CHEMISTRY 101
Hour Exam II
March 16, 2017
Dr. D. DeCoste

Name ______________________________

Signature ___________________________

T.A. _______________________________

This exam contains 17 questions on 5 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·atm/mol·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(I), 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. Consider the chemical equation $H_2(g) + O_2(g) \rightarrow H_2O(l)$. Can we balance this equation so that the coefficient for $H_2(g)$ is "1"?

   a) No. We never have a coefficient of "1" in the standard form of a balanced equation.
   b) Yes. With a "1" for the coefficient of $H_2(g)$, the equation is balanced in standard form.
   c) No. This would require one of the other coefficients to be a fraction, and this is never allowed.
   d) Yes. By having a coefficient of "1" for $H_2(g)$, the equation can still be balanced, although not in standard form.
   e) No. There is no way to balance this equation with $H_2(g)$ having a coefficient of "1".

Questions 2 and 3 deal with an aqueous solution of calcium nitrate added to an aqueous solution of sodium phosphate. Write and balance the equation for this reaction to answer questions 2 and 3.

2. What is the sum of the coefficients when the molecular equation is balanced in standard form?

   a) 5 b) 7 c) 10 d) 11 e) 12

3. What is the formula of the solid formed in the reaction?

   a) $Ca(PO_4)_2$ b) $CaPO_4$ c) $Ca_3(PO_4)_2$ d) $Ca_3(PO_3)_2$ e) None of these

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4. Recall the Nuts & Bolts activity in which you started with various amount of nuts and bolts and you made a product in which two nuts were attached to one bolt. Which of the following statements were always true?

   a) If you started with more nuts, the bolts were always limiting.
   b) If you started with more bolts, the nuts were always limiting.
   c) Neither "a" nor "b" were always true.
   d) Both "a" and "b" were always true.

5. Octane is a main ingredient in gasoline. It has the formula C_8H_{18}. It burns with the oxygen in the air to produce carbon dioxide and water. When the chemical equation for the reaction of octane and oxygen gas is balanced in standard form, what is the coefficient for water?

   a) 1 b) 2 c) 9 d) 18 e) 25

6. What mass of solid potassium sulfate is required to prepare 250.0 mL of a 0.250 *M* potassium sulfate solution?

   a) 6.32 g b) 7.45 g c) 8.45 g d) 9.89 g e) 10.9 g

7. You have 2 solutions of sodium chloride. One is a 2.00 *M* solution, the other is a 4.00 *M* solution. You mix the two solutions together, and you add more of the 4.00 *M* solution than the 2.00 *M* solution. How many of the following could be the concentration of the final solution?

I. 2.48 *M*
II. 2.86 *M*
III. 3.00 *M*
IV. 3.14 *M*
V. 4.20 *M*

a) 1 b) 2 c) 3 d) 4 e) 5

8. You have 245 mL of a sugar solution at 1.20 *M*. The next day the sugar solution has a concentration of 1.30 *M*. How much water evaporated from the solution?

a) 18.8 mL
b) 26.4 mL
c) 226 mL
d) 265 mL
e) This is an impossible problem. The concentration of the solution will never go up.

9. Which of the following aqueous solutions has the greatest number of chloride ions in solution?

a) 2.0 L of a 5.0 *M* sodium chloride solution
b) 2.0 L of a 4.0 *M* calcium chloride solution
c) 1.0 L of a 3.0 *M* potassium chloride solution
d) 1.0 L of a 4.0 *M* aluminum chloride solution
e) 1.0 L of a 4.0 *M* iron(II) chloride solution

10. Consider the reaction represented by the following balanced chemical equation

$$3MnO_2(s) + 4Al(s) \rightarrow 3Mn(s) + 2Al_2O_3(s)$$

How many moles of Al_2O_3 can be produced from 1.25 mol MnO_2 and an excess of Al?

a) 0.833 mol b) 1.00 mol c) 2.00 mol d) 2.50 mol e) 3.00 mol

11. Consider the reaction represented by the following balanced chemical equation

$$4NH_3(g) + 3Cl_2(g) \rightarrow 3NH_4Cl(s) + NCl_3(g)$$

What mass of NH_4Cl can be produced from 10.0 g of NH_3 and an excess of Cl_2?

a) 160.5 g b) 53.5 g c) 35.3 g d) 23.6 g e) 10.0 g

12. Ethane (C_2H_6) reacts with oxygen in the air to produce carbon dioxide and water. What mass of oxygen is required to react completely with 10.0 g ethane?

a) 10.6 g b) 26.6 g c) 37.2 g d) 53.2 g e) 74.5 g

13. Methanol (CH_3OH) can react with oxygen gas to produce formaldehyde (H_2CO) and water. How much formaldehyde can be produced by reacting 4.0 mol of methanol with 4.0 mol of oxygen gas?

a) 2.0 mol b) 4.0 mol c) 6.0 mol d) 8.0 mol e) 10. mol

14. Determine the maximum mass of water that can be produced by reacting 10.0 g of hydrogen gas with 65.0 g of oxygen gas.

a) 29.3 g b) 51.7 g c) 73.2 g d) 75.0 g e) 89.4 g

15. 2.00 L of a 4.00 *M* solution of lead(II) nitrate is added to 3.00 L of a 5.00 *M* solution of sodium iodide and a solid is formed. Which of the following correctly labels the ion with the highest concentration after the reaction is complete, and the ion that is **not** in solution after the reaction (concentration is 0 *M*)?

	ion with highest concentration	0 *M*
a)	Na^+	I^-
b)	NO_3^-	Pb^{2+}
c)	Pb^{2+}	NO_3^-
d)	Na^+	Pb^{2+}
e)	NO_3^-	I^-

16. Butane (C_4H_{10}), which is found in lighters, reacts with oxygen gas as represented by the following **unbalanced** equation: $C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$

Suppose 10.0 g of butane reacts with 50.0 g of oxygen gas. Address the following:

- Balance the chemical equation in standard form.
- Determine which reactant is limiting.
- Determine the mass of excess reactant left over after the reaction is complete.
- Determine the mass of $CO_2(g)$ produced and the mass of $H_2O(l)$ produced.
- Use your numbers to prove that mass is conserved.

All answers should be on this page beneath the dotted line below. Provide **complete** mathematical support for your answer. **Show all work.**

4(12.01) + 10(1.008) = 58.12 g/mol

$10.0 \text{ g } C_4H_{10} \times \frac{1 \text{ mol } C_4H_{10}}{58.12 \text{ g } C_4H_{10}} = 0.172 \text{ mol } C_4H_{10}$ $50.0 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} = 1.56 \text{ mol } O_2$

$0.172 \text{ mol } C_4H_{10} \times \frac{13 \text{ mol } O_2}{2 \text{ mol } C_4H_{10}} = 1.12 \text{ mol } O_2$

$0.172 \text{ mol } C_4H_{10} \times \frac{8 \text{ mol } CO_2}{2 \text{ mol } C_4H_{10}} = 0.688 \text{ mol } CO_2$ $0.172 \text{ mol } C_4H_{10} \times \frac{10 \text{ mol } H_2O}{2 \text{ mol } C_4H_{10}} = 0.860 \text{ mol } H_2O$

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

	$2C_4H_{10}(g)$	$13O_2(g)$	$8CO_2(g)$	$10H_2O(l)$
I	0.172 mol	1.56 mol	0	0
C	-0.172 mol	-1.12 mol	+0.688 mol	+0.860 mol
E	0	0.44 mol	0.688 mol	0.860 mol

Butane is limiting. Work will vary.

$1.12 \text{ mol } O_2 \times \frac{32.00 \text{ g } O_2}{1 \text{ mol } O_2} =$ 35.8 g O_2 used, so 14.2 g O_2 is left over.

$0.688 \text{ mol } CO_2 \times \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} =$ 30.3 g CO_2

$0.860 \text{ mol } H_2O \times \frac{18.016 \text{ g } H_2O}{1 \text{ mol } H_2O} =$ 15.5 g H_2O

10.0 g + 35.8 g = 45.8 g = 30.3 g + 15.5 g

17. Iron can react with the oxygen in the air to form **either** iron(II) oxide **or** iron(III) oxide.

a. Write balanced equations for each of these two reactions (do not worry about phases).

$$2Fe + O_2 \rightarrow 2FeO$$
$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

You have a 10.0-g sample of iron and you let it react completely with the oxygen in the air. You measure the product and find it has a mass of 14.3 g.

b. What is the formula of the product? Provide **complete** mathematical support for your answer. **Show all work.**

$$10.0 \text{ g Fe x } \frac{1 \text{ mol}}{55.85 \text{ g Fe}} = 0.179 \text{ mol Fe}$$

$$14.3 \text{ g FeO x } \frac{1 \text{ mol}}{71.85 \text{ g FeO}} = 0.199 \text{ mol FeO (not equal to mol Fe)}$$

$$14.3 \text{ g } Fe_2O_3 \text{ x } \frac{1 \text{ mol}}{159.7 \text{ g } Fe_2O_3} = 0.0895 \text{ mol } Fe_2O_3 \text{ (equal to ½ mol Fe)}$$

$$\boxed{Fe_2O_3}$$

c. What mass of product would be expected if the other product (from what you found in part b) was formed? Provide **complete** mathematical support for your answer. **Show all work.**

$$10.0 \text{ g Fe x } \frac{1 \text{ mol}}{55.85 \text{ g Fe}} \text{ x } \frac{2 \text{ mol FeO}}{2 \text{ mol Fe}} \text{ x } \frac{71.85 \text{ g FeO}}{1 \text{ mol FeO}} = \boxed{12.9 \text{ g FeO}}$$

d. To completely react the 10.0 g of iron to form 14.3 g of product, what volume of oxygen gas at 1.00 atm and 22°C is required? Provide **complete** mathematical support for your answer. **Show all work.**

$$10.0 \text{ g Fe x } \frac{1 \text{ mol}}{55.85 \text{ g Fe}} \text{ x } \frac{3 \text{ mol } O_2}{4 \text{ mol Fe}} = 0.134 \text{ mol } O_2$$

$$V = nRT/P = (0.134 \text{ mol})(0.08206 \text{Latm/molK})(295 \text{K})/(1.00 \text{ atm})$$

$$\boxed{V = 3.25 \text{ L}}$$