CHEMISTRY 101
Hour Exam II
March 15, 2018
Dr. D. DeCoste

Name _____

Signature _____

T.A. _____

This exam contains 17 questions on 6 numbered pages. Check now to make sure you have a complete exam. You have one hour and thirty minutes to complete the exam. Determine the best answer to the first 15 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. Show all of your work and provide complete answers to questions 16 and 17.

1-15	(30 pts.)	_____
16	(15 pts.)	_____
17	(15 pts.)	_____
Total	(60 pts)	_____

Useful Information:
1.000 L = 1000.0 mL

Always assume ideal behavior for gases (unless explicitly told otherwise).

$PV = nRT$

$R = 0.08206\ L \cdot atm/mol \cdot K$

$K = °C + 273$

Solubility Rules:
1. Most nitrate salts are soluble.
2. Most salts of sodium, potassium, and ammonium cations are soluble.
3. Most chloride salts are soluble. Exceptions: silver, lead(II), and mercury(I) chloride.
4. Most sulfate salts are soluble. Exceptions: calcium, barium, and lead(II) sulfate.
5. Most hydroxide salts can be considered insoluble. Soluble ones: sodium, potassium, and calcium hydroxide.
6. Consider sulfide, carbonate, and phosphate salts to be insoluble. Soluble ones: sodium and potassium.

1. Which of the following statements is **true** concerning balanced chemical equations?

   a) Only whole numbers can be used as coefficients in a balanced chemical equation.
   b) The ratio of the coefficients are the relative masses of the reactants and products.
   c) Subscripts in the chemical formulas of the reactants or products can be changed to balance a given chemical equation.
   d) The sum of the coefficients on the reactant side is always equal to the sum of the coefficients on the product side.
   e) The ratio of coefficients in a balanced equation is much more useful than an individual coefficient.

2. Balance the following equation in standard form (lowest whole numbers) and determine the **sum of the coefficients**.

   $$FeO(s) + O_2(g) \rightarrow Fe_2O_3(s)$$

   a) 3 b) 4 c) 6 d) 7 e) 9

3. When balanced in standard form (lowest whole numbers) which of the following has the **largest** coefficient for water?

   a) $C_2H_5OH(l) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$
   b) $Fe_3O_4(s) + H_2(g) \rightarrow Fe(l) + H_2O(g)$
   c) $NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(g) + H_2O(l)$
   d) $NH_4NO_3(s) \rightarrow N_2O(g) + H_2O(g)$
   e) $C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

4. How many of the following will **not** result in the formation of a precipitate?

   I. $Ca(NO_3)_2(aq) + Na_3PO_4(aq) \rightarrow$
   II. $NaCl(aq) + K_2SO_4(aq) \rightarrow$
   III. $CaCl_2(aq) + AgNO_3(aq) \rightarrow$
   IV. $HCl(aq) + KOH(aq) \rightarrow$
   V. $Na_2SO_4(aq) + CaCl_2(aq) \rightarrow$

   a) 0 b) 1 c) 2 d) 4 e) 5

5. Consider 10.0-g samples of different solutes dissolved in equal volumes of solution. Which solute would make the solution with the **highest concentration** in molarity?

   a) LiOH b) KCl c) KOH d) NaOH e) All the same

6. If you mix 20.0 mL of a 3.00 *M* sugar solution with 30.0 mL of a 5.00 *M* sugar solution, you will end up with a sugar solution of _____.

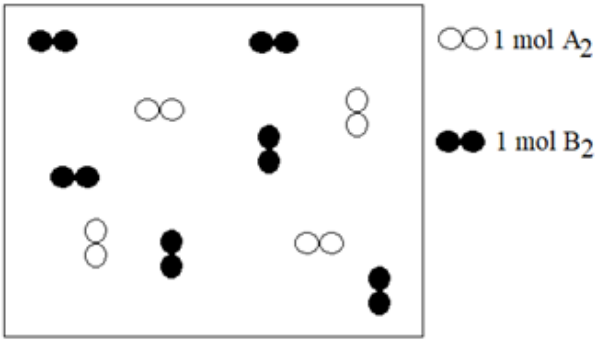
   a) 2.00 M b) 3.80 M c) 4.00 M d) 4.20 M e) 8.00 M

7. You have 25.00 mL of a 1.000 *M* sugar solution. How much water must be added to make a 0.2500 *M* solution?

a) 6.250 mL b) 10.00 mL c) 25.00 mL d) 75.00 mL e) 100.0 mL

8. Consider the following container, displaying molecules of generic diatomic gases A_2 and B_2 before any chemical reaction has occurred (each symbol represents a mole of diatomic molecules). These react according to the following balanced chemical equation:

$$A_2 + 3B_2 \rightarrow 2AB_3.$$



Determine the number of moles of product after the reaction has gone to completion.

a) 2 mole b) 3 moles c) 4 moles d) 6 moles e) 8 moles

For questions 9-11, consider that calcium metal reacts with oxygen gas in the air to form calcium oxide. Suppose we react 6.00 mol of calcium with 4.00 mol of oxygen gas.

9. Determine the number of moles of calcium oxide produced after the reaction is complete.

a) 2.00 mol b) 4.00 mol c) 6.00 mol d) 8.00 mol e) 10.0 mol

10. Determine the number of moles of calcium left over after the reaction is complete.

a) 0 mol (limiting) b) 1.00 mol c) 2.00 mol d) 3.00 mol e) 4.00 mol

11. Determine the number of moles of oxygen gas left over after the reaction is complete.

a) 0 mol (limiting) b) 1.00 mol c) 2.00 mol d) 3.00 mol e) 4.00 mol

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12. Magnesium metal reacts with hydrochloric acid to form magnesium chloride and hydrogen gas according to the following balanced equation:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Suppose we react an excess of magnesium metal with 20.0 mL of 3.00 *M* hydrochloric acid and collect all of the hydrogen in a balloon at 25°C and 1.00 atm. What is the expected volume of the balloon?

a) 0.672 L b) 0.734 L c) 1.34 L d) 1.47 L e) 22.4 L

13. Which of the following statements is **always** true concerning a reaction represented by the following balanced chemical equation?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

a) If we have more mass of H_2 than O_2, then O_2 must be limiting.
b) If we have a greater number of moles of H_2 than O_2, then O_2 must be limiting.
c) If we have an equal number of moles of H_2 and O_2 there is no limiting reactant.
d) If we have more mass of O_2 than H_2, then H_2 must be limiting.
e) Since the ratio of coefficients of reactants in the balanced equation is 2:1, there is never a limiting reactant.

For questions 14 and 15, consider the reaction when 150.0 mL of 0.300 *M* aqueous barium nitrate is mixed with 120.0 mL of 0.300 *M* aqueous sodium phosphate.

14. Which ions are present in solution **after** the reaction is complete? Note: the solid is not considered to be in solution.

a) Only solid and water are left – there are no ions in solution.
b) barium ions, nitrate ions, sodium ions, and phosphate ions
c) barium, nitrate, and sodium ions
d) sodium and nitrate ions
e) nitrate, sodium, and phosphate ions

15. Determine the mass of solid produced.

a) 4.18 g b) 9.03 g c) 10.8 g d) 21.7 g e) 27.1 g

16. Ammonia gas (NH_3) reacts with oxygen gas to produce nitrogen dioxide gas and water.

a. Write the balanced chemical equation for this reaction.

b. Suppose you react ammonia and oxygen gases to completion and produce 10.0 g of water.

i. Determine the mass of ammonia required to produce 10.0 g of water. **Show all work.**

ii. Determine the mass of oxygen gas required to produce 10.0 g of water. **Show all work.**

iii. Determine the mass of nitrogen dioxide gas produced if 10.0 g of water is produced. **Show all work.**

c. Suppose you react **equal masses** of ammonia and oxygen gases to completion to produce 10.0 g of water. Use your answers above to determine the following: (**Show all work.**)

- **The initial mass of each reactant.**
- **The identity of the limiting reactant**
- **The mass of excess reactant** after the reaction is complete.

17. For each scenario below, determine if the given substance is always, never, or sometimes limiting. Fill in the blanks with *sometimes*, *always*, or *never* (each word can be used once, more than once, or not at all). Support your answers with **explanations** and **example numbers and calculations**. If you answer *sometimes* for any statement you will need to provide **two examples** (and **support them**), one for each case.

    a. Recall in the *Nut & Bolts and Stoichiometry* activity that you added two hex nuts to a bolt and represented the process as follows: $B(s) + 2N(s) \rightarrow BN_2(s)$.

If you were given a greater number of nuts than bolts, the bolts would _____ be limiting.

NOTE: **Use examples in which the number of hex nuts is always even.**

    b. In a few of the lectures, you have seen the "pop" bottles, which are filled with hydrogen and oxygen gases that, when placed in the flame of a Bunsen burner, react to produce water.

    If you react a greater number of moles of oxygen gas than hydrogen gas, the hydrogen gas would _____ be limiting.

PLEASE TURN THE PAGE FOR PART "c" OF PROBLEM #17.

17. c. Consider the reaction between nitrogen and hydrogen gases to produce ammonia gas as represented by the following balanced equation:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

If you react a greater mass of $N_2(g)$ than $H_2(g)$, the $N_2(g)$ would _____ be limiting.