CHEMISTRY 101
Hour Exam II
March 29, 2022
McCarren

Name _____KEY_____

Signature _____

Section _____

"You are the artist of your life. Don't give the paintbrush to anyone else." — Iva Ursano

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. A periodic table and one sheet of scratch paper are provided after the exam. Anything written on the periodic table and scratch paper will not be graded.

1-15	(30 pts.)	_____
16	(12 pts.)	_____
17	(18 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. You are doing your chemistry homework with your friend and are given the equation $H_2 + O_2 \rightarrow H_2O$ to balance.

   Your friend says "This one is pretty easy. If we just put a '2' subscript after the oxygen in H_2O, then we can balance this equation." How should you respond?

   a. You should *agree* with your friend, because this will mean that there are an equal number of hydrogen and oxygen atoms on the left and right side of the equation.
   b. You should *agree* with your friend, because it is possible to form H_2O_2 by combining H_2 and O_2.
   c. <u>You should *disagree* with your friend, because adding the "2" after the H_2O changes its identity from water to hydrogen peroxide.</u>
   d. You should *disagree* with your friend, because the equation will be balanced completely once you add the "2" in front of the H_2O as a coefficient instead of a subscript.
   e. You should *disagree* with your friend, because you need to add a "3" after the oxygen in H_2O instead of a "2" in order to balance the equation.

2. Gaseous nitrogen dioxide reacts with water to form nitric acid (HNO_3) and gaseous nitrogen monoxide.

   $$\mathbf{NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + NO(g)}$$

   What is the sum of coefficients when this equation is balanced in standard form?

   a. 4
   b. 5
   c. 6
   d. <u>7</u>
   e. 8

3. What is the concentration of the resulting solution when 80.0 grams of sodium hydroxide is dissolved in water to make 300.0 mL of solution?

   a. 0.00667 M
   b. 0.267 M
   c. <u>6.67 M</u>
   d. 133 M
   e. 267 M

4. We have said that we can think of a balanced chemical equation as a "for every" statement. Use the equation below showing the reaction between solid carbon and nitric acid to complete the "for every" statement.

$$\mathbf{C(s) + 4HNO_3(aq) \rightarrow CO_2(g) + 4NO_2(g) + 2H_2O(l)}$$

For every two moles of carbon dioxide formed, _____ moles of nitrogen dioxide are also formed.

   a. 2
   b. 4
   c. 6
   d. <u>8</u>
   e. 10

5. Using the same chemical equation, if 2.00 moles of nitric acid (HNO_3) react, how many **<u>grams</u>** of solid carbon are also needed to react?
   a. 0.042 grams
   b. 0.500 grams
   c. <u>6.01 grams</u>
   d. 24.0 grams
   e. 96.0 grams

6. The combination of aqueous calcium nitrate and aqueous sodium chromate react and form a precipitate. A possible molecular equation for this process is shown below. Is this reaction correct? Chose the best answer and reasoning for that answer.

$$\mathbf{Ca(NO_3)_2(aq) + Na_2CrO_4(aq) \rightarrow CaCrO_4(s) + 2NaNO_3(aq)}$$

   a. <u>*Yes*: The correct precipitate has been chosen and all of the atoms and charges balance on each side.</u>
   b. *No:* The formula for at least one reactant or product substance is incorrect.
   c. *No:* The correct precipitate is not selected.
   d. *No:* The sodium has a "2" subscript on the left so it also needs a "2" subscript on the right.
   e. *No:* The charges in the precipitate do not properly balance.

7. Recall the lab activity in which you observed the combinations of several aqueous solutions similar to those shown in the table below. How many of these combinations result in the formation of a precipitate?

	sodium hydroxide	**sodium sulfate**
calcium nitrate		
silver nitrate		

a. 0 (No precipitates are formed.)
b. 1
c. <u>2</u>
d. 3
e. 4 (All four combinations form a precipitate.)

The molecular equation for the reaction between aqueous calcium hydroxide and aqueous hydrochloric acid is shown below, *not* including phases. Use this reaction to help answer the next three questions.

$$\mathbf{2HCl + Ca(OH)_2 \rightarrow 2H_2O + CaCl_2}$$

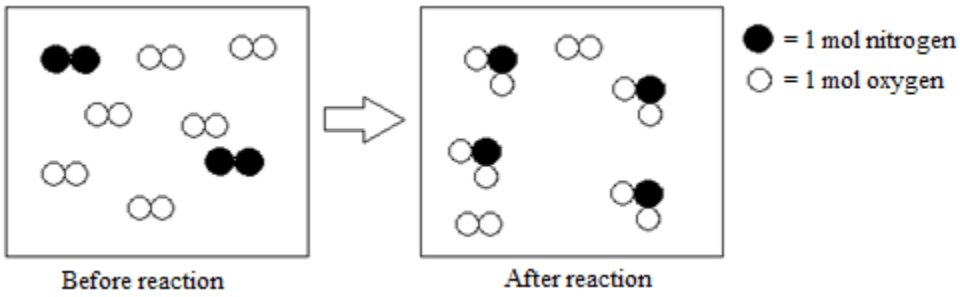
8. Select the correct **<u>net ionic</u>** equation for this reaction.

a. $Ca^{+2}(aq) + Cl^{-}(aq) \rightarrow CaCl_2(s)$
b. $Ca^{+2}(aq) + 2Cl^{-}(aq) \rightarrow CaCl_2(s)$
c. $Ca^{+2}(aq) + 2Cl^{-}(aq) + 2OH^{-}(aq) + 2H^{+}(aq) \rightarrow 2H_2O(l) + CaCl_2(s)$
d. <u>$H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O(l)$</u>
e. $H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O(s)$

9. 3.00 M of 2.00 M calcium hydroxide neutralizes (exactly reacts with) 2.00 L of aqueous hydrochloric acid. What is the concentration of the hydrochloric acid solution?
a. 0.375 M
b. 0.750 M
c. 1.50 M
d. 3.00 M
e. <u>6.00 M</u>

10. After the reaction that occurred in question #9 between calcium hydroxide and aqueous hydrochloric acid, which ions are still present <u>in the solution</u>?
a. Calcium, chloride, and hydrogen ions
b. <u>Calcium and chloride ions</u>
c. Hydrogen and hydroxide ions
d. Hydroxide ions only
e. Hydrogen ions only

Nitrogen gas and oxygen gas react in a rigid, sealed container at constant temperature. The diagrams below represent the substances present in the container before and after the reaction. Use these diagrams to answer the next two questions.



11. What is the reaction that took place in this container? Assume that all substances are in the gas phase and be sure the reactions balanced in standard form.
    - **a. $\underline{N_2 + 2O_2 \rightarrow 2NO_2}$**
    - b. $N + 2O \rightarrow NO_2$
    - c. $N_2 + O_2 \rightarrow 2NO$
    - d. $N_2 + 3O_2 \rightarrow 2NO + O_2$
    - e. $2N_2 + 6O_2 \rightarrow 4NO_2 + 2O_2$

12. Does the pressure increase, decrease, or remain constant after the reaction? Choose the best answer and reasoning.
    - a. *Increase*: The product particles have a greater molar mass than the reactant particles. These have harder collisions with the container walls, increasing the pressure.
    - b. *Remain constant:* The temperature does not change so the particles do not move faster or slower.
    - c. *Remain constant:* Mass is conserved so there are the same number of atoms before and after the reaction which keeps the pressure constant.
    - d. *Decrease:* The particles in the container hit the walls less forcefully which decreases the pressure.
    - **e. <u>*Decrease:* Fewer moles of gas particle are present in the container after the reaction so there are fewer particle collisions.</u>**

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). Use this reaction to answer the next three questions.

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

13. If 200.0 mL of 1.00 M sulfuric acid reacted with sufficient baking soda, what volume of carbon dioxide gas formed? Assume this reaction occurs at 25.0°C and 1.0 atm.
    a. 0.103 L
    b. 0.410 L
    c. 0.821 L
    d. 4.89 L
    e. <u>9.78 L</u>

14. In balloon 1, you react 0.100 moles of baking soda with 200.0 mL of 1.00 M sulfuric acid and it inflates the balloon. How many moles of CO_2 were produced?
    a. 0.0500
    b. <u>0.100</u>
    c. 0.150
    d. 0.200
    e. 0.250

15. In balloon 2, you react 0.100 moles baking soda with 400.0 mL of 1.00 M sulfuric acid. How does the size of balloon 2 compare to the size of balloon 1? Assume the balloons are full of carbon dioxide.
    a. Balloon 2 will be twice as large as balloon 1.
    b. Balloon 2 will be larger than balloon 1 but less than twice as large.
    c. <u>Both balloons will inflate to the same size.</u>
    d. Balloon 1 will be larger than balloon 2 but less than twice as large.
    e. Balloon 1 will be twice as large as balloon 2.

Part 2: Free Response

16. Consider the balanced equation below between ammonia gas (NH_3) and oxygen gas to form nitrogen gas and water. Use it to answer the questions below. Please show all work below your answers.

$$4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$$

+4 points total

a. Twelve moles of ammonia react with twelve moles of oxygen gas. How many moles of nitrogen gas form, and how many moles of excess reactant are left over? Show your work in the space below, including identifying the limiting reactant. Write your answers in the boxes provided.

	$4NH_3(g)$	$+ 3O_2(g)$	$\rightarrow 2N_2(g)$	$+ 6H_2O(g)$
B	12	12	0	0
C	-12	-9	+6	+18
A	0	3	6	18

+1 work

+1 each box, continuation credit possible

Moles nitrogen gas formed	Moles excess reactant leftover	Limiting reactant
6 moles nitrogen	**3 moles oxygen**	**Ammonia (NH_3)**

In another situation, **before** the reaction, an otherwise empty container holds 204.0 g ammonia gas and some mass of oxygen gas. These react via the same equation. **After** this reaction 112.0 of grams nitrogen gas are present in the container.

+4 points total

b. What mass of water also formed along with 112.0 grams of nitrogen gas? Show all work below.

$$112.0\ g\ N_2 \times \frac{1\ mol\ N_2}{28.0\ g\ N_2} \times \frac{6\ mol\ H_2O}{2\ mol\ N_2} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = \mathbf{216.2\ g\ H_2O}$$

+1 +1 ratio or BCA table +1 +1

+4 points total

c. Was ammonia a limiting or excess reactant in this process? Show work and explain.

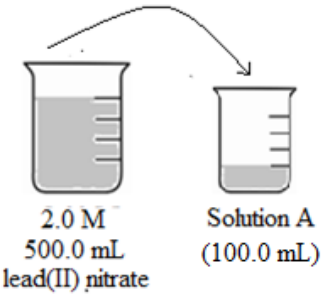
+1 **Ammonia was an excess reactant. There are multiple ways to solve this one but one of them is shown below. You can also do this using a BCA table or demonstrate that fewer than 204 grams of NH_3 are required to produce 112.0 g N_2. In my work below, 204.0 grams ammonia will produce more than 112.0 grams of nitrogen gas if it is limiting, so that means the other reactant must have been limiting.**

+2 explain

+1 work

$$204.0\ g\ NH_3 \times \frac{1\ mol\ NH_3}{17.01\ g\ NH_3} \times \frac{2\ mol\ N_2}{4\ mol\ NH_3} \times \frac{28.0\ g}{1\ mol\ N_2} = \mathbf{167.9\ g\ N_2}$$

17. A stock solution consists of 500. mL of 2.00 M aqueous lead(II) nitrate. 100.0 mL of this solution is poured into a new beaker. This new beaker is labeled solution A.



a. How does concentration and number of moles of solute of solution A compare to the concentration of the stock solution? Write "greater than", "less than", or "equal to" in the spaces below, and then explain your answers for both blanks in the space below.

+3 points total

+0.5 each blank

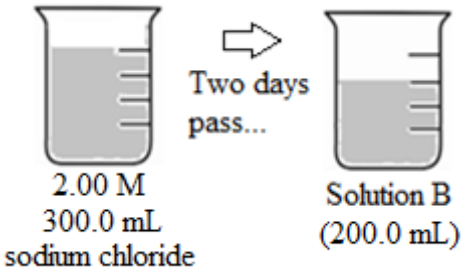
- ***The concentration of solution A is __equal to__ the concentration of the stock solution.***
- ***The number of moles of solute in solution A is __less than__ the number of moles of solute in the stock solution.***

+1 concentration explanation

The concentration of the solution does not change when it is poured into the smaller container; there is the same moles solute/ total volume ratio in terms of overall concentration) so solution A also has a concentration of 2.0 M. However, the volume of solution A is lower than the stock solution, so the moles of solution A must be lower proportionally. (They could also solve it out mathematically and then explain if they want.)

+1 moles solute explanation

Another stock solution consists of 300.0 mL of 2.00 M aqueous sodium chloride which is labeled solution B. This solution is left on the table untouched for two days. After the two days have passed, the volume of the solution is now 200.0 mL.



+3 points total

b. How do the concentration and number of moles of solute in solution B after two days passed compare to the concentration of solution B at the beginning? Write "higher", "lower", or "the same" in the space below, and then explain your answers for both blanks in the spaces below.

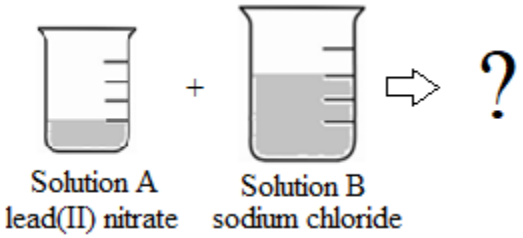
+0.5 each blank

- ***The concentration of solution B is __higher__ after the two days have passed.***
- ***The number of moles of solute in solution B is __the same__ after the two days have passed.***

+1 concentration explanation

The volume of the solute in the solution decreases because water evaporates. This increases the overall concentration. (Using M= mol/L, we can see that a decrease in the volume of the solution results in a higher molarity.) The moles of solute in the solution remain the same because no sodium chloride is added or removed (i.e. the loss of water does not affect the amount of NaCl present because it does not evaporate likes the water does.)

+1 moles solute explanation



+12 points total

Solution A, consisting of lead(II) nitrate, and solution B, consisting of sodium chloride are poured together. A precipitate forms.

c. Give the molecular, complete ionic, and net ionic equations for this combination of substances. Include all phases as well as ion charges where applicable:

Molecular:

$Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$

+1 reactant formulas
+1 product formulas
+1 phases
+1 balance

Complete:

$Pb^{+2}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s) + 2Na^+(aq) + 2NO_3^-(aq)$

+1 correctly separate aqueous reactants
+1 correctly separate aqueous products
+1 solid stays together
+1 ion charges shown correctly
+1 balanced overall

Net ionic:

$Pb^{+2}(aq)\ 2Cl^-(aq) \rightarrow PbCl_2(s)$

+1 no spectator ions from complete ionic
+1 ion charges shown correctly
+1 balanced overall

STOP. You have reached the end of the exam. Nothing written after this page will be graded