Chemistry: Form TR6-10A Name _____

TEST 6 REVIEW Date _____ Period _____

Test Review № 6

Types of Bonds. Pure substances can be held together by ionic bonds, covalent bonds, metallic bonds, or intermolecular forces. All ionic substances are crystalline solids. Diamonds are also crystalline solids, but they are made of pure carbon. Large crystals such as diamond or sand (SiO_2) that have a network of covalent bonds are called **macromolecules** or **network solids**. Smaller compounds containing covalent bonds are called **molecules**. The molecules of a substance may be attracted to each other to form solids or liquids by intermolecular forces. These are often called **molecular** compounds. Molecular solids are softer than covalent solids (network solids) and ionic solids, because intermolecular forces are weaker than chemical bonds. If the substance is polar, it is held together by **dipole-dipole attractions**. If the polar substance contains hydrogen atoms attached to either oxygen, nitrogen, or fluorine atoms, it forms especially strong dipole-dipole attractions called a **hydrogen bonds**. Hydrogen bonds are responsible for the three dimensional shapes of many proteins because the large protein molecule folds in such a way that hydrogens in one part of the molecule are close to oxygens or nitrogens in another part of the molecule. Nonpolar molecules are attracted to each other only by the weakest intermolecular forces called **Van der Waal's forces**.

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.

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

Procedural Steps

Step 1: Determine the empirical formula mass.

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

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

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: CH_2O
C = 12 × 1 = 12
H = 1 × 2 = 2
O = 16 × 1 = 16
30

Step 2: $\frac{90}{30} = 3$

Step 3: $[CH_2O] \times 3 = C_3H_6O_3$

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*** to the right.

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 Change vs. Physical Change. Any change in which no new substances are formed, is only a physical change. When new substances form, there are not only physical changes, there are chemical changes as well. Typically, there are a number of changes that serve as evidence of a chemical change. They are: [1] energy changes; [2] release of gases; [3] formation of a solid in solution or the formation of water; [4] a change in color; and [5] a change in odor. These five changes serve only as evidence of a chemical change. There is no rule that identifies chemical changes unequivocally except that new substances are formed.

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.

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

In the above reaction, 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:

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

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.

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

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

1. Which of the following is an example of hydrogen bonding? (1) $H_2(\ell)$ (2) $I_2(s)$ (3) $CH_3OH(\ell)$ (4) $C_8H_{18}(\ell)$

2. The boiling point increases as you go down the halogen family because of the increase in (1) van der Waal's forces, (2) metallic properties, (3) polarity, (4) covalent bonding.

3. In the family of compounds including H_2O, H_2S, H_2Se, and H_2Te, water has the highest boiling point because it has the greatest (1) van der Waal's forces, (2) metallic bonding, (3) polarity, (4) covalent bonding.

4. Water forms a liquid with a high boiling point due to (1) covalent bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waals forces.

5. Mercury is a liquid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

6. Table salt (NaCl) is a solid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

7. Iodine is a solid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

8. 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

9. Which is an empirical formula? (1) C_2H_2 (2) Al_2Cl_6 (3) C_2H_4 (4) K_2O

10. A 60. gram sample of $LiCl \cdot H_2O$ 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

11. Which is an empirical formula? (1) CH_2 (2) C_3H_6 (3) C_2H_4 (4) C_4H_8

12. 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

13. The empirical formula of a compound is CH. Its molecular mass could be (1) 21 (2) 51 (3) 40 (4) 78

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

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

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

17. The mass in amu of $CaSO_4 \cdot 2H_2O$ is (1) 172 amu (2) 154 amu (3) 136 amu (4) 118 amu

18. 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

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

20. 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

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

22. 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

23. 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

24. What is the formula mass of $CuSO_4 \cdot 5H_2O$? (1) 160. amu (2) 178 amu (3) 186 amu (4) 250. amu

25. 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}

26. 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) $\frac{3}{17} \times 100$

27. The formula mass of NH_4Cl is (1) 22.4 amu (2) 53.5 amu (3) 28.0 amu (4) 95.5 amu

28. An example of an empirical formula is (1) C_2H_2, (2) H_2O_2, (3) C_2Cl_2, (4) $CaCl_2$

29. 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%

30. 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.

31. The percent by mass of oxygen in $Ca(OH)_2$ (formula mass = 74) is closest to (1) 16, (2) 22, (3) 43, (4) 74.

32. What is the percent by mass of oxygen in NaOH (formula mass = 40.)? (1) 80. (2) 40. (3) 32 (4) 16

33. A compound whose empirical formula is CH_2O could be (1) HCOOH, (2) CH_3OH, (3) CH_3COOH, (4) CH_3CH_2OH.

34. 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}.

35. 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%

36. 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}

37. 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) $^{28}/_{50} \times 100$.

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

39. 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

40. 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) $^{12}/_{28} \times 100$

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

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

43. 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%

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

45. What is the approximate percent composition by mass of $CaBr_2$ (formula mass = 200)? (1) 20% calcium and 80% bromine (2) 25% calcium and 75% bromine (3) 30% calcium and 70% bromine (4) 35% calcium and 65% bromine

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

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

48. The fact that burning wood gives off heat is evidence of a (1) change in mass, (2) chemical change, (3) physical change, (4) phase change.

49. A reaction in which heat is given off is (1) exothermic, (2) endothermic, (3) caloric, (4) acaloric.

50. Which of the following is *NOT* evidence of a chemical change? (1) release of a gas (2) change in color (3) change in odor (4) change in shape

51. When silver nitrate solution is mixed with sodium chloride solution, a white solid forms immediately with no noticeable change in temperature. Which of the following is a true statement regarding the observed change. (1) The change is probably only physical because there is no change in temperature. (2) The change is probably only physical because no gas is released. (3) The change is probably chemical because a precipitate forms. (4) The change is probably chemical because the reaction is exothermic.

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

53. 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 54–55 by referring to the equation below:

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

54. 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.

55. $MnO_2(s)$ 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 56-62, write the correct number to indicate whether the reaction type is (1) DECOMPOSITION, (2) DIRECT COMBINATION, (3) SINGLE REPLACEMENT, or (4) DOUBLE REPLACEMENT

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

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

58. Magnesium burns.

59. Two salt solutions react with each other.

60. Two elements unite to form a compound.

61. A compound breaks down.

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

Answers

1.	3	14.	4	27.	2	40.	2	53.	2
2.	1	15.	2	28.	4	41.	1	54.	2
3.	3	16.	2	29.	2	42.	3	55.	3
4.	3	17.	1	30.	1	43.	2	56.	1
5.	1	18.	4	31.	3	44.	3	57.	3
6.	2	19.	4	32.	2	45.	1	58.	2
7.	4	20.	3	33.	3	46.	2	59.	4
8.	4	21.	3	34.	3	47.	2	60.	2
9.	4	22.	1	35.	2	48.	2	61.	1
10.	2	23.	4	36.	4	49.	1	62.	4
11.	1	24.	4	37.	3	50.	4		
12.	3	25.	1	38.	2	51.	3		
13.	4	26.	4	39.	4	52.	4		