Test Review № 7

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. For example, $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$.

Silver Nitrate			*Sodium Chloride*			*Sodium Nitrate*			*Silver Chloride*		
$AgNO_3$			NaCl			$NaNO_3$			AgCl		
Ag =	1 × 108 =	108	Na =	1 × 23 =	23	Na =	1 × 23 =	23	Ag =	1 × 108 =	108
N =	1 × 14 =	14	Cl =	1 × 35 =	35	N =	1 × 14 =	14	Cl =	1 × 35 =	35
O =	3 × 16 =	48			58	O =	3 × 16 =	48			143
		170						85			

$AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

170 + 58 = 85 + 143

228 = 228

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.

$H_2 + O_2 \rightarrow H_2O$

$2 + 32 \neq 18$

$2H_2 + O_2 \rightarrow 2H_2O$

$2(2) + 32 = 2(18)$

$36 = 36$

Moles. A mole is a formula mass expressed in grams. (1 mole = 1 gram formula mass). Atomic mass units are too small to measure on a laboratory balance, but grams are not. An atom of carbon has a mass of 12 amu and a molecule of glucose has a mass of 180 amu. Each mass represents one particle. Since the mass ratios in formula masses and gram formula masses are the same (12 amu:180 amu::12 g:180 g), the ratio of particles must still be the same (1mole:1 mole). The gram formula mass (GFM) is the number of grams in 1 mole. This results in the mathematical relationships shown above and to the right.

Substance	Formula Mass	Gram Formula Mass
carbon	12 amu	12 g
sodium chloride (NaCl)	58 amu	58 g
glucose ($C_6H_{12}O_6$)	180 amu	180 g

1. $GFM = \frac{g}{mole}$
2. $g = GFM \times mole$
3. $mole = \frac{g}{GFM}$

Stoichiometry. Stoichiometry is the branch of chemistry that deals with the application of the laws of definite proportions and of the conservation of mass and energy to chemical activity. It shows the quantitative relationship between constituents of a chemical reaction. Stoichiometric calculations are based on several assumptions. It is assumed that the reaction has no side reactions, the reaction goes to completion, and the reactants are completely consumed. One type of problem that can be solved stoichiometrically is based on the mole ratios of a balanced equation. A sample problem is shown to the right.

Sample Problem

How many moles of oxygen are consumed when 0.6 moles of hydrogen burns to produce water?

Step 1: Write a balanced equation and determine the mole ratios from the equation

Step 2: Identify the known and the unknown

Step 3: Set up a proportion and solve for the unknown

	$2\,H_2(g)$	$+\ O_2(g)$	$\rightarrow 2\,H_2O$
mole ratio	2	1	2
moles	known 0.6	unknown x	

- $\frac{2}{0.6mol} = \frac{1}{x}$
- $2x = 0.6mol$
- $x = 0.3mol$

Formulas from Masses. The molecular formula for a compound can be determined from the percentage composition by assuming the sample has a mass of 100 g. Using the percentages, the number of grams out of 100 can be determined for each component. This can be converted to moles by dividing by the GFM. The mole ratio and empirical formula can be determined by dividing each number of moles by the smallest number of moles. The atomic masses are added together to find the empirical formula mass. The empirical formula mass is divided into the molecular weight to find the number of times "n," the formula is repeated. Finally, "n" is multiplied by the empirical formula to find the molecular formula. See the ***Sample Problem*** to the right.

Mass/Mass Problems. With a balanced equation, a *Periodic Table*, and some knowledge of chemistry, you can figure out how much of any product will form from a given amount of reactant. There is a sample problem below solved by the factor label method. You will notice that, in applying the factor label method, you are first converting grams of the known to moles, then moles of the known to moles of the unknown using a proportion from the coefficients of the balanced equation, and, finally, moles of the unknown to grams as shown above. You can use the equations to the lower right instead of using the factor label method.

Sample Problem

Find the molecular formula for a compound composed of 5.9% hydrogen and 94.1% oxygen and having a molecular weight of 34 amu.

Step 1: Assume a 100 g sample

Step 2: Find the mass of each element in the sample
mass of H = 5.9 % of 100 g = 5.9 g
mass of O = 94.1 % of 100 g = 94.1 g

Step 3: Convert grams to moles

moles of H = $\frac{5.9g}{1g/mol}$ = 5.9 moles

moles of O = $\frac{94.1g}{16g/mol}$ = 5.9 moles

Step 4: Find the mole ratio by dividing both numbers by the smaller number
5.9 ÷ 5.9 = 1 H
5.9 ÷ 5.9 = 1 O
empirical formula = HO

Step 5: Find the empirical formula mass
atomic mass of H = 1
atomic mass of O = 16
EFM = 17

Step 6: Find the number of times, "n," the empirical formula is repeated and multiply through

$\frac{M.W.}{EFM} = n = \frac{34}{17} = 2$

molecular formula $(HO)_n = (HO)_2 = H_2O_2$

How much oxygen is needed to produce 27.0 g of water by burning hydrogen?

Step 1: Write a balanced equation
$2H_2 + O_2 \rightarrow 2H_2O$

Step 2: Calculate the GFM of the known and unknown.

O_2: O = 16 × 2 = 32

H_2O: H = 1 × 2 = 2; O = 16 × 1 = 16; 18

Step 3: Apply the factor label method

$$\mathbf{27 g_{H_2O}} \times \frac{\mathbf{1 mol_{H_2O}}}{\mathbf{18 g_{H_2O}}} \times \frac{\mathbf{1 mol_{O_2}}}{\mathbf{2 mol_{H_2O}}} \times \frac{\mathbf{32 g_{O_2}}}{\mathbf{1 mol_{O_2}}} = \mathbf{24 g_{O_2}}$$

$$Grams_{KNOWN} \xrightarrow{STEP\,1} Moles_{KNOWN} \xrightarrow{STEP\,2} Moles_{UNKNOWN} \xrightarrow{STEP\,3} Grams_{UNKNOWN}$$

- *STEP* 1: $moles = \frac{g}{GFM}$
- *STEP* 2: $\frac{Moles_{KNOWN}}{Coefficient_{KNOWN}} = \frac{x}{Coefficient_{UNKNOWN}}$
- *STEP* 3: $g = moles \times GFM$

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

1. 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

2. 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%

3. A compound contains 50% sulfur and 50% oxygen by mass. What is the empirical formula of' the compound? (1) SO (2) SO_3 (3) SO_2 (4) SO_4

4. Given the balanced equation: $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
What is the total number of moles of H_2 produced atSTP when 36.0 grams of H_2O is consumed? (1) 1 (2) 2 (3) 3 (4) 4

5. 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

6. Given the reaction: $2CO + O_2 \rightarrow 2CO_2$
What is the minimum number of moles of O_2 required to produce one mole of CO_2? (1) 1.0 (2) 2.0 (3) 0.25 (4) 0.50

7. 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

8. In the reaction $Zn + 2HCl \rightarrow ZnCl_2 + H_2$, how many moles of hydrogen will be formed when 4 moles of HCl are consumed? (1) 6 (2) 2 (3) 8 (4) 4

9. 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

10. Given the reaction: $N_2 + 3H_2 \rightarrow 2NH_3$
What is the total number of grams of H_2 that reacts when 14 grams of N_2 are completely consumed? (1) 6.0 (2) 2.0 (3) 3.0 (4) 4.0

11. A compound contains 0.5 mole of sodium, 0.5 mole of nitrogen, and 1.0 mole of hydrogen. The empirical formula of the compound is
(1) NaNH (3) $NaNH_2$
(2) Na_2NH (4) $Na(NH)_2$

12. In the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, how many grams of H_2 are needed to produce exactly 1 mole of ammonia? (1) 1 g (2) 2 g (3) 3 g (4) 4 g

13. A compound is 92.3% carbon and 7.7% hydrogen. The empirical formula of this compound is (1) CH (2) CH_3 (3) CH_2 (4) CH_4

14. 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_4H_8 (3) C_3H_6 (4) C_5H_{10}

15. Given the reaction: $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
What is the total number of moles of NaOH needed to react completely with 2 moles of H_2SO_4? (1) 1 (2) 2 (3) 0.5 (4) 4

16. 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

17. 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}

18. 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? (1) 1 (2) 2 (3) 3 (4) 4

19. 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

20. Given the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
What is the ratio of moles of $H_2(g)$ consumed to moles of $NH_3(g)$ produced? (1) 1:2 (2) 2:3 (3) 3:2 (4) 6:6

21. 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

22. Given the reaction: $(NH_4)_2CO_3 \rightarrow 2NH_3 + CO_2 + H_2O$
What is the minimum amount of ammonium carbonate that reacts to produce 1.0 mole of ammonia? (1) 0.25 mole (2) 0.50 mole (3) 17 moles (4) 34 moles

23. 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

24. Which quantity is equivalent to 39 grams of LiF? (1) 1.0 mole (2) 2.0 moles (3) 0.30 mole (4) 1.5 moles

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 (3) C_2H_4 (4) C_8H_{18}

26. What is the ratio by mass of carbon to hydrogen in the compound C_2H_6? (1) 6:2 (2) 1:4 (3) 2:6 (4) 4:1

27. What is the total number of molecules contained in 0.50 mole of O_2 at STP [*NOTE:* 1 mol = 6.0×10^{23} particles]? (1) 6.0×10^{23} (2) 4.5×10^{23} (3) 3.0×10^{23} (4) 1.5×10^{23}

28. At STP, what mass of CH_4 has the same number of molecules as 64 grams of SO_2? (1) 16 g (2) 32 g (3) 64 g (4) 128 g

29. According to the equation $HCl + NaOH \rightarrow NaCl + H_2O$, the total number of moles of HCl that can be neutralized by 80. grams of NaOH is (1) 1.0 (2) 2.0 (3) 36 (4) 72

30. What is the total number of moles contained in115 grams of C_2H_5OH? (1) 1.00 (2) 1.50 (3) 3.00 (4) 2.50

31. How many moles of water are contained in 0.250 mole of $CuSO_4 \cdot 5H_2O$? (1) 1.25 (2) 40.0 (3) 4.50 (4) 62.5

32. Given the balanced equation: $NaOH + HCl \rightarrow NaCl + H_2O$
What is the total number of grams of H_2O produced when 116 grams of the product, NaCl, is formed? (1) 9.0 g (2) 18 g (3) 36 g (4) 54 g

33. What is the mass of 3.0×10^{23} atoms of neon [*NOTE:* 1 mol = 6.0×10^{23} particles]? (1) 1.0 g (2) 10. g (3) 0.50 g (4) 20. g

34. Which represents the greatest mass of chlorine (1) 1 mole of chlorine (2) 1 atom of chlorine (3) 1 gram of chlorine (4) 1 molecule of chlorine

35. Given the reaction: $4Al + 3O_2 \rightarrow 2Al_2O_3$
How many moles of Al_2O_3 will be formed when 27 grams of Al reacts completely with O_2? (1) 1.0 (2) 2.0 (3) 0.50 (4) 4.0

36. What is the total mass of iron in 1.0 mole of Fe_2O_3? (1) 160 g (2) 72 g (3) 112 g (4) 56 g

37. What is the mass, in grams, of 1.0 mole of $(NH_4)_2S$? (1) 50. (2) 54 (3) 64 (4) 68

38. A compound consists of 85% silver and 15% fluorine by mass. What is its empirical formula? (1) AgF (2) Ag_2F (3) AgF_2 (4) Ag_6F

39. What is the gram atomic mass of the element chlorine? (1) 17 g (2) 35 g (3) 52 g (4) 70. g

40. A compound is found to contain 2 grams of hydrogen atoms to every 16 grams of oxygen atoms. The empirical formula of the compound is (1) HO (2) H_2O_2 (3) H_2O (4) HO_2

41. Given the equation: $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
When 30. grams of C_2H_6 (molecular mass = 30) are completely burned, the total number of moles of CO_2 produced is (1) 1.0 (2) 2.0 (3) 8.0 (4) 4.0

42. The mass in grams of 1.00 mole of $CaSO_4 \cdot 2H_2O$ is (1) 172 g (2) 154 g (3) 136 g (4) 118 g

43. Given the reaction: $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$
What is the total mass of H_2O produced when 32 grams of Cu is completely consumed? (1) 9.0 g (2) 18 g (3) 36 g (4) 72 g

44. The gram molecular mass of CO_2 is the same as the gram molecular mass of (1) CO (2) C_2H_6 (3) SO_2 (4) C_3H_8

Answers

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