?

b) What is the molecular formula (molar mass = 126.9g)

REGENTS CHEMISTRY **Moles & Stoich Practice Test** **Name** ______________________

Mr. Dolgos **Period** ____

1. _____
2. _____
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17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____

For questions 24 and 25, show all work and express your answer in the appropriate units.

24) Calculate the gram formula mass of $ZnSO_4$. (3 pts)

25) Use your answer from 23 to calculate the percent by mass of zinc in $ZnSO_4$. (3 pts)

26) Balance the following reaction using the lowest whole number coefficients: (1 pt)

_____ H_2SO_4 + _____ $B(OH)_3$ → _____ $B_2(SO_4)_3$ + _____ H_2O

27) Li and KNO3 according to the following equation:

$Li + KNO_3 \rightarrow LiNO_3 + X$

Write the formula for the missing product X. ______ (1 pt)

_____ N_2 + _____ H_2 → _____ NH_3

28) Balance the equation above using the lowest whole number coefficients.

29) How many moles of H_2 are required to produce 6.5 moles of NH_3? Show all work and make sure your answer has the correct number of significant figures and proper units.

30) How many grams of NH_3 are produced if 50.0 grams of N_2 are consumed? Show all work and make sure your answer has the correct number of significant figures and proper units.

31) A compound consists of 85% silver and 15% fluorine by mass (molar mass = 126.9*g*).

a) What is the empirical formula for this compound?

b) What is the molecular formula?