CHEMISTRY 101
Hour Exam II
October 24, 2023
McCarren

Name ______________________________

Signature ___________________________

Section _____________________________

"Life starts all over again when it gets crisp in the fall."

– F. Scott Fitzgerald, "The Great Gatsby"

This exam contains 17 questions on 9 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	(14 pts.)	_________
17	(16 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·atm/mol·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.

Section 1: Multiple Choice

1. Which of the follow statements is **true** regarding balanced equations?
   a. Equations are balanced by changing subscripts.
   b. Phases indicating solid, liquid, and gas, are required to be the same on the left and right side of a balanced equation.
   c. Balanced equations contain the same number of molecules on the left and the right.
   d. Balanced equations tell us the number of particles inside the reaction container at any given time.
   e. **Subscripts are used to show the number of atoms of each type within an individual molecule in a balanced equation.**

2. Which of the following is **true** regarding limiting reactants?

   The limiting reactant is the reactant that….
   a. is remaining in the container after the reaction.
   b. has the smallest number of moles initially present of any of the reactants.
   c. has the largest coefficient.
   d. that has the largest molar mass.
   e. **can produce the lowest mass of product.**

3. Consider the unbalanced equation below which is a combustion reaction between propane (C_3H_8) and oxygen gas to form carbon dioxide gas and water vapor.

   $$C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$$

   What is the sum of the coefficients when this reaction is balanced in standard form with lowest possible whole number coefficients?
   a. 4
   b. 8
   c. 9
   d. 12
   e. **13**

4. A reaction begins with 28 grams of nitrogen gas and 96 grams of oxygen gas. These both react completely, with no excess reactant remaining, to form an unknown product NO_x, in which x is some unknown whole number. What is x?
   a. 2
   b. **3**
   c. 4
   d. 5
   e. 6

Consider the balanced equation below showing the decomposition of silver oxide into solid silver and oxygen gas. Use this equation to answer the next two questions.

5. For every 4.0 moles silver produced, how many moles of oxygen are also produced?*

$$2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$$

   a. **<u>1.0 mole</u>**
   b. 2.0 moles
   c. 4.0 moles
   d. 6.0 moles
   e. 8.0 moles

*The original exam had a typo, so choices A and B were both accepted as correct.

6. A sample of silver oxide decomposes and produces 14.8 grams of oxygen gas. What was the mass of the silver oxide sample?
   a. **<u>214 grams</u>**
   b. 107 grams
   c. 14.8 grams
   d. 7.40 grams
   e. 0.923 grams

Equal moles of hydrogen and oxygen gas react to form water vapor in a closed, rigid container at constant temperature. Use this information to answer the next two questions.

7. How does the number of atoms and the number of molecules in the container before the reaction compare to the number of atoms and the number of molecules after the reaction?

   - ***The number of atoms in the container is __________ after the reaction compared to before the reaction.***
   - ***The number of molecules in the container is ________ after the reaction compared to before the reaction.***

   a. **<u>the same; lower</u>**
   b. the same; the same
   c. the same; higher
   d. lower; lower
   e. higher; higher

8. If the pressure in the container before the reaction is P, what is the pressure in the container after the reaction?
   a. 1/4P
   b. 1/2P
   c. **<u>3/4P</u>**
   d. P
   e. 2P

Recall the laboratory activity when you observed the formation of precipitates as a result of the combinations of pairs of several aqueous solutions. You have two unknown solutions labeled A and B similar to those found in the activity. Use the information below to answer the next two questions and identify the solutions.

9. Solution A forms a precipitate when it combines with sodium chloride. Which of the five options below could be the identity of solution A?
   a. KNO_3
   b. $Ni(NO_3)_2$
   c. $Ca(NO_3)_2$
   d. **$AgNO_3$**
   e. $Fe(NO_3)_3$

10. Solution B does not form a precipitate when combined with sodium hydroxide or sodium carbonate. Which of the five options below could be the identity of solution B?
    a. **KNO_3**
    b. $Ni(NO_3)_2$
    c. $Ca(NO_3)_2$
    d. $AgNO_3$
    e. $Fe(NO_3)_3$

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11. Consider the reaction between aqueous solutions of sodium chromate (Na_2CrO_4) and silver nitrate ($AgNO_3$) which forms a dark red precipitate. What is the correct balanced net ionic equation for this reaction?
    a. $Ag^{+2}(aq) + CrO_4^{-2}(aq) \rightarrow AgCrO_4(s)$
    b. **$2Ag^{+}(aq) + CrO_4^{-2}(aq) \rightarrow Ag_2CrO_4(s)$**
    c. $Ag_2^{+}(aq) + CrO_4^{-2}(aq) \rightarrow Ag_2CrO_4(s)$
    d. $Ag^{+}(aq) + CrO_4^{-}(aq) \rightarrow AgCrO_4(s)$
    e. $Na^{+}(aq) + NO_3^{-}(aq) \rightarrow NaNO_3(s)$

12. You dissolve 50.0 grams of calcium chloride solute in water to form a 125 mL solution. (Note: molar mass $CaCl_2$ = 110.98 g/mol) What is the concentration of this solution?
    a. 0.00360 M
    b. 0.400 M
    c. **3.60 M**
    d. 5.30 M
    e. 400. M

13. How many of the following result in a change to the concentration of an aqueous calcium chloride solution?
    - Doubling the mass of calcium chloride in the solution while also adding enough water to double the volume of the solution
    - Pouring some of the solution into another container
    - Leaving the solution out on the counter for several days
    - Adding several more grams of calcium chloride to the solution without adding water

    a. 0 (None of the changes result in a change of concentration.)
    b. 1
    c. **<u>2</u>**
    d. 3
    e. 4 (All four changes result in changes in concentration of the solution.

Consider the balanced molecular equation shown below in which calcium nitrate and sodium carbonate react to form the calcium carbonate precipitate. Use this information to answer the next two questions.

$$\mathbf{Ca(NO_3)_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaNO_3(aq)}$$

You react 0.200 mol calcium nitrate with a solution volume of 200.0 mL with 0.300 mol sodium carbonate with a solution volume of 100.0 mL.

14. Which ion is **<u>not</u>** present in the solution after the reaction?
    a. **<u>Ca^{+2}</u>**
    b. NO_3^-
    c. Na^+
    d. CO_3^{2-}
    e. All four of the ions above are still present in the solution after the reaction.

15. What is the concentration of sodium ions after the reaction?
    a. 0 M (Sodium ions are not present in the solution after the reaction.)
    b. 1.0 M
    c. 1.5 M
    d. **<u>2.0 M</u>**
    e. 3.0 M

Please go on to the next page.

Section 2: Free Response

16. The problems below all relate to limiting and excess reactants. Please show all work in the space below each problem each section.

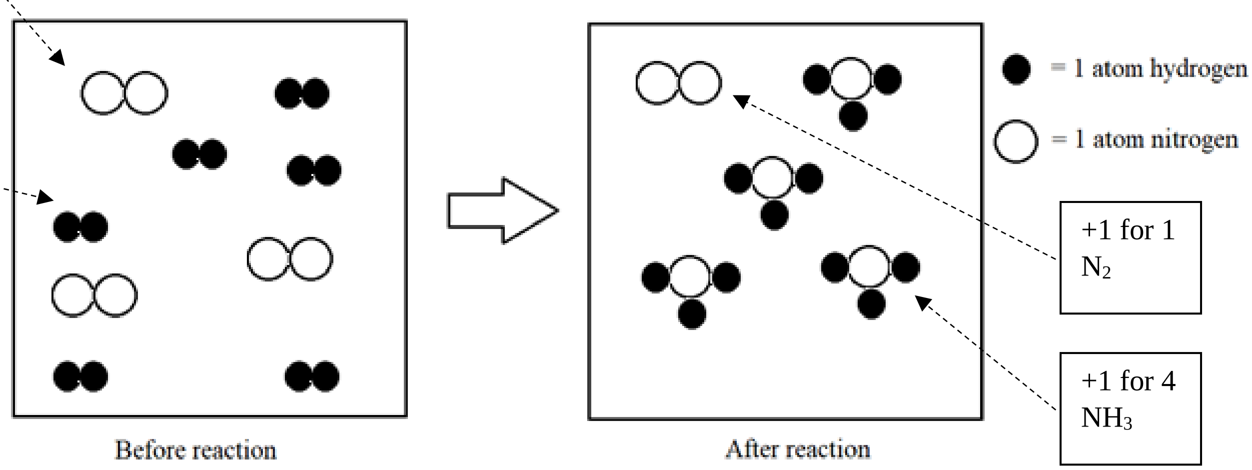
+4 points total

a. Consider the reaction between nitrogen and hydrogen gases to form ammonia (NH_3). Three molecules of nitrogen gas and six molecules of hydrogen gas are present together in a container before any reaction. What is present in the container after the reaction?

To answer this question, draw particle diagrams in the box below to represent the particles present before and after the reaction. Use the key to the right to represent atoms of hydrogen and nitrogen. Make sure that the correct number of each molecule is present.

+1 for 3 N_2

+1 for 6 H_2



+1 for 1 N_2

+1 for 4 NH_3

+3 points total

b. Was mass conserved in this reaction? State yes or no. Then, explain your answer in words. Your explanation should include describing specific numerical information from part a. and discussing how this supports your response.

+1

+1

+1

Yes, mass was conserved in this reaction. There are the same number and type of atoms in the container on both the left and right side of the reaction (12 atoms of hydrogen are present on the left and the right and 6 atoms of nitrogen are present on the left and the right.)

+4 points total

c. Consider the reaction between hydrogen gas and oxygen gas to form liquid water. Suppose this reaction begins with hydrogen gas and oxygen gas in a 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. What masses of which substances were present **before** the reaction? Show your work.

Multiple ways to solve, one of them is shown below.

+1 grams to moles

$$20.0\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g\ H_2O} = 1.11\ mol\ H_2O$$

$$10.0\ g\ O_2 \times \frac{1\ mol\ O_2}{32.0\ g\ O_2} = 0.3125\ mol\ O_2$$

+1 appropriate use of ratios

	$2H_2$ +	O_2 →	$2H_2O$
B	1.11	0.863	0
C	-1.11	-0.55	+1.11
A	0	0.3125	1.11

+1

$$1.11\ mol\ H_2 \times \frac{2.02\ g\ H_2}{1mol\ H_2} = \mathbf{2.24\ g\ H_2}$$

+1

$$0.863\ mol\ O_2 \times \frac{32.0\ g\ O_2}{1mol\ O_2} = \mathbf{27.6\ g\ O_2}$$

+3 points total

d. Was mass conserved in this reaction? State yes or no. Then, explain your answer in words. Your explanation should include describing specific numerical information from part c. and discussing how this supports your response.

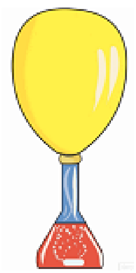
+1

+1

<u>Yes.</u> We know that mass was conserved because there are 30.0 grams total after the reaction (the 10.0 g leftover oxygen and 20.0 grams water) and 30.0 grams before the reaction (2.24 g H_2 plus 27.6 g O_2 is 30.0 g total).

+1

17. We have worked with the following reactions which we have worked with in lab, lecture, and discussion. Use these to answer question 17.



Recall the lab activity in which you observed the combination of sulfuric acid and baking soda to form several products. One of these products was carbon dioxide gas which inflated a balloon according to the balanced equation below.

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

+4 points total

a. You wish to inflate a balloon full of carbon dioxide to a volume of 30.0 L at a temperature of 298 K and a pressure of 1.0 atm. You have 2.00 moles of baking soda and sufficient sulfuric acid. With this amount of baking soda, are you able to fill the balloon to less than 30.0 L, exactly 30.0 L, or to more than 30.0 L? Explain in words and also show mathematical support.

+2 greater

This amount of baking soda is able to inflate the balloon to <u>greater</u> than 30.0 L. See work below; this produces more than 30.0 L of carbon dioxide. (Note: this is not the only way to solve the problem. You can also start with the carbon dioxide balloon and work back to moles baking soda.)

+1 must include a mole ratio

$$2.00\ moles\ NaHCO_3 \times \frac{2\ moles\ CO_2}{2\ moles\ NaHCO_3} = 2.00\ moles\ CO_2$$

$$PV = nRT$$

+1 math support

$$(1.00\ atm)V = (2.00\ moles)\left(0.8206\frac{L \cdot atm}{mol \cdot K}\right)(298\ K)$$

$$V = 48.0\ L$$

+4 points total

b. What volume (in mL) of 3.00 M sulfuric acid (H_2SO_4) is required to inflate the balloon full of carbon dioxide to 30.0 L? Assume the same temperature and pressure. Show your work.

$$PV = nRT \qquad (1.00\ atm)(30.0\ L) = n\left(0.8206\frac{L \cdot atm}{mol \cdot K}\right)(298\ K)$$

+1

$$n = 1.22\ mol\ CO_2$$

$$1.22\ mol\ CO_2 \times \frac{1\ mol\ H_2SO_4}{2\ mol\ CO_2} = 0.61\ mol\ H_2SO_4 \qquad 3.00\ M = \frac{0.61\ mol}{x\ L}$$

+1

$$x = .203\ L\ or\ \mathbf{203.mL}$$

+1

+1

Recall the lecture demonstration in which an aqueous solution of potassium iodide was mixed with an aqueous solution of lead(II) nitrate. These reacted to form a bright yellow precipitate according to the balanced equation below.

$$\mathbf{Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)}$$

c. You wish to form exactly 18.5 grams of lead(II) iodide precipitate. You currently have 50.0 mL of 2.00 M potassium iodide solution and sufficient lead(II) nitrate solution. With these reactants, are you able to produce more than 18.5 grams of precipitate, exactly 18.5 grams precipitate, or less than 18.5 grams of precipitate? Explain your answer in words and support it with calculations. (Note: Molar mass PbI_2 = 461.0 g/mol)

+4 points total

This amount of potassium iodide is able to produce more than 18.4 grams of lead(II) iodide. This is because only 39.9 mL of the potassium iodide are needed to produce this much lead(II) iodide as shown below. (Note: there are multiple ways to solve this problem. You can also start with the KI solution and determine the mass of precipitate produced.)

+2 greater

+1 must include a mole ratio

$$18.5\ g\ PbI_2 \times \frac{1\ mol\ PbI_2}{461.0\ g\ \ PbI_2} \times \frac{2\ mol\ KI}{1\ mol\ \ PbI_2} = 0.0803\ mol\ KI$$

+1 math support

$$2.00\ M\ KI = \frac{0.0803\ mol\ KI}{x\ L}$$

$$x = 0.401\ L\ or\ 40.1\ mL$$

d. Creating 18.5 grams of lead(II) iodide precipitate required 10.0 mL of an aqueous lead(II) nitrate solution. What was the concentration of this solution? Show your work.

+4 points total

$$18.5\ g\ PbI_2 \times \frac{1\ mol\ PbI_2}{461.0\ g\ \ PbI_2} \times \frac{1\ mol\ Pb(NO_3)_2}{1\ mol\ \ PbI_2} = 0.0401\ mol\ Pb(NO_3)_2$$

+1 (conversion to moles) +1 (moles of $Pb(NO_3)_2$)

$$\frac{0.0401\ mol\ KI}{0.010\ L} = \mathbf{4.01\ M\ KI}$$

+1 (volume in L) +1 (final answer)