CHEMISTRY 101
Hour Exam II
March 31, 2020
McCarren

Name _____

Signature _____

Section _____

"Be positive. Be true. Be kind." – Roy Bennett

This exam contains 17 questions including 15 multiple choice questions and 2 multi-part fill in the blank or free response questions. Be sure to select or enter an answer for each question. You will receive your grade after the entire class has taken the exam and all questions have been graded.

1-15	(30 pts.)	_____
16	(18 pts.)	_____
17	(12 pts.)	_____
Total	(60 pts.)	_____

Useful Information:

1 L = 1000 mL (exactly)

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

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

$K = °C + 273$ $N_A = 6.022 \times 10^{23} = 1\ mole$

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, ammonium, and calcium hydroxide.
6. Consider sulfide, carbonate, and phosphate salts to be insoluble. Soluble ones: sodium, potassium, and ammonium.

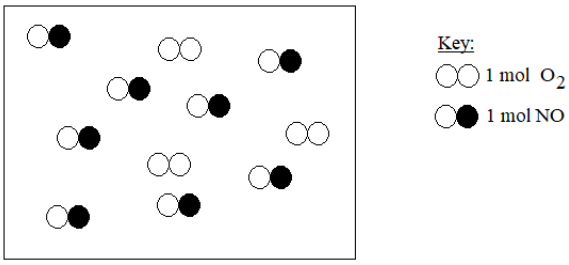
****Note: Many questions have been randomized. Your questions and numbers may not be the same as someone else's questions but are at the same difficulty and address the same content.****

Part 1: Multiple Choice

1. Which of the following is false about coefficients and subscripts in chemical reactions?
   a. Coefficients represent the amount of reactants available in the container before the reaction occurs.
   b. Coefficients may be fractions to indicate numbers of moles of substances.
   c. Changing a subscript changes the chemical make-up and identity of the substance.
   d. The subscript for a particular element on one side of the reaction can be different than the subscript for that same element on the other side of the reaction.
   e. When used in pairs, coefficients represent ratios of reactants needed compared to products produced.

2. Nitrogen monoxide gas (NO) reacts with oxygen gas (O_2) to form nitrogen dioxide. What is the sum of the coefficients when this reaction has been balanced in standard form?
   a. 2
   b. 3
   c. 4
   d. 5
   e. 6

Use your reaction from question #2 to help answer questions 3 and 4.



3. The container above shows several moles of nitrogen monoxide and oxygen gas before any reaction occurs. Using your reaction from question #2, what is the **total** number of moles of gas in the container **after** the reaction takes place?
   a. 2
   b. 3
   c. 6
   d. 8
   e. 11

4. If the total pressure in the container above before the reaction was 1.0 atm, what is the total pressure in the container after the reaction? Assume the temperature remains constant and the container is rigid.
   a. 0.18 atm
   b. 0.27 atm
   c. 0.55 atm
   d. 0.73 atm
   e. 1.0 atm

5. Iron(II) oxide reacts with oxygen to form iron(III) oxide according to the balanced equation shown below.

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

If 2.50 moles of iron(II) oxide react with sufficient oxygen, how many moles of iron(III) oxide can be formed?

a. 0.625 moles
b. 1.25 moles
c. 2.00 moles
d. 2.50 moles
e. 5.00 moles

6. 5.00 moles of sulfur (S_8) are mixed with 5.00 moles of oxygen gas and react to form 10.0 moles of a compound containing sulfur and oxygen. After the reaction 2.50 moles of sulfur are leftover. What is the formula of the sulfur and oxygen compound formed?

a. SO
b. SO_2
c. S_8O
d. S_2O_3
e. S_2O

7. In lecture, were able to generate acetylene gas by reacting calcium carbide and water.

$$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s)$$

If 1.80 grams of water (molar mass = 18.02 g/mol) were needed to react with the calcium carbide present, what volume of acetylene gas (C_2H_2) could be produced? Assume this reaction occurs at 25.0ºC and 1.50 atm.

a. 0.0500 L
b. 0.815 L
c. 1.63 L
d. 14.7 L
e. 29.3 L

8. Consider two solutions, A and B. Solution A has a greater concentration than solution B. Which **must** be true about these solutions?

a. Solution B can have the same concentration as solution A if some water is allowed to evaporate from solution B.
b. **Solution B** must have a greater number of moles if the volumes of both solutions are equal.
c. **Solution A** can have the same concentration as solution B if more solute is added to solution A.
d. **Solution A** must have a greater volume of the number of moles of solute in both solutions are equal.
e. All of these are true about the two solutions.

9. Consider a 0.500 M solution of sodium hydroxide with a volume of 300. mL. What is the mass of sodium hydroxide that needed to be dissolved to create this solution?

a. 0.150 g
b. 6.00 g
c. 66.7 g
d. 240. g
e. 6,000. g

10. A sodium hydroxide solution is mixed with a solution of sulfuric acid. What is the molecular equation for the reaction that occurs between sodium hydroxide and sulfuric acid?

a. $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
b. $2Na^+(aq) + SO_4^{2-} \rightarrow Na_2SO_4(s)$
c. $2H^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$
d. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow 2H_2O(l) + 2NaSO_4(aq)$
e. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow 2H_2O(l) + Na_2SO_4(aq)$

11. It required 100.0 mL of sulfuric acid to completely react with a 300. mL of 0.500 M solution of sodium hydroxide. What is the concentration of the sulfuric acid solution? Use your equation from #10 to help answer this question.

a. 0.500 M
b. 0.750 M
c. 1.00 M
d. 1.50 M
e. 3.00 M

12. Recall the lab experiment in which you observed several chemical reactions between different aqueous solutions. The grid below is similar to the grid you observed in the video where several chemicals are combined with sodium hydroxide. For each of the combinations present, determine whether or not a precipitate forms.

	Ammonium nitrate	Iron(III) nitrate	Barium nitrate	Silver nitrate
Sodium hydroxide				

How many precipitates formed out of these four combinations of reactants?

a. 0 (No precipitates form.)
b. 1
c. 2
d. 3
e. 4 (All four combinations form precipitates.)

Consider the reaction between hydrogen and oxygen gases to form water, as shown by the balanced equation below. Use this equation to answer the next several questions.

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

13. What mass of water can be formed if 10.0 grams of oxygen and 10.0 grams of hydrogen react?
    a. 0.625 grams
    b. 5.65 grams
    c. 10.0 grams
    d. 11.3 grams
    e. 20.0 grams

14. What mass of excess reactant is leftover when this happens? Choose the closest answer.
    a. 0 grams
    b. 4.325 grams
    c. 8.70 grams
    d. 10.0 grams
    e. 11.3 grams

15. Has mass been conserved in this process? Choose the correct answer *and* explanation.
    a. **No**: The total mass of the starting materials was 20.0 grams, but fewer than 20.0 grams of product formed.
    b. **No:** The balanced equation shows that three molecules are present before the reaction, but only two molecules are present after the reaction.
    c. **No:** Not all substances have been completely reacted; there is an excess reactant leftover.
    d. **Yes:** Before the reaction, 20.0 grams of reactants were present, and after the reaction, 20.0 grams of water formed.
    e. Yes: The total mass of all substances in the container both before and after the reaction is approximately 20.0 grams.

Please go on to the next page.

Part 2: Free Response

Please answer the questions below as completely as possible. Explain your answers and show all work where required.

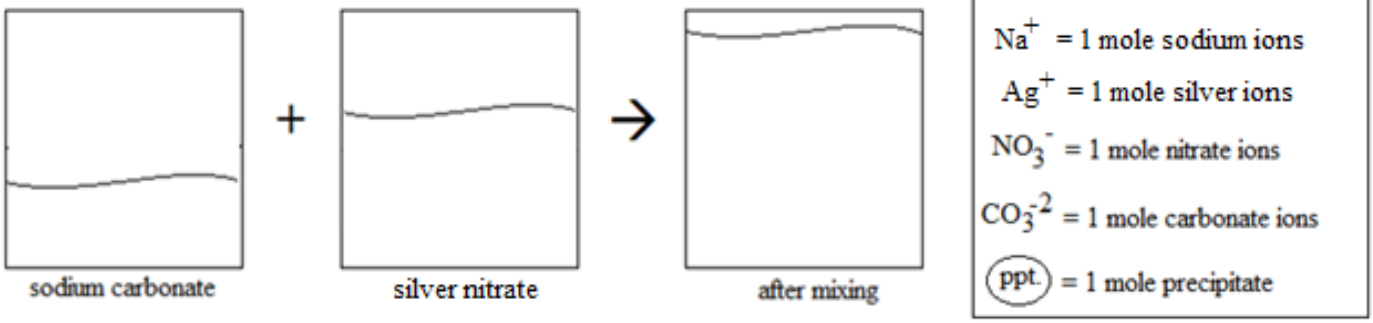
16. Consider the reaction between aqueous silver nitrate and aqueous sodium carbonate.

a. Predict the products and the molecular equation below, clearly showing all phases.

Molecular equation	$AgNO_3(aq) + Na_2CO_3(aq) \rightarrow \mathbf{Ag_2CO_3(s) + 2NaNO_3(aq)}$

b. You mix a 1.0 L solution containing 1.0 moles of sodium carbonate with a 2.0. L solution containing 5.0 moles silver nitrate. Draw a particle picture to represent the reaction containers before and after these two substances are combined. Use the symbols in the key to the right below to represent each of the ions in solutions as well as any precipitate formed. Show any work in the space below.

+3 for each correct answer in part A (hand graded)



Containers should show:

+3 before (0.5 points each deducted if incorrect)

Before reaction:

- **2 moles sodium ions**
- **1 mole carbonate ions**
- **5 moles silver ions**
- **5 moles nitrate ions**

After reaction:

+3 before (0.5 points each deducted if incorrect)

- **2 moles sodium ions**
- **0 moles carbonate ions**
- **5 moles nitrate ions**
- **3 moles silver ions**
- **1 mole precipitate**

c. What are the concentrations of each of the ions present in solution after the reaction? Please show work and write your final answers in the boxes below.

+3 before (0.5 points each deducted if incorrect)

Ion	Concentration
Sodium ion	**0.67 M**
Silver ion	**1.00 M**
Nitrate ion	**1.67 M**
Carbonate ion	**0**

Work:

Use moles from "after" and then divide by total volume of 1.0 L + 2.0 L = 3.0 L in each case.

+3 total for explanation of work and identification of ions (0.50 points deducted for each incorrect answer)

Carbonate: limiting (0 moles remaining, concentration is 0 M)

Sodium: spectator (2.0 moles remaining, 2.0 mol/3.0 L = 0.67 M)

Nitrate: spectator (5.00 moles remaining, 5.0 mol/3.0 L = 1.67 M)

Silver: excess (3.0 moles remaining, 3.0 mol/3.0 L = 1.00 M)

Please go on to the next page.

17. Recall the lab experiment in which you observed several balloons inflating after reacting two different acids with sodium bicarbonate (baking soda). One of the reactions you saw took place below between the baking soda and sulfuric acid (H_2SO_4).

$$2NaHCO_3(s) + H_2SO_4(aq) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4(aq)$$

a. You mix 16.8 grams of baking soda (molar mass = 84.0 g/mol) with 100.0 mL of 2.00 M H_2SO_4. This inflates the balloon full of carbon dioxide. How many moles of carbon dioxide are produced?

0.200 moles CO_2 are produced

+3 for correct answer

- **16.8 grams baking soda is 0.200 moles**
- **100.0 mL of 2.00 M H_2SO_4 is 0.200 moles sulfuric acid.**
- **Limiting reactant is baking soda in the BCA table.**
- **0.400 moles CO_2 can be produced.**

b. In a second balloon balloon and flask, you mix the 16.8 grams of baking soda just as you did in part a. but you instead add twice the volume (200. mL) of 2.00 M H_2SO_4 before mixing and inflating the balloon. If the inflated balloon size depends on the amount of carbon dioxide produced, how would the size of this second inflated balloon compare to the size of the balloon in part a? Explain and provide mathematical support for your answer.

+3 for correct answer

I. The second balloon would be half as large.
II. <u>The second balloon would be the same size.</u>
III. The second balloon would be larger but less than twice as large.
IV. The second balloon would be twice as large.
V. The second balloon would be greater than twice as large.

Baking soda is the limiting reactant, so adding more sulfuric acid will not increase the size of the balloon because more carbon dioxide is not able to be produced.

Problem #17 (continued)

The following problem refers to the reaction below from the previous page:

$$2NaHCO_3(s) + H_2SO_4(aq) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4(aq)$$

c. In a third balloon and flask, you react three times as much baking soda (50.4 g) as you did in part a. with the same 100.0 mL of 2.00 M H_2SO_4. If the inflated balloon size depends on the amount of carbon dioxide produced, how would the size of this third inflated balloon compare to the size of the balloon in part a? Explain and provide mathematical support for your answer.

+3 for correct answer

I. The third balloon would be the same size.
II. The third balloon would be larger but less than twice as large.
III. The third balloon would be twice as large.
IV. The third balloon would be three times as large.
V. The third balloon would be greater than three times as large.

The original balloon (in part A) had 0.200 moles CO_2 produced. This combination resulted 0.400 moles CO_2 being produced. The limiting reactant was the sulfuric acid. See the BCA table below.

- **50.4 grams baking soda is 0.600 moles $NaHCO_3$.**
- **100.0 mL of 2.00 M H_2SO_4 is 0.200 moles H_2SO_4.**

	$2NaHCO_3(s) + H_2SO_4(aq) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4(aq)$				
B	**0.600**	**0.200**	**0**	**0**	**0**
C	**-0.400**	**-0.200**	**+0.400**	**+0.400**	**+0.200**
A	**0.200**	**0**	**0.400**	**0.400**	**0.200**

Because there are twice the number of moles of carbon dioxide, the balloon is expected to double in size.

+3 explanation of work for parts, A, B, and C. (1 point each)

STOP **This is the end of the exam. Nothing written after this page will be graded.**