Name ______________________________

Date _________________ Period _____

Test Review № 7

Binary Covalent Compounds. Two nonmetals can combine to form compounds. When two nonmetals combine, they form covalent bonds. The nonmetal with the lower electronegativity behaves like a metal and has a positive oxidation state. In carbon dioxide (CO_2), the carbon behave like a metal while the oxygen behaves like a nonmetal. The metal is written first in the name and the formula. The name of the metal is the same as the name of the element. If there is more than one atom of the metal, the number of atoms is indicated with a prefix. (See the list of prefixes below.) The nonmetal is written last in the name and formula..The name of the nonmetal is the same as the name of the element minus the final syllable or two, plus IDE.The number of nonmetal atoms is indicated with a prefix (even when there is only one). Writing formulas for these compounds is easy, because the prefix tells the subscript.

Finding the Formula Mass

Find the formula mass of $CuSO_4$

Step 1: Look up the mass of each element on the *Periodic Table* and round it off.
Step 2: Multiply each element's atomic mass by its subscript to get the product.
Step 3: Add the products together to get the total

Element	Atomic Mass		Subscript		Product
Cu	64	×	1	=	64
S	32	×	1	=	32
O	16	×	4	=	64
			TOTAL		160

Formula Mass. The masses of ionic and covalent compounds are found the same way–from the formula. The atomic masses of the elements in the compound and the formula are used to determine the mass. The mass determined from the formula is called a formula mass. A molecular mass is a type of formula mass. The terms are sometimes used interchangeably. Formula masses are determined by following the steps in the box to the right. The results are in atomic mass units (amu)

Empirical Formulas. The chemical formula for a molecular compound shows the number and type of atoms present in a molecule. Ionic crystals are a collections of ions. The chemical formula for an ionic compound shows the ratio ions in the compound. The ratio of ions in the formula for an ionic compound is always in lowest terms. A chemical formula in which the ratio of the elements are in lowest terms is called an empirical formula. The molecular formula for glucose ($C_6H_{12}O_6$) is not an empirical formula. All the subscripts are divisible by six. When the subscripts are divided by six, the empirical formula for glucose, CH_2O, is obtained. Some molecular formulas, such as the one for carbon dioxide, CO_2, are already empirical formulas without being reduced.

There are two skills you need to learn in order to work with empirical formulas: Finding the empirical formula from the molecular formula; and finding the molecular formula from the empirical formula and the molecular mass. To find the empirical formula from the molecular formula, divide all the subscripts by the greatest common factor. To find the molecular formula from the empirical formula and the molecular mass.

Sample Problem

A compound with an empirical formula of CH_2O has a molecular mass of 90 amu. What is its molecular formula?

Step 1: Determine the empirical formula mass.

CH_2O

C = 12 × 1 = 12
H = 1 × 2 = 2
O = 16 × 1 = 16
30

Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple.

$$\frac{90}{30} = 3$$

Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula

$[CH_2O] \times 3 = C_3H_6O_3$

Percent Composition. Percentage composition is determined by finding the formula mass of a compound, multiplying the mass of each element by 100, and dividing the product by the formula mass of the compound. Use the periodic table to find the masses of individual elements. See the ***Sample Problem*** below

Sample Problem: Find the percentage composition of $MgCO_3$.

Formula Mass		Percentage Composition	
Mg = 24 × 1 = 24		% Mg = 24 × 100÷ 84 =	29
C = 12 × 1 = 12		% C = 12 × 100 ÷ 84 =	14
O = 16 × 3 = 48		% O = 48 × 100 ÷ 84 =	57
84			100

Chemical Equations. Chemical equations provide a shorthand way to easily describe what occurs during a chemical reaction. In a typical chemical equation, the reactants are written on the left, while the products are written on the right. The reactants and products are separated by an arrow, or yield sign, which indicates that reactants yield products. (**REACTANTS** → **PRODUCTS**) There are other symbols as well that show the state of the chemicals involved in the reaction. They are: (*s*) or ↓ for a solid precipitate; (ℓ) for a liquid; (*g*) or ↑ for a gas; and (*aq*) for dissolved in water or aqueous. Symbols can also be used to show other factors involved in the reaction such as sources of energy used. These include: Δ for heat or ↑| for light. These symbols are written above or below the yield sign because they are neither reactants nor products. The complete equation shows the identity of the reactants and products using chemical formulas and symbols, the phases of the reactants and products, any energy changes involved in the reaction, and the mole ratios of all the substances indicated by the coefficients. Equations may occasionally be written omitting information about phases or energy changes. The example below shows a complete chemical equation with all the components.

$$2KClO_3(s) \xrightarrow[\Delta]{MnO_2(s)} 2KCl(s) + 3O_2(g)$$

The equation shows that the reactant is solid potassium chlorate, the products are solid potassium chloride and oxygen gas, manganese dioxide is a catalyst, and the reaction is endothermic. Symbols for manganese dioxide and heat are shown above and below the yield sign because they are neither reactants nor products.

Reaction Types. Chemical reactions can be grouped into four basic types. They are direct combination or synthesis, decomposition, single replacement or substitution, and double replacement or exchange of ions.

An example of **synthesis** is shown below: Synthesis often results in the formation of only one product from two reactants, but not always. Combustion, as in the following example, $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O$, is also a form of synthesis because the oxygen combines with both the metal and the nonmetal to form two oxides.

$$N_2(g) + 3H_2(g) \xrightarrow[\Delta]{catalyst} 2NH_3(g)$$

Decomposition is the reverse of synthesis. One reactant breaks apart to form several products. This is what happens when hydrogen peroxide decomposes over time to leave behind plain, ordinary water [$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$].

During a **single replacement** reaction, a more active metal replaces a less active metal in a compound, or a more active nonmetal replaces a less active nonmetal in a compound. This is what happens when a metal becomes corroded by an acid [$2Fe(s) + 6HCl(aq) \rightarrow 2FeCl_3(aq) + 3H_2(g)$]. In single replacement reactions, an element is reacting with a compound.

Double replacement reactions occur between aqueous compounds. The cations and anions switch partners. If an insoluble precipitate forms, the reaction is an end reaction, otherwise the result is an aqueous mixture of ions. An example of a double replacement reaction is $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$.

Patterns of the Reaction Types

Legend:

- **A** and **C** = *metals*
- **B** and **D** = *nonmetals*

— ◆ —

Direct combination (synthesis)

A + B → AB *or*

AB + D → AD + BD

Decomposition

AB → A + B

Single Replacement (substitution)

AB + C → CB + A *or*

AB + D → AD + B

Double Replacement (Exchange of Ions)

AB + CD → AD + CB

Conservation of Mass. Matter is neither created nor destroyed. During a chemical reaction the mass does not change. A properly written equation shows conservation of mass. Balancing the equation will make it show conservation of mass. **Balancing Equations.** The equation at the top of the box to the right does *not* show conservation of mass. Starting with two molecules of hydrogen, as shown in the equation at the bottom of the box by writing a **coefficient** 2 in front of the hydrogen and forming two molecules of water by writing a **coefficient** 2 in front of the water shows conservation. Coefficients are used to **balance** equations. Coefficients make the number of atoms of each type the same on the reactant and product side. As a result, coefficients make the mass the same on the reactant and product side of the equation. Balancing is done by counting the number and type of atoms on the reactant and product side of the equation and making them equal.

$$H_2 + O_2 \rightarrow H_2O$$
$$2 + 32 \neq 18$$

$$2H_2 + O_2 \rightarrow 2H_2O$$
$$2(2) + 32 = 2(18)$$
$$36 = 36$$

Answer the questions below by circling the number of the correct response

1. Which is the compound whose formula is P_2O_5? (1) potassium dioxide (2) dipotassium pentoxide (3) phosphorus dioxide (4) diphosphorus pentoxide
2. The formula for sulfur hexafluoride is (1) SHF, (2) SF, (3) SF_6, (4) S_6F.
3. The IUPAC name for N_2O_3 is (1) dinitrogen trioxide, (2) nitrogen oxide, (3) nitrogen trioxide, (4) dinitrogen oxide.
4. The prefix used to show there are four atoms of an element in a binary covalent compound is (1) quadra, (2) recta, (3) hepta, (4) tetra.
5. Which of the following is a binary covalent compound? (1) Na_2O (2) P_2S_5 (3) Hg_2Cl_2 (4) KI
6. The molecular mass of CO_2 is the same as the molecular mass of (1) CO (2) C_2H_6 (3) SO_2 (4) C_3H_8
7. Which is an empirical formula? (1) C_2H_2 (2) Al_2Cl_6 (3) C_2H_4 (4) K_2O
8. Which is an empirical formula? (1) CH_2 (2) C_3H_6 (3) C_2H_4 (4) C_4H_8
9. A compound with a molecular mass of 34 contains hydrogen and oxygen in a ratio of 1:1. The molecular formula of the compound is (1) HO (2) OH (3) H_2O_2 (4) HOH
10. The empirical formula of a compound is CH. Its molecular mass could be (1) 21 (2) 51 (3) 40 (4) 78
11. What is the empirical formula of the compound whose molecular formula is $C_6H_{12}O_6$? (1) $C_{12}H_{24}O_{12}$ (2) $C_2H_4O_2$ (3) $C_6H_{12}O_6$ (4) CH_2O
12. A compound contains nitrogen and oxygen in a ratio of 1:1. The molecular mass of the compound could be (1) 14 (2) 16 (3) 30 (4) 40
13. What is the ratio by mass of sulfur to oxygen in SO_2? (1) 1:1 (2) 1:2 (3) 1:3 (4) 1:4
14. What is the mass in amu of 1.00 molecule of O_2 gas? (1) 11.2 (2) 16.0 (3) 22.4 (4) 32.0
15. What is the formula mass of $CuSO_4{\bullet}5H_2O$? (1) 160. amu (2) 178 amu (3) 186 amu (4) 250. amu
16. What is the molecular formula of a compound whose empirical formula is CH_4 and molecular mass is 16? (1) CH_4 (2) C_4H_8 (2) C_2H_4 (4) C_8H_{18}
17. The formula mass of NH_4Cl is (1) 22.4 amu (2) 53.5 amu (3) 28.0 amu (4) 95.5 amu
18. An example of an empirical formula is (1) C_2H_2, (2) H_2O_2, (3) C_2Cl_2, (4) $CaCl_2$
19. A compound has an empirical formula of CH_2 and a molecular mass of 56. Its molecular formula is (1) C_2H_4, (2) C_3H_6, (3) C_4H_8, (4) C_5H_{10}.
20. The empirical formula of a compound is CH_2 and its molecular mass is 70. What is the molecular formula of the compound? (1) C_2H_2 (2) C_2H_4 (3) C_4H_{10} (4) C_5H_{10}
21. Which formulas could represent the empirical formula and the molecular formula of a given compound? (1) CH_2O, $C_4H_6O_4$ (2) CHO $C_6H_{12}O_6$ (3) CH_4, C_3H_8 (4) CH_2, C_3H_6
22. The empirical formula of a compound is CH_4. The molecular formula of the compound could be (1) CH_4, (2) C_2H_6, (3) C_3H_8, (4) C_4H_{10}
23. A compound has an empirical formula of CH_3 and a molecular mass of 30. What is its molecular formula? (1) CH_3 (2) C_2H_6 (3) CH_{18} (4) C_3H_9
24. A compound has the empirical formula NO_2. Its molecular formula could be (1) NO_2 (2) N_2O (3) N_4O_2 (4) N_4O_4
25. 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? (1) 18 g (2) 42 g (3) 24 g (4) 60 g

26. What is the percentage by mass of bromine in $CaBr_2$? (1) 20% (3) 40% (3) 60% (4) 80%

27. The percent by mass of Li in $LiNO_3$ (formula mass = 69) is closest to (1) 6% (2) 10% (3) 18% (4) 20%

28. The percent by mass of oxygen in CO is approximately (1) 73% (2) 57% (3) 43% (4) 17%

29. The percent by mass of aluminum in Al_2O_3 is approximately (1) 18.9 (2) 35.4 (3) 47.1 (4) 52.9

30. The percent by mass of oxygen in Na_2SO_4 (formula mass = 142) is closest to (1) 11% (2) 22% (3) 45% (4) 64%

31. The percent by mass of hydrogen in NH_3 is equal to (1) $\frac{17}{1} \times 100$ (2) $\frac{1}{17} \times 100$ (3) $\frac{17}{3} \times 100$ (4) $\frac{3}{17} \times 100$

32. What is the percent by mass of hydrogen in NH_3 (formula mass = 17.0)? (1) 5.9% (2) 17.6% (3) 21.4% (4) 82.4%

33. The percent by mass of nitrogen in $Mg(CN)_2$ is equal to (1) $^{14}/_{76} \times 100$, (2) $^{14}/_{50} \times 100$, (3) $^{28}/_{76} \times 100$, (4) $^{28}/_{50} \times 100$.

34. What is the percent by mass of oxygen in Fe_2O_3 (formula mass = 160)? (1) 16% (2) 30.% (3) 56% (4) 70.%

35. The percent by mass of carbon in CO_2 is equal to (1) $^{44}/_{12} \times 100$, (2) $^{12}/_{44} \times 100$, (3) $^{28}/_{12} \times 100$, (4) $^{12}/_{28} \times 100$

36. What is the percent by mass of oxygen in CH_3OH? (1) 50.0 (2) 44.4 (3) 32.0 (4) 16.0

37. The approximate percent by mass of potassium in $KHCO_3$ is (1) 19 %, (2) 24 %, (3) 39 %, (4) 61 %

38. What is the percent by mass of hydrogen in CH_3COOH (formula mass = 60.)? (1) 1.7% (2) 6.7% (3) 5.0% (4) 7.1%

39. What is the percentage by mass of oxygen in CuO? (1) 16% (2) 25% (3) 20% (4) 50%

40. When the equation $H_2 + N_2 \rightarrow NH_3$ is completely balanced using smallest whole numbers, the sum of all the coefficients will be (1) 6 (2) 7 (3) 3 (4) 12

41. 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? (1) 12.5% (2) 20.0% (3) 25.0% (4) 80.0%

42. When the equation $H_2 + Fe_3O_4 \rightarrow Fe + H_2O$ is completely balanced using *smallest* whole numbers the coefficient of H_2 would be (1) 1 (2) 2 (3) 3 (4) 4

43. When the equation $\_\_C_2H_4 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$ is correctly balanced, using *smallest* whole-numbered coefficients, the sum of all the coefficients is (1) 16 (2) 12 (3) 8 (4) 4

44. When the equation $NH_3 + O_2 \rightarrow HNO_3 + H_2O$ is completely balanced using smallest whole numbers, the coefficient of O_2 would be (1) 1 (2) 2 (3) 3 (4) 4

45. When the equation $\_\_Na(s) + \_\_H_2O(\ell) \rightarrow \_\_NaOH(aq) + \_\_H_2(g)$ is correctly balanced using smallest whole numbers, the coefficient of the water is (1) 1 (2) 2 (3) 3 (4) 4

46. When the equation $\_\_Al(s) + \_\_O_2(g) \rightarrow \_\_Al_2O_3(s)$ is correctly balanced using the smallest whole numbers, the coefficient of Al(s) is (1) 1 (2) 2 (3) 3 (4) 4

47. Given the unbalanced equation: $Al_2(SO_4)_3 + Ca(OH)_2 \rightarrow Al(OH)_3 + CaSO_4$., when the equation is completely balanced using the smallest whole-number coefficients, the sum of the coefficients is (1) 15 (2) 9 (3) 3 (4) 4

48. Which compound contains the greatest percentage of oxygen by mass? (1) BaO (2) MgO (3) CaO (4) SrO

49. The precent by mass of oxygen in MgO (formula mass = 40) is closest to (1) 16% (2) 40% (3) 24% (4) 60%

50. The symbol (aq) after a chemical formula means (1) solid or precipitate, (2) liquid, (3) gas, (4) aqueous or dissolved.

51. In the reaction, $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$, the reactants are (1) AgCl and $NaNO_3$, (2) $AgNO_3$ and NaCl, (3) Ag and Na, (4) Cl and NO_3

Answer questions 52–53 by referring to the equation below:

$$2KClO_3(s) \xrightarrow[\Delta]{MnO_2(s)} 2KCl(s) + 3O_2(g)$$

52. The symbol Δ under the yield sign indicates that (1) the reaction is exothermic, (2) the reaction is endothermic, (3) a solid precipitate forms, (4) heat is a product of the reaction.

53. $MnO_2(s)$ is written above the yield sign because $MnO_2(s)$ is (1) a reactant, (2) a product, (3) neither a reactant nor a product, (4) both a reactant and a product.

For each of the reactions described in questions 54-60, write the correct number to indicate whether the reaction type is (1) DECOMPOSITION, (2) SYNTHESIS, (3) SINGLE REPLACEMENT, or (4) DOUBLE REPLACEMENT

54. A reaction occurs in which only one reactant is present.

55. A metal reacts with an acid. ($2Fe + 6HCl \rightarrow 2FeCl_3 + 3H_2$)

56. Magnesium burns.

57. Two salt solutions react with each other.

58. Two elements unite to form a compound.

59. A compound breaks down.

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

Answers

1. 4	11. 4	21. 4	31. 4	41. 2	51. 2
2. 3	12. 3	22. 1	32. 2	42. 4	52. 2
3. 1	13. 1	23. 2	33. 3	43. 3	53. 3
4. 4	14. 4	24. 1	34. 2	44. 2	54. 1
5. 2	15. 4	25. 2	35. 4	45. 2	55. 3
6. 4	16. 1	26. 4	36. 1	46. 4	56. 2
7. 4	17. 2	27. 2	37. 3	47. 2	57. 4
8. 1	18. 4	28. 2	38. 2	48. 2	58. 2
9. 3	19. 3	29. 4	39. 3	49. 2	59. 1
10. 4	20. 4	30. 3	40. 1	50. 4	60. 4