CHEMISTRY 101
Hour Exam II
March 28, 2023
McCarren

Name _____KEY_____

Signature _____

Section _____

"Obstacles don't have to stop you. If you run into a wall, don't turn around and give up. Figure out how to climb it, go through it, or work around it." – Michael Jordan

This exam contains 17 questions on 10 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	(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).

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

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

Standard temperature and pressure (STP) is 1.0 atm and 273 K.

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.

Part 1: Multiple Choice

1. Which is <u>true</u> about a limiting reactant?

   The limiting reactant always is the reactant that…

   a. <u>can produce less product.</u>
   b. has the largest coefficient in the balanced equation.
   c. remains in the container after the reaction is complete.
   d. has the greatest molar mass.
   e. has the smallest number of moles before the reaction.

2. Consider the following balanced equation which shows acetylene gas burning in oxygen. Balance the equation in standard form (using lowest whole number coefficients) and give the coefficient in front of the oxygen gas.

$$\mathbf{C_2H_2(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)}$$

   a. 1
   b. 2
   c. 3
   d. 4
   e. <u>5</u>

Consider the equation shown below for the reaction between solid sulfur (S_8) and solid carbon to form liquid CS_2. Use this reaction to answer the next two questions.

$$\mathbf{S_8(s) + 4C(s) \rightarrow 4CS_2(l)}$$

3. Each time 2.50 moles of S_8 react, _____ moles of CS_2 form.
   a. 2.50 moles
   b. 5.00 moles
   c. 7.50 moles
   d. <u>10.0 moles</u>
   e. 12.5 moles

4. Each time 65.0 grams of CS_2 forms, _____ moles of S_8 were required.
   a. <u>0.214 moles</u>
   b. 0.427 moles
   c. 0.853 moles
   d. 3.41 moles
   e. 54.7 moles

You dissolve 55.5 g solid calcium chloride in water and end up with a 0.250 M solution. Use this solution to answer the next three questions.

5. What is the volume of this solution?
   a. <u>2.00 L</u>
   b. 1.00 L
   c. 500. mL
   d. 250. mL
   e. 125 mL

6. How many moles of **chloride** ions are present in this solution?
   a. 0.0500 moles
   b. 0.500 moles
   c. <u>1.00 moles</u>
   d. 55.5 moles
   e. 110. moles

7. If you add an additional 100. mL of water to this solution, which of the following change? Select the best option from a. – e.

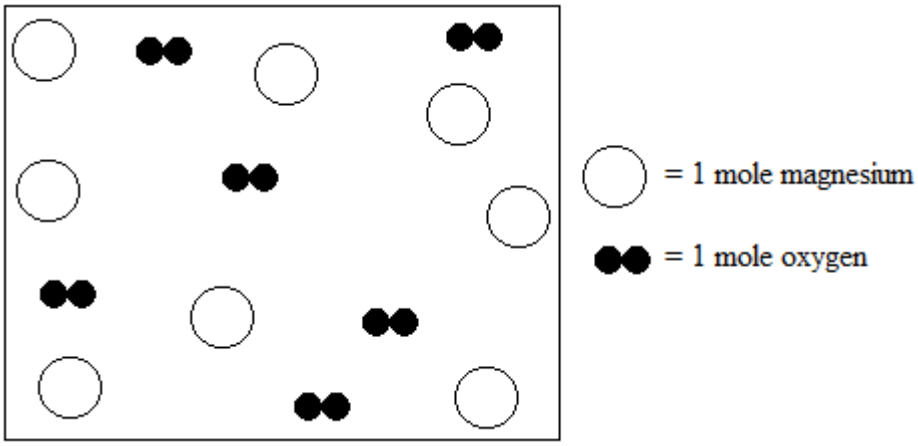
   I. The concentration of the solution.
   II. The number of moles of calcium ions in the solution.
   III. The number of moles of chloride ions in the solution.
   IV. The overall volume of the solution.

   a. I only
   b. IV only
   c. <u>I and IV</u>
   d. II, III, and IV
   e. I, II, III, and IV

As seen in a lecture demonstration, magnesium metal reacts with oxygen gas to produce solid magnesium oxide according to the balanced equation below.

$$\mathbf{2Mg(s) + O_2(g) \rightarrow 2MgO(s)}$$

The image below shows the contents of a reaction container holding some magnesium and some oxygen. The labeled particles of different sizes each represent one mole of magnesium and one mole of oxygen, respectively. Use this information and the balanced equation to answer the next three questions.



8. How many moles of magnesium oxide are formed in this reaction?
   a. 2 moles
   b. 6 moles
   c. 4 moles
   d. <u>8 moles</u>
   e. 10 moles

9. How many moles of excess reactant are left-over after this reaction?
   a. 0 moles (Both reactants are completely consumed.)
   b. <u>2 moles</u>
   c. 4 moles
   d. 6 moles
   e. 8 moles

10. Is mass conserved in this reaction? Choose the best answer and explanation.
    a. *No:* There are fewer particles in the container after the reaction.
    b. *No:* The overall mass of the magnesium oxide product formed is less than the total mass of the magnesium and oxygen present before the reaction.
    c. No: The atoms of magnesium react to form magnesium oxide.
    d. <u>*Yes:* The same number of oxygen atoms and the same number of magnesium atoms are present before and after the reaction.</u>
    e. *Yes:* Particles of oxygen gas are present both before and after the reaction.

Consider the reaction between aqueous magnesium nitrate and aqueous potassium hydroxide as shown below. Use this reaction to answer the next three questions.

$$\mathbf{Mg(NO_3)_2(aq) + 2KOH(aq) \rightarrow Mg(OH)_2(s) + 2KNO_3(aq)}$$

11. Select the balanced **complete ionic** equation for this reaction.

    a. $\mathbf{Mg^{+2}(aq) + 2NO_3^-(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s) + 2K^+(aq) + 2NO_3^-(aq)}$

    b. $Mg^{+2}(aq) + (NO_3^-)_2(aq) + 2K^+(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s) + 2K^+(aq) + (NO_3^-)_2(aq)$

    c. $Mg^{+2}(aq) + 2NO_3^-(aq) + K^+(aq) + OH^-(aq) \rightarrow Mg(OH)_2(s) + K^+(aq) + NO_3^-(aq)$

    d. $Mg^+(aq) + NO_3^-(aq) + K^+(aq) + OH^-(aq) \rightarrow MgOH(s) + K^+(aq) + NO_3^-(aq)$

    e. $Mg^{+2}(aq) + NO_3^-(aq) + K^+(aq) + OH^-(aq) \rightarrow Mg(OH)_2(s) + K^+(aq) + NO_3^-(aq)$

12. When a 100.0 mL solution of 0.200 M aqueous magnesium nitrate is mixed with 100.0 mL of 0.200 M aqueous potassium hydroxide, which ion limits the amount of product that can be produced?
    a. The magnesium ion
    b. The potassium ion
    c. The nitrate ion
    d. The hydroxide ion
    e. Both magnesium ion and the hydroxide ion limit the amount of product.

13. After mixing the two solutions in #12, which ions are remaining **in the solution** after the reaction?
    a. magnesium and potassium ions
    b. magnesium and hydroxide ions
    c. nitrate and potassium ions
    d. nitrate, potassium, and hydroxide ions
    e. magnesium, nitrate, and potassium ions

Consider the reaction between hydrogen gas and oxygen gas to form liquid water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

We have seen this reaction several times in class, in both the "pop" bottles and balloons. Suppose this reaction begins with hydrogen gas and oxygen gas in a sealed container with no water present. **After** the reaction, the container held 20.0 g water, 10.0 g leftover oxygen gas, and no hydrogen gas.

14. What mass of hydrogen gas was required to produce 20.0 grams water?
    a. 0.555 grams
    b. 1.11 grams
    c. <u>2.24 grams</u>
    d. 4.48 grams
    e. 40.4 grams

15. What was the total mass of oxygen gas present **<u>before</u>** the reaction?
    a. 0.865 grams
    b. 10.0 grams
    c. 17.8 grams
    d. 20.0 grams
    e. <u>27.8 grams</u>

Please go on to the next page.

Part 2: Free Response

16. Recall the lab activity in which you observed the combinations of several aqueous solutions. Use the solubility rules on the equation sheet to help answer the following questions related to these solutions.

a. The table below shows possible combinations of aqueous solutions of several salts. For each combination, determine whether or not a precipitate formed. Write "ppt" or "no" in each of the boxes below accordingly.

+6 total

+1 each box

	iron(III) nitrate	**sodium sulfate**	**potassium chloride**
calcium nitrate	**no**	**ppt**	**no**
sodium carbonate	**ppt**	**no**	**no**

+8 total,

(+4 each set scored below)

b. For each combination above which resulted in the formation of a precipitate, give the balanced molecular and net ionic equations in the space below. Be sure to include all phases and charges as required, and label which is the molecular equation and which is the net ionic equation.

Set 1:

+1 molecular: reactants

+1 molecular: products & phases

Molecular: $2Fe(NO_3)_3(aq) + 3Na_2CO_3(aq) \rightarrow Fe_2(CO_3)_3(s) + 6NaNO_3(aq)$

Net: $2Fe^{+3}(aq) + 3CO_3^{-2}(aq) \rightarrow Fe_2(CO_3)_3(s)$

Set 2:

+1 molecular: balance

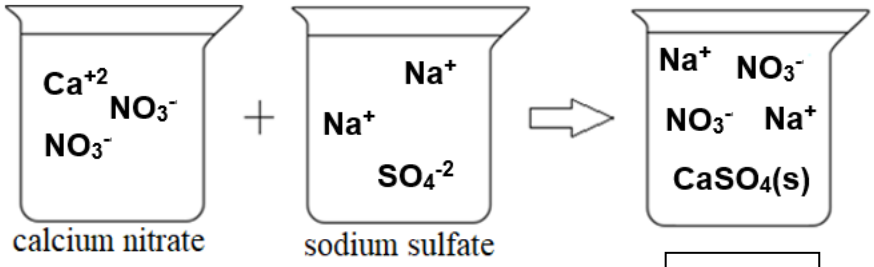
Molecular: $Ca(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow 2NaNO_3(aq) + CaSO_4(s)$

Net: $Ca^{+2}(aq) + SO_4^{-2}(aq) \rightarrow CaSO_4(s)$

+1 net ionic: correct based on molecular equation (can give 0.5 if one minor issue)

c. Give a particle picture diagram for the balanced complete ionic equation for the combination of calcium nitrate and sodium sulfate from the table in part a. In your particle picture, be sure to include:
   - All particles in aqueous solutions before and after
   - Any solid present after the reaction (if a solid is formed)
   - Charges on substances in ion form, where applicable

+4 total



calcium nitrate

+1

sodium sulfate

+1

+1 solid

+1 spectators

Doing the problem with sodium carbonate instead of sodium sulfate is also fine.

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 occurred between baking soda and sulfuric acid (H_2SO_4) according to the balanced equation below.

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

In the table below, the H_2SO_4 reacted with baking soda to inflate a balloon full of carbon dioxide to 0.700 L. The balloon was in a room of pressure 0.900 atm and temperature 22.0°C.

+5 total

a. What is the minimum **volume** of 0.100 M sulfuric acid (in mL) required to inflate this balloon to this volume?

****Watch for continuation credit between parts a and b.****

Find moles carbon dioxide using PV = nRT

+1 **(0.900 atm)(0.700 L) = n(0.08206)(22.0°C + 273)**

+1 **n = 0.0260 moles CO_2**

Use mole ratio or BCA table to find moles H_2SO_4 required.

+1

$$0.0260\ moles\ CO_2 \times \frac{1\ mol\ H_2SO_4}{2\ moles\ CO_2} = 0.0130\ moles\ H_2SO_4$$

+1 **Find volume of H_2SO_4 using provided concentration and moles.**

$$M = \frac{mol}{L} \qquad 0.100\ M = \frac{0.0130\ mol}{x\ L} \qquad x = 0.130\ L = 130.\ mL$$

+1 **130. mL of H_2SO_4 are required.**

+3 total

b. What **mass** of baking soda is required to inflate this balloon to this volume? (molar mass $NaHCO_3$ = 84.0 g/mol)

Using 0.0260 moles CO_2 from the previous part of the problem….

$$0.0260\ moles\ CO_2 \times \frac{2\ mol\ NaHCO_3}{2\ moles\ CO_2} \times \frac{84.0\ g\ NaHCO_3}{1\ mol\ NaHCO_3}$$ **= 2.18 g $NaHCO_3$ is required.**

+1 +1 +1

c. In another scenario, you find an unknown white solid which consists of a bicarbonate compound and some unknown cation X consisting of an ion of one element. This compound reacts with sulfuric acid according to the balanced equation below and similarly inflates a balloon.

$H_2SO_4(aq) + 2XHCO_3(s) \rightarrow 2H_2O(l) + 2CO_2(g) + X_2SO_4(aq)$

+4 total

This reaction occurs when 50.0 mL of 0.100 M H_2SO_4 and 0.680 g of the unknown solid react completely, with no excess reactant remaining. What is the identity of X? Show work to support your answer.

Find moles H_2SO_4 present.

+1

$$M = \frac{mol}{L} \qquad 0.100\ M = \frac{x\ mol}{0.0500\ L} \qquad x = 0.00500\ mol\ H_2SO_4$$

+1

Use moles H_2SO_4 present to find moles of $XHCO_3$ needed.

$$0.00500\ mol\ H_2SO_4 \times \frac{2\ mol\ XHCO_3}{1\ mol\ H_2SO_4} = 0.0100\ mol\ XHCO_3$$

+1

Find molar mass $XHCO_3$.

0.680 g/0.0100 mol = 68.0 g/mol

Find molar mass of X alone.

68.0 g/mol – 1.008g/mol – 12.011 g/mol – 16.00 g/mol* 3 = 6.98 g/mol

+1

X is lithium!