CHEMISTRY 101
Hour Exam II
October 26, 2021
Leveritt/McCarren

Name ___KEY___

Signature ______________________

Section ______________________

"Success is liking yourself, liking what you do, and liking how you do it." – Maya Angelou

Please be sure to answer all questions on the exam. The first 15 questions are multiple choice questions. The remaining questions consist of two separate larger problems divided up into parts that link together. You may need to explain, calculate, or show work for answers.

Useful Information:

1 L = 1000 mL (exactly)

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

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

$K = °C + 273$ $\quad$ $N_A = 6.022 \times 10^{23} = 1$ 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 of the following is **true** about the coefficients in a balanced equation?

   Coefficients tell us….

   a. the number and type of atoms that make up a substance.
   b. **how many moles of one substance react with a certain amount of the other substances.**
   c. how many moles of each reactant are present in the container and available to use.
   d. how many total atoms of each type are present on each side of the reaction.
   e. the number of products that are in the container once the reaction happens.

2. Hexene (C_6H_{12}) reacts with oxygen gas to form carbon dioxide and water. What is the sum of coefficients when this reaction has been balanced in standard form?
   a. 10
   b. 21
   c. **22**
   d. 24
   e. 44

Consider the reaction occurring when potassium chlorate decomposes to form potassium chloride and oxygen gas according to the balanced equation below.

$$2KClO_3(s) \rightarrow 2KCl(aq) + 3O_2(g)$$

3. If 4.50 moles of oxygen gas were formed as a result of this reaction, how many moles of potassium chloride were also formed?
   a. 2.00 moles
   b. **3.00 moles**
   c. 4.50 moles
   d. 6.75 moles
   e. 7.00 moles

4. What **mass** of potassium chlorate decomposed to form 4.50 moles of oxygen gas? (Molar mass potassium chlorate = 122.55 g/mol)
   a. 3.00 g
   b. 245 g
   c. **368 g**
   d. 558 g
   e. 827 g

5. Aluminum metal and oxygen gas react to form solid aluminum oxide according to the balanced equation below.

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

What mass of aluminum oxide (molar mass = 101.92 g/mol) is formed when 67.45 grams of solid aluminum react? Assume there is sufficient oxygen for the complete reaction to occur.

a. 1.250 grams aluminum oxide
b. 2.500 grams aluminum oxide
c. 63.75 grams aluminum oxide
d. **127.5 grams aluminum oxide**
e. 255.0 grams aluminum oxide

6. **Equal masses** of unknown substances "A" and "B" react to form substances "C" and "D" according to the hypothetical balanced equation below.

$$A + 3B \rightarrow 2C + D$$

In which case below **must** A be the limiting reactant?

a. Both A and B have the same molar mass.
b. The molar mass of A is double the molar mass of B.
c. The molar mass of B is double the molar mass of A.
d. The molar mass of B is four times greater than the molar mass of A.
e. **The molar mass of A is four times greater than the molar mass of B.**

7. **Equal mole** samples of unknown element "X" and chlorine gas react to form some product, either XCl or XCl_2.

Option 1	Option 2
$2X(s) + Cl_2(g) \rightarrow 2XCl$	$X(s) + Cl_2(g) \rightarrow XCl_2$

After the reaction, there is some chlorine gas leftover. Which product formed? Choose the best answer *and* explanation.

a. ***XCl:* In option 1, twice as many moles X are used for each mole chlorine gas so chlorine gas is leftover.**
b. ***XCl:*** In option 1, the product has one X and one Cl per molecule, so there is an extra chlorine atom on the left.
c. ***XCl_2****:* In option 2, twice as many atoms chlorine are used for each mole X, so chlorine is left over.
d. ***XCl_2:*** In option 2, one mole X is used for each mole chlorine gas, resulting in both being consumed at the same speed.
e. ***Either XCl or XCl_2*****:** It depends on the exact number of equal moles that were used.

8. Water and potassium nitrate are the products of a strong acid-strong base reaction. What were the reactants?

_____ + ______ $\rightarrow KNO_3(aq) + H_2O(l)$

a. KOH and HNO_2
b. K_2OH and HNO_3
c. K_2O and HNO_2
d. K_2O and HNO_2
e. KOH and HNO_3

9. What is the concentration of 10.0 g NaCl dissolved in enough water to make a 200.0 mL solution?

a. 0.0500 M
b. 0.171 M
c. 0.500 M
d. 0.855 M
e. 50.0 M

10. You add water to 40.0 mL of a 0.150 M Na_2SO_4 solution. Do the moles of Na_2SO_4 solute and the concentration increase, decrease, or remain constant after adding the water?

	Moles solute (mol)	**Concentration (M)**
a.	Decrease	Remain constant
b.	**Remain constant**	**Decrease**
c.	Decrease	Decrease
d.	Increase	Increase
e.	Remain constant	Increase

11. Recall the observations you made in lab in which you saw several aqueous solutions being mixed in a well plate. In a similar scenario, you combine an aqueous sample of calcium nitrate and iron(III) nitrate with aqueous samples of potassium chloride and sodium sulfate as shown in the table below.

	KCl	Na_2SO_4
$Ca(NO_3)_2$		
$Fe(NO_3)_3$		

How many precipitates were formed as a result of these combinations of reactants?

a. 0 (no precipitates were formed)
b. **1**
c. 2
d. 3
e. 4 (All four combinations formed precipitates.)

12. Using the following balanced chemical equation, what will be the partial pressure of the ozone gas (O_3) **after** the reaction if you initially reacted 5.0 moles of water and 10.0 moles of O_3? Assume the reaction is occurring in a rigid container at constant temperature, and the initial pressure of the ozone was 1.0 atmosphere.

$$H_2O(l) + O_3(g) \rightarrow H_2(g) + 2O_2(g)$$

a. 0 atm
b. 1.0 atm
c. 2.0 atm
d. 1.5 atm
e. 0.5 atm

13. Silver nitrate reacts with sodium chromate to form a precipitate according to the balanced molecular equation below:

$$2AgNO_3(aq) + Na_2CrO_4(aq) \rightarrow Ag_2CrO_4(s) + 2NaNO_3(aq)$$

If 3.32 grams of silver chromate (molar mass = 331.7 g/mol) is formed as a result of this reaction, what volume of 0.500 M silver nitrate was required to react?

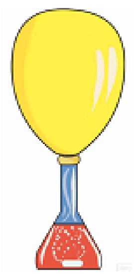
a. 20.0 mL
b. 25.0 mL
c. **40.0 mL**
d. 100.0 mL
e. 400.0 mL

Recall the lab experiment in which you observed several balloons inflating after reacting two different acids with sodium bicarbonate (baking soda).

14. One of the reactions occurred between baking soda and sulfuric acid 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 series of three balloons each full of carbon dioxide.



Trial	**Moles H_2SO_4**	**Moles $NaHCO_3$**	**Moles CO_2 produced**
1	0.400	0.300	?
2	0.300	0.400	?
3	0.200	0.500	?

How should the sizes of the balloons inflated in each of trials #1-3 compare to each other?

a. **Balloon 3 = Balloon 2 > Balloon 1**
b. Balloon 3 = Balloon 2 = Balloon 1
c. Balloon 3 > Balloon 2 > Balloon 1
d. Balloon 3 > Balloon 2 = Balloon 1
e. Balloon 2 > Balloon 1 = Balloon 3

15. In a separate scenario, you wish to react a combination of sulfuric acid and baking soda to make a larger balloon under STP conditions (1 atm and 273 K). Which of the following four combinations would result in a balloon that contains a volume of 17.92 L carbon dioxide? Select all that apply.

I. Using 0.400 moles H_2SO_4 and 0.600 moles of $NaHCO_3$.
II. Using 0.400 moles H_2SO_4 and 0.800 moles of $NaHCO_3$.
III. Using 0.400 moles H_2SO_4 and 0.900 moles of $NaHCO_3$
IV. Using 0.800 moles H_2SO_4 and 0.800 moles of $NaHCO_3$

a. Options I and II
b. Options II and IV
c. Options I, II, and III
d. Options II, III, and IV
e. All four options I-IV would generate the same volume.

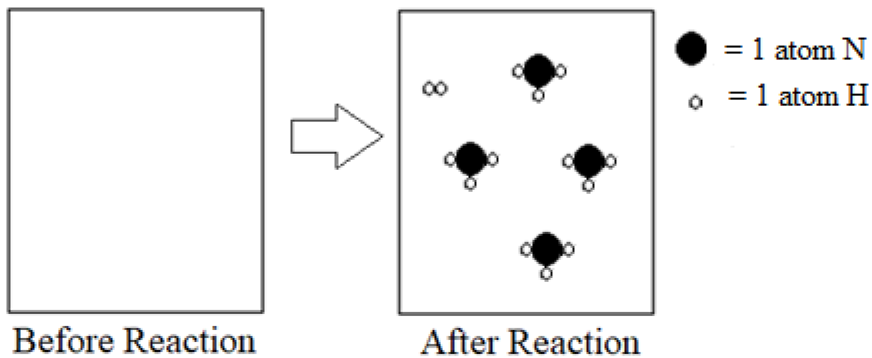
Part 2: Free Response

Part A:

Several molecules of nitrogen and hydrogen gases were mixed in a rigid steel container to form ammonia gas according to the balanced equation below.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The diagram below represents the contents of the container *after* the reaction.



16. How many molecules of nitrogen gas, hydrogen gas, and ammonia are present **before** the reaction? Fill in the table below in **molecules**. If a substance is not present, please enter a zero as your answer.

+4.5

(1.5 points each)

	Molecules present in container **before** reaction
Nitrogen gas	**2.0**
Hydrogen gas	**7.0**
Ammonia gas	**0**

17. How do the total number of nitrogen and hydrogen **atoms** in the container after the reaction compare to the number of atoms in the container before the reaction?

+0.5

- The total number of atoms nitrogen in the container is **the same** after the reaction compared to before the reaction.

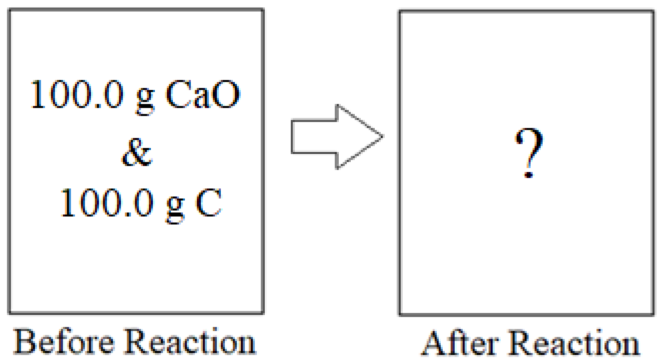
+0.5

- The total number of atoms hydrogen in the container is **the same** after the reaction compared to before the reaction.

Part B

100 grams each of pure solid carbon and solid calcium oxide were mixed in a separate rigid steel container as shown below. The reaction results in the production of solid calcium carbide and carbon dioxide gas. Assume the reaction occurred at constant temperature.

$$2CaO(s) + 5C(s) \rightarrow 2CaC_2(s) + CO_2(g)$$



100.0 grams calcium oxide react with 100.0 grams carbon as shown in the diagram above.

18. What is present in the container after the reaction? Fill in the table below, giving masses of substances present in **grams** to two decimal places. If a substance is not present, please enter zero as your answer.

+6 (1.5 each)

	CaO (grams)	C (grams)	CaC_2 (grams)	CO_2 (grams)
Before	100.0 g	100.0 g	0	0
After	**0 grams**	**46.46 grams**	**114.30 grams**	**39.24 grams**

19. How does the mass of all substances in the container after the reaction compare to the mass of all substances in the container before the reaction?

+1

The total mass of all substances in the container is **the same** after the reaction compared to before the reaction.

20. Explain the answer you gave for the question above. Has mass been conserved in this reaction? State whether or not mass has been conserved, explain why or why not using words, and give specific numerical evidence from the table you completed above that indicates this.

+1

Yes, mass has been conserved in this reaction.

+1

We know this because the total mass of substances before the reaction is equal to 200.0 g total and the total mass of substances after the reaction is equal to 200.0 g total.

Numerical evidence:

+1

Before the reaction:

100.0 g CaO + 100.0 g C = 200.0 g total

After the reaction(approximate):

46.47 g C + 114.29 g CaC_2 + 39.23 g CO_2 $\approx$ 200.0 g total

A solution of $X(NO_3)_2$, containing unknown element "X", and potassium hydroxide to form a precipitate according to the balanced molecular equation below.

$$X(NO_3)_2(aq) + 2KOH(aq) \rightarrow X(OH)_2(s) + 2KNO_3(aq)$$

21. The net ionic equation for this reaction is

$$X^{+2}(aq) + 2OH^{-}(aq) \rightarrow X(OH)_2(s)$$

Explain how this net ionic equation comes from the molecular equation. Your answer should include:

- How a net ionic equation is different from a molecular equation
- What a spectator ion is, and how to identify those in a molecular equation
- Which ions are included in this net ionic equation and why, and which ions are not and why

+1 The molecular equation gives the identity of all of the reactants and products, and the net ionic equation only shows what is actually participating in the reaction.

+1 A spectator ion is an ion that is present in the solution but doesn't actually participate in the reaction.

+1 In this case, the nitrate and potassium ions are spectator ions because they are aqueous on both the right and left side of the molecular equation, so they are not included in the net ionic equation because they do not participate in the reaction.

+1 The X^{+2} and OH^{-} ions are included in the net ionic equation because they do participate in the reaction (i.e. they change from aqueous to solid from the reactants to the products).

The 200.0 mL of $X(NO_3)_2$ reacted completely with the 100.0 mL 0.100 M KOH. After these were mixed, 0.497 grams of $X(OH)_2$ precipitate were formed.

22. What was the concentration of the **potassium ion** after the two solutions were mixed?

0.033 M K^+ +2

23. Show work below, clearly displaying all steps.

+1

Find moles of KOH and also K+ ion.

0.100 M KOH = x mol KOH/0.100 L

x = 0.0100 mol KOH = **0.0100 mol K+ present**

Find (or show) total volume in calculation.

+1

0.100 L + 0.200 L = **0.300 L**

Show a calculation for the concentration.

+1

0.0100 mol K+/0.300 L = **0.033 M K+**

24. What is the identity of X? **Zinc** +1.5

25. Show work below, clearly displaying all steps.

Show, find, or use moles of KOH present initially:

+1 0.100 M KOH = x mol KOH/0.100 L

x = **0.0100 mol KOH**

Find moles $X(OH)_2$ formed.:

+1 0.0100 mol KOHx(1 mol $X(OH)_2$/2 mol KOH) = **0.00500 mol $X(OH)_2$**

Find molar mass $X(OH)_2$:

+1 0.445 g $X(OH)_2$/0.00500 mol $X(OH)_2$ = **99.40 g/mol $X(OH)_2$**

Subtract to find molar mass of just X

+1 99.40 g/mol – (2)16.0 g/mol O – (2)1.008 g/mol H = **<u>65.38 g/mol = Zn</u>**