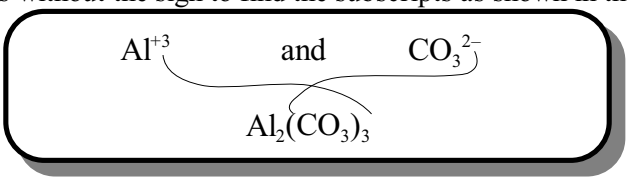
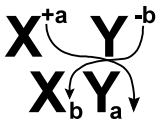
Test Review № 6

Formula Writing. The quickest way to determine the formula of a compound of two elements or polyatomic ions is to use the Cross-Over Rule. Look up the oxidation state of each element or ion and reduce to lowest terms. Then cross over the oxidation states in lowest terms without the sign to find the subscripts as shown in the diagram to the right and the example below.





Finding the Charge on Polyvalent Metals. Many transition metals have more than one oxidation state. They are called polyvalent. The fact that a metal is polyvalent becomes important when the compound is named. In order to properly name a compound, it is necessary to first check the *Periodic Table* to see if the metal is polyvalent. If it is, you need to figure out the oxidation state of the metal by checking to see which one will make the sum of the oxidation states in the compound add up to zero. The process is only applied for metals that have more than one oxidation state.

The Stock System . The stock system is a set of rules for naming compounds of metals and non metals. The metal always comes first in the name and the formula. Monatomic metal ions, those consisting of only one type of atom, come in two varieties – univalent and polyvalent. For univalent metal ions, those having only one oxidation state, the name of the ion is exactly the same as that of the element that formed it. For polyvalent metal ions, those having multiple oxidation states, a roman numeral indicates the oxidation state. Polyatomic metal ions, those consisting of more than one type of element such as NH_4^+, ammonium, are found on *Table E*.

The nonmetal always comes last in the name and in the formula. For monatomic nonmetal ions, delete the last part of the elements name and add "IDE". Polyatomic nonmetal ions, such as SO_4^{-2} (sulfate) or OH^- (hydroxide) are found on *Table E*.

To write the name from the formula, it is necessary to first check the *Periodic Table* to see if the metal is polyvalent. If it is, you need to figure out the oxidation state of the metal by checking to see which one will make the sum of the oxidation states in the compound add up to zero. To write the formulas from the name, you need to look up the oxidation states of the ions, and apply the crossover rule

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.

Number of Atoms	Prefix
1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

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

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
$[CH_2O] \times 3 = C_3H_6O_3$

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.

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

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

1. The formula of a compound between Ba^{+2} and PO_4^{-3} is (1) $BaPO_4$ (2) $Ba_2(PO_4)_3$ (3) $Ba_3(PO_4)_2$ (4) $Ba_4(PO_3)_2$

2. In which compound is the oxidation state of iron +3? (1) $FeCl_2$ (2) FeO (3) $FePO_4$ (4) FeS_2O_3

3. What is the formula for a compound of NH_4 and CO_3? (1) NH_4CO_3 (2) $(NH_4)_2CO_3$ (3) $NH_4(CO_3)_2$ (4) NH_3CO_4

4. What is the correct formula for copper II nitrate? (1) $Cu(NO_3)_2$ (2) Cu_3N_2 (3) Cu_2NO_3 (4) Cu_2N_3

5. What is the correct name for BaO? (1) barium oxide (2) barium oxygen (3) barium II oxide (4) barium oxalate

6. The formula for zinc hydroxide is (1) $Zn(OH)_2$, (2) $ZnOH_2$, (3) ZnH_2, (4) Zn_2H.

7. The formula for ammonium carbonate is (1) $(NH_3)_2(CO_4)_3$, (2) $NH_2(CO_3)_4$, (3) $(NH_4)_3CO$, (4) $(NH_4)_2CO_3$.

8. The formula for iron II sulfide is (1) $Fe_2(SO_4)_3$, (2) FeS, (3) Fe_2S_3 (4) $FeSO_4$.

9. The name of the compound $CuCO_3$ is (1) copper II carbonate, (2) copper I carbonate, (3) copper III carbonate, (4) copper oxide.

10. The formula for barium nitrate is (1) Ba_3NO_2, (2) Ba_3N_2, (3) $Ba(NO_3)_2$, (4) BaN.

11. The name of the compound H_2S is (1) hydrogen II sulfate, (2) hydrogen sulfate, (3) helium I sulfide, (4) hydrogen sulfide.

12. Which is the compound whose formula is P_2O_5? (1) potassium dioxide (2) dipotassium pentoxide (3) phosphorus dioxide (4) diphosphorus pentoxide

13. The formula for sulfur hexafluoride is (1) SHF, (2) SF, (3) SF_6, (4) S_6F.

14. The IUPAC name for N_2O_3 is (1) dinitrogen trioxide, (2) nitrogen oxide, (3) nitrogen trioxide, (4) dinitrogen oxide.

15. 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.

16. Which of the following is a binary covalent compound? (1) Na_2O (2) P_2S_5 (3) Hg_2Cl_2 (4) KI

17. 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

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

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

20. 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

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

22. 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

23. 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

24. 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

25. 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

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

27. 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}

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

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

30. 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}.

31. 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}

32. 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

33. 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}

34. 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

35. 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

36. 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

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

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

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

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

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

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

43. 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%

44. 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) $^{28}/_{50} \times 100$.

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

46. 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) $^{12}/_{28} \times 100$

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

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

49. 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%

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

Answers

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