## CHEMISTRY 101 Name \_\_\_\_\_\_\_\_\_\_\_\_KEY\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hour Exam II

October 25, 2022 Signature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

McCarren

 Section \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***"Never be afraid to try something new because life gets boring when you stay within the limits of what you already know." ~*Anonymous**

This exam contains 26 questions. The first 15 questions are multiple choice, and the remaining questions may be numerical entry, free response, or drop down questions. Please be sure to answer all questions before submitting the exam. A periodic table is attached to this equation sheet and you may also use it as scratch paper.

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 NA = 6.022 × 1023 = 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. Consider the following unbalanced chemical reaction. What is the sum of coefficients when the reaction is balanced in standard form?

**Cl2 + NaOH 🡪 NaCl + NaClO + H2O**

* 1. 5
	2. **6**
	3. 10
	4. 12
	5. 15
1. How do the number of atoms and molecules on the left and right side of a balanced equation compare? Select the best answer that completes both blanks below.

***The number of atoms on the left and right side of a balanced equation \_\_\_\_\_\_\_\_\_, and the number of molecules on the left and right side of a balanced equation \_\_\_\_\_\_\_\_\_.***

* 1. Need to be equal; need to be equal
	2. **Need to be equal; do not need to be equal**
	3. Do not need to be equal; need to be equal
	4. Do not need to be equal; do not need to be equal
	5. Are not ever equal; are always equal

Combustion reactions between hydrocarbons (compounds containing only carbon and hydrogen) and oxygen are very common in car engines. Write the balanced combustion equation for the reaction between propane (C3H8) and oxygen gas to form carbon dioxide and water and use it to answer the questions below.

1. If 8.0 **moles** of water vapor form, how many moles of carbon dioxide gas were also formed?
	1. 3.0 moles
	2. 4.0 moles
	3. **6.0 moles**
	4. 8.0 moles
	5. 10. moles
2. If 22.0 **grams** of carbon dioxide gas form, how many moles of propane gas were required to react?
	1. **0.167 moles**
	2. 1.50 moles
	3. 7.33 moles
	4. 66.0 moles
	5. 323 moles

Consider the reaction between nitrogen gas and hydrogen gas shown below:

**N2(g) + 3H2(g) 🡪2NH3(g)**

Suppose six moles of nitrogen gas and six moles of hydrogen gas react to form ammonia gas in a flexible balloon as shown below. Assume that the balloon does not pop after the reaction.

Use this information to answer the next three questions.

1. How many moles of ammonia are present in the container **after** the reaction?
	1. 0 (There is no ammonia present.)
	2. 2
	3. **4**
	4. 6
	5. 12
2. How many moles of nitrogen gas are present in the container after the reaction?
3. 0 (Zero moles of nitrogen gas are present.)
4. 2
5. **4**
6. 6
7. 12
8. If the volume of the container before the reaction is V, what is the volume of the container after the reaction?
9. 2V
10. V
11. **2/3V**
12. 1/2V
13. 1/3V
14. Elements A and B react to form product AB in the balanced equation shown below:

A + B 🡪 AB

50.0 grams A are mixed with 200.0 grams B. 100. grams AB product forms. If A is the limiting reactant, how many grams B are remaining?

1. 0 grams (Both A and B are completely consumed.)
2. 50.0 grams
3. 100.0 grams
4. **150.0 grams**
5. 200.0 grams
6. 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? Use the solubility rules on the equation sheet to help.

|  |  |  |
| --- | --- | --- |
|  | **barium nitrate** | **lead(II) nitrate** |
| **sodium sulfate** |  |  |
| **sodium chloride** |  |  |

1. 0 (No precipitates are formed.)
2. 1
3. 2
4. **3**
5. 4 (All four combinations form a precipitate.)
6. Aqueous iron(III) chloride and aqueous sodium carbonate are combined and a precipitate forms. What is the net ionic equation for this process?
	1. Na+(aq) + Cl-(aq) 🡪 NaCl(s)
	2. 3Fe+3(aq) + CO3-2(aq) 🡪 Fe3CO3(s)
	3. Fe+3(aq) + CO3-3(aq) 🡪 FeCO3(s)
	4. Fe+3(aq) + CO3-2(aq) 🡪 FeCO3(s)
	5. **2Fe+3(aq) + 3CO3-2(aq) 🡪 Fe2(CO3)3(s)**
7. Sodium hydroxide reacts with sulfuric acid (H2SO4) to form water in a neutralization reaction as shown below.

**2NaOH(aq) + H2SO4(aq) 🡪 2H2O(l) + Na2SO4(aq)**

50.0 mL of 0.250 M NaOH is added to 0.100 M H2SO4. What volume of the sulfuric acid solution is needed to completely react with (neutralize) the NaOH?

1. 6.25 mL
2. 12.5 mL
3. **62.5 mL**
4. 125 mL
5. 250. mL

Consider the reaction we saw in lecture between sodium iodide and lead(II) nitrate to form a yellow lead(II) iodide precipitate. The balanced equation is shown below.

**2NaI(aq) + Pb(NO3)2(aq) 🡪 PbI2(s) + 2NaNO3(aq)**

1.00 L of a 1.00 M solution of sodium iodide is mixed with 1.00 L of a 1.00 M solution of lead(II) nitrate.

1. **Before** these two solutions are mixed, which ion does **not** have a concentration of

1.00 M?

* 1. All of the ions have concentrations of 1.00 M.
	2. Sodium ion
	3. Iodide ion
	4. Lead(II) ion
	5. **Nitrate ion**
1. What is the concentration of the lead(II) ion after the reaction?
	1. **0**
	2. 0.125 M
	3. **0.250 M**
	4. 0.500 M
	5. 1.00 M

***Please go on to the next page.***

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 according to the balanced equation below.

H2SO4(aq) + 2NaHCO3(s) 🡪 2H2O(l) + 2CO2(g) + Na2SO4(aq)

In the table below, the H2SO4 reacted with baking soda to inflate a series of three balloons each full of carbon dioxide. Use this information to answer questions 14 and 15.

|  |  |  |  |
| --- | --- | --- | --- |
| **Trial** | **Moles H2SO4** | **Moles NaHCO3** | **Moles CO2 produced** |
| 1 | 0.100 | 0.300 | ? |
| 2 | 0.300 | 0.400 | ? |
| 3 | 0.200 | ? | ? |

1. The reaction in trial #1 took place at 0.900 atm and 25.0°C. What volume of carbon dioxide was produced?
2. 8.15 L
3. **5.43 L**
4. 2.71 L
5. 0.300 L
6. 0.200 L
7. The reaction occurred and the balloons inflated so **that balloons 2 and 3 were the same size**. What is possible about the moles of baking soda used in trial #3? Select all possible true statements.
	1. In trial #3, exactly 0.400 moles of baking soda could have been used.
	2. In trial #3, less than 0.400 moles of baking soda could have been used.
	3. In trial #3, more than 0.400 moles of baking soda could have been used.
8. I only
9. II only
10. II and III
11. I and II
12. **I and III**

***Please go on to the next page.***

**Part 2: Free Response**

You have 500.0 mL of a solution of 3.00 M calcium chloride. This is solution A. Use this solution to answer the next several questions.

1. How many moles of calcium chloride solute are present in solution A?

**+1**

**1.5 moles**

You add solid calcium chloride to the original 500.0 mL of 3.00 M solution A. The calcium chloride dissolves.

1. Do the concentration and moles of solute in the solution increase, decreases, or remain the same after adding the calcium chloride? Assume that adding the solid does not change the volume of the solution.

**+1**

* ***The moles of solute in solution A* increase *after adding the calcium chloride.***
* ***The concentration of solution A* increases *after adding the calcium chloride.***
1. Explain your answer to both parts of question #17.

**+2 total**

**Using the molarity equation, increasing the mass of calcium chloride increases the moles of solute. This means that the overall molarity increases because the total volume of the solution has not changed. (M = mol/L.)**

**+1**

**+1**

1. Assume 100.0 grams calcium chloride were added to solution A. Give the concentration of the new solution after adding the solid calcium chloride. If the concentration has not changed, enter the same concentration as the original solution A. **4.80 M**

**+1**

1. Show your work for #19 in the space below.

**+1**

**+3 total**

$$100.0 g CaCl\_{2}×\frac{1 mol CaCl\_{2}}{110.98 g CaCl\_{2}}=0.901 mol CaCl\_{2}$$

****

**+1**

$$\frac{1.50 mol+0.901 mol}{0.500 L }=\frac{1.50 mol+0.901 mol}{0.500 L}=\frac{2.401 mol}{0.500 L}=4.80 M$$

**+1**

***Please go on to the next page.***

You mix 500.0 mL of another 3.00 M calcium chloride solution with the original 500.0 mL of 3.00 M solution A.

1. Are the moles of solute and concentration of the new solution greater than, less than, or equal to the concentration of the original solution A?
* ***The moles of solute in the new solution are* greater than *the moles of solute in solution A.***

**+1**

* ***The concentration of the new solution is* equal to *the concentration of the original solution A.***
1. Explain your answer and show your work to both parts of question #21.

**There are more moles of solute because we have added another solution to the initial solution – i.e. more calcium chloride particles in the container. However, the overall concentration remains the same because we are simply mixing two solutions with the same concentration. Therefore, the original solution was 3.00 M and we are adding a solution that is 3.00 M, so the concentration is still 3.00 M.**

**+1**

**+1**

**+3 total**

**Both solutions have 1.50 moles solute.**

**+1**

$$M=\frac{mol}{L }=\frac{1.50 mol+1.50 mol}{.500 L+0.500 L}=\frac{3.00 mol}{1.00 L}=3.00 M$$

1. Give the concentration of the new solution that results from the mixing. If the concentration has not changed, enter the same concentration as the original solution A.

3.00 M

**+1**

***Please go on to the next page.***

Consider the balanced equation below between ammonia gas (NH3) and oxygen gas to form nitrogen gas and water. Use it to answer the questions below.

**4NH3(g) + 3O2(g)  2N2(g) + 6H2O(g)**

1. – 27. 34.0 grams of ammonia react with 64.0 grams of oxygen gas. What **mass** of water forms, what **mass** of nitrogen gas forms, and what mass of excess reactant is leftover **after** the reaction? Give your answers in the boxes below to two decimal places. If a substance is not present after the reaction, please put a “0” as your answer.

**+6 total**

(Molar masses which may be helpful: NH3: 17.01 g/mol, O2: 32.00 g/mol, N2: 28.00 g/mol, H2O: 18.02 g/mol)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **NH3** | **O2** | **N2** | **H2O** |
| Mass before | 34.0 g | 64.0 g | 0 | 0 |
| Mass after | **0** | **16.0 g** | **28.0 g** |  **54.0 g** |

28. – 32. In another situation, an otherwise empty container holds only ammonia and oxygen gas

which react via the same equation shown below.

**4NH3(g) + 3O2(g)  2N2(g) + 6H2O(g)**

**After** this reaction, the container holds 70.0 grams of nitrogen gas, 17.0 grams of ammonia gas, and some mass of water. Fill in the table below to show the **masses** of all substances present in the container both **before** and after the reaction. If a substance is not present before or after the reaction, you can put “0” in the box.

**+5 total**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **NH3** | **O2** | **N2** | **H2O** |
| Mass before | **102 g** | **120 g** | **0** | **0** |
| Mass after | 17.0 g | 0 | 1. g
 | **135 g** |

1. Show your work for #29-33 in the space below. You should include calculations and/or explanations as needed for determining the mass of each of the substances for the five questions. A BCA table will go a long way in showing your work!

Please include any grams to moles calculations and be sure to show how mole ratios and/or BCA tables were used in solving the problem. Note that if a substance is not present before or after the reaction, please explain how you know.

* **Nitrogen and water are not present before the reaction because the problem says that before the reaction, the container holds only ammonia and oxygen. See the BCA table below for the rest.**

**+1**

**(moles after)**

**+1**

**(zeros)**

**+5 total**

**17.0 g NH3\* (1 mol NH3/17.01 g NH3) = 1.00 mole NH3.**

**70.0 g N2\*(1 mol N2/28.00 g N2) = 2.5 mol N2.**

**4NH3(g) + 3O2(g) 🡪 2N2(g) + 6H2O(g)**

**B 6 3.75 0 0**

**+1 (ratio)**

**C -5 -3.75 +2.5 +7.5**

****A 1 0 2.5 7.5**

* **6 moles of ammonia are present before the reaction (see BCA table.) 6 mol NH3\*17.01 g NH3/1 mol NH3 = 102.1 g NH3.**

**+1 (moles before)**

* **3.75 moles oxygen are present before the reaction.**

**+1**

**(moles water after)**

 **3.75 moles O2\*(32.0 g O2/1 mol O2) = 120. g oxygen.**

* **7.5 moles water are present after the reaction.**
	1. **moles H2O\*(18.02 g H2O/1 mol H2O) = 135.15 g water.**