CHEMISTRY 101
Hour Exam II
October 29, 2019
Leveritt/McCarren

Name ___________KEY_________________

Signature ______________________________

Section ________________________________

Q: What do mummies like listening to on halloween?

A: Wrap!

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	(15 pts.)	__________
17	(15 pts.)	__________
Total	(60 pts.)	__________

Useful Information:

1 L = 1000 mL (exactly)

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

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

$K = °C + 273$ $\quad\quad$ $N_A = 6.022 \times 10^{23} = 1$ 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. Ethane (C_2H_6) reacts with oxygen gas to produce carbon dioxide and water according to the unbalanced equation below.

$$C_2H_6(g) + \quad O_2(g) \rightarrow CO_2(g) + \; H_2O(g)$$

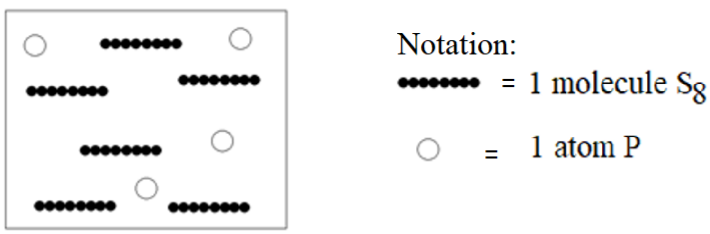
What is the sum of coefficients in this equation when it has been balanced in standard form?

a. 4 b. 8 c. 9 d. 9.5 e. **<u>19</u>**

Consider the balanced equation below where an atom of phosphorus reacts with a molecule of sulfur (S_8) to form a compound of P_2S_3.

$$16P + \quad 3S_8 \rightarrow \; 8P_2S_3$$

2. A container holds some of both of the reactants as shown below where the particles represent molecules of sulfur and atoms of phosphorus.



How many atoms of phosphorus need to be **<u>added</u>** to this container so that both of the reactants are completely consumed when the reaction occurs? (This would mean that there is no limiting reactant.)

a. 4 atoms
b. 8 atoms
c. 16 atoms
d. <u>28 atoms</u>
e. 32 atoms

3. Now that we have added phosphorus such that both sulfur and phosphorus are totally used up, how many P_2S_3 molecules could be formed as a result of this reaction?

a. 1 molecule
b. 2 molecules
c. 8 molecules
d. <u>16 molecules</u>
e. 32 molecules

Ammonia (NH_3) is able to react with oxygen gas to form nitrogen dioxide gas and water vapor according to the balanced equation below. Use this equation to answer the next several questions.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO_2(g) + 6H_2O(g)$$

4. If eight moles of nitrogen dioxide gas were formed in this reaction, how many moles of water were also formed?
   a. 4.00 moles
   b. 6.00 moles
   c. 8.00 moles
   d. <u>12.00 moles</u>
   e. 16.00 moles

5. 14.00 moles of ammonia and 15.00 moles of oxygen were reacted. How many moles of excess reactant were left over after the reaction?

   a. 1.00 moles
   b. <u>2.00 moles</u>
   c. 3.00 moles
   d. 4.00 moles
   e. 6.00 moles

6. If 100.0 **<u>grams</u>** of ammonia reacted with excess oxygen, what **<u>mass</u>** of water formed?
   a. 5.89 grams
   b. 8.82 grams
   c. <u>159 grams</u>
   d. 257 grams
   e. 953 grams

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7. The generation of sulfur trioxide is a key reaction needed to produce sulfuric acid in large quantities. One potential reaction is shown below.

$$2SO_2(s) + O_2(g) \rightarrow 2SO_3(g)$$

If the reaction consumed 3.90 moles of oxygen gas, what would be the volume of the sulfur trioxide produced gas at STP?

   a. 1.00 L
   b. 5.74 L
   c. 22.4 L
   d. 87.4 L
   e. **<u>174.7 L</u>**

The table below which represents combinations of aqueous solutions similar to those which you observed in the precipitation reactions video. Use this table and information about solubility rules to answer the next three questions.

	Sodium chloride	**Sodium sulfate**	**Sodium sulfide**
Unknown solution	No reaction	Precipitate	Precipitate

8. The table above shows which substances formed precipitates when combined with an unknown solution. What is the identity of the unknown solution? (Hint: check the solubility rules on the cover page!)

    a. Lead(II) nitrate
    b. Barium nitrate
    c. Potassium nitrate
    d. Copper(II) nitrate
    e. Sodium phosphate

9. According to the "Precipitation Reactions" activity, the reaction between silver nitrate and sodium sulfide formed a precipitate. Give the net ionic equation that results when these two react.
    a. $\mathbf{2Ag^{+}(aq) + S^{2-}(aq) \rightarrow Ag_2S(s)}$

    b. $Ag_2^{+}(aq) + S^{2-}(aq) \rightarrow Ag_2S(s)$

    c. $Na^{+}(aq) + NO_3^{-}(aq) \rightarrow NaNO_3(s)$

    d. $2Na^{+}(aq) + NO_3^{-}(aq) \rightarrow Na_2NO_3(s)$

    e. $2Ag^{+}(aq) + SO_4^{2-}(aq) \rightarrow Ag_2SO_4(s)$

10. Consider the reaction between silver nitrate and sodium sulfide. If 250.0 mL of 2.00 M silver nitrate react with 500.0 mL of 2.00 M sodium sulfide, which ion has a concentration of zero after the reaction?
    a. Sodium ion
    b. Silver ion
    c. Nitrate ion
    d. Sulfide ion
    e. There is more than one ion after the reaction that has a concentration of zero.

Use the following combinations of reactants to answer the next two questions.

Combination 1	$H_2SO_4(aq) + NH_4OH(aq) \rightarrow$
Combination 2	$Ca(OH)_2(aq) + NaCl(aq) \rightarrow$
Combination 3	$K_2CO_3(aq) + Fe(NO_3)_3(aq) \rightarrow$
Combination 4	$Na_3PO_4(aq) + Ca(OH)_2(aq) \rightarrow$
Combination 5	$NH_4OH(aq) + K_2CO_3(aq) \rightarrow$

11. For how many of the combinations above does a precipitate form?

a. 1
b. 2
c. 3
d. 4
e. 5 (Precipitates form in all cases.)

12. For which of the combinations does a reaction occur, but **no precipitate** forms?

a. Combination 1
b. Combination 2
c. Combination 3
d. Combination 4
e. Combination 5

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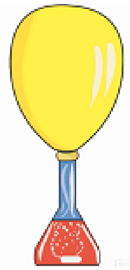
13. The products of an acid-base reaction are sodium nitrate and water. What were the reactants? Assume that both reactants are in the aqueous phase.

a. $NaNO_3$ and Na_2O
b. HNO_3 and NaOH
c. HNO_3 and NaH
d. HNO_2 and NaOH
e. HNO_3 and Na_2O

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 you saw took place below between the baking soda and sulfuric acid (H_2SO_4).



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

The sulfuric acid and baking soda react to produce a balloon full of carbon dioxide that has volume 2.20 L at a temperature of 23.0°C and a pressure of 1.10 atm.

14. What mass of baking soda was required to produce this much carbon dioxide? Assume that sufficient sulfuric acid was present for the baking soda to be able to react.
    a. 0.100 g
    b. 0.200 g
    c. 4.20 g
    d. <u>8.40 g</u>
    e. 16.80 g

15. If the mass of baking soda you determined in question #14 was used to react with sulfuric acid, which solution of sulfuric acid could **<u>not</u>** be used to completely react with this amount of baking soda?
    a. <u>25.0 mL of 1.00 M H_2SO_4</u>
    b. 25.0 mL of 2.00 M H_2SO_4
    c. 50.0 mL of 1.00 M H_2SO_4
    d. 50.0 mL of 2.00 M H_2SO_4
    e. All of these can be used to make that amount of carbon dioxide.

Please go on to the next page.

Part 2: Free Response

16. Recall the demonstration from lecture in which we created solutions of varying concentrations. Use your knowledge of these solutions to answer the questions below.

a. You place 234 grams of sodium chloride into a very large beaker and add water until the total volume of the solution is 2,000. mL. What is the concentration of this solution? (Note: The molar mass of sodium chloride is 58.45 g/mol.)

+2 points

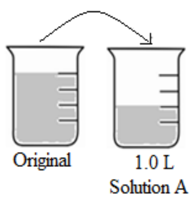
$$\mathbf{234\ g\ NaCl \times \frac{1\ mol\ NaCl}{58.45\ g\ NaCl} = 4.00\ mol\ NaCl}$$

+1 work, +1 answer

$$\mathbf{2,000.\,mL \times \frac{1\ L}{1000mL} = 2.000\ L} \qquad \mathbf{M = \frac{mol}{L}} \qquad \mathbf{\frac{4.00\ mol}{2.000\ L} = \boxed{2.00\ M}}$$

b. You pour one liter of this solution into a second beaker. This new solution is solution A.

i. Give the concentration of solution A. Explain your answer.



The concentration of solution A is 2.00 M. The original solution had a concentration of 2.00 M, and pouring out some of it means that the concentration is still 2.00 M. The volume is half that of the original solution and the moles are half as much as well, meaning that the ratio of moles to total volume of solution is still the same so the concentration is still the same.

+2 points

+0.5 answer, +0.5 explain

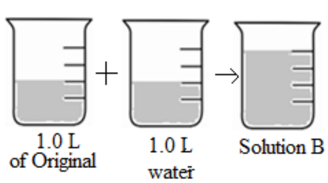
i. Give the number of moles of solute within solution A. Show work.

$$2.00\ M = \frac{x\ mol}{1.00\ L} \quad \boxed{\mathbf{x = 2.00\ mol}}$$

+0.5 answer, +0.5 work

c. You take the remaining 1.00 liter sodium chloride solution and add an additional 1.00 liters of water. This new solution is solution B.

i. Give the concentration of solution B in the beaker after the water has been added. Show work.



The original solution contains 2.00 moles of solute per one liter of solution. When 1.00 liter of water is added, the new concentration is 1.00 M.

$$\frac{2.00\ mol}{1.00\ L + 1.00\ L\ water\ added} = \boxed{\mathbf{1.00\ M}}$$

+0.5 answer, +0.5 work

i. Give the number of moles of solute in solution B. Show your work and explain how you got your answer.

+2 points

There are 2.00 moles of solute in solution B. The original 1.0 liter solution contained 2.00 moles of solute, and adding water to the solution only changed the total volume of the solution, not the moles solute.

+0.5 answer, +0.5 explain/work

Original solution: $2.00\ M = \frac{x\ mol}{1.00\ L}$ $\boxed{\mathbf{x = 2.00\ mol}}$

d. You combine solutions A and B together into one container to form solution C. Compare the moles of solute in solution C, the volume of solution C, and the concentration of solution C to that of both solutions A and B by filling in the table below. Show mathematical support in each case.

+3 points	**i. Moles of solute in solutions** Fill in each box below with <, >, or =. Solution C $\boxed{>}$ Solution A Solution C $\boxed{>}$ Solution B **+1 each box**	Mathematical support for part i: 2.00 moles solution A + 2.00 moles solution B = **4.00 moles total** **+1**
+3 points	**ii. Volume of solutions** Solution C $\boxed{>}$ Solution A Solution C $\boxed{>}$ Solution B **+1 each box**	Mathematical support for part ii: 1.00 L solution A + 2.00 L solution B = **3.00 L total** **+1**
+3 points	**iii. Concentration of solutions** Solution C $\boxed{<}$ Solution A Solution C $\boxed{>}$ Solution B **+1 each box**	Mathematical support for part iii: $\frac{4.00\ moles}{3.00\ L} = \mathbf{1.33\ M}$ This is less than the initial concentration of solution A (2.00 M) and greater than the initial concentration of solution B (1.00 M.) **+1**

Please go on to the next page.

17. Recall the demonstration from lecture in which solid magnesium reacted with solid carbon dioxide to produce solid magnesium oxide and solid carbon.

- **<u>Before</u>** the reaction, some magnesium and 10.14 grams carbon dioxide were placed in a closed container.
- **<u>After</u>** this reaction, the container held 1.20 grams of carbon, some magnesium oxide and potentially some leftover reactant.

a. Give the balanced equation for this reaction. Include phases.

+3 points

$2Mg(s) + CO_2(s) \rightarrow 2MgO(s) + C(s)$

+1 substances, +1 balance, +1 phases

b. Determine the masses of magnesium, carbon dioxide, magnesium oxide, and carbon present both before and after the reaction by completely filling in the table below. Show all work in the space below the table. (Hint: A BCA table may be helpful in this situation!)

+4 points (1 point each blank)

	Mass Magnesium	Mass carbon dioxide	Mass magnesium oxide	Mass carbon
Before Reaction	**4.86 g**	10.14 g	0	0
After Reaction	**0 g**	**5.74 g**	**8.06 g**	1.20 g

*It is <u>not</u> necessary to solve the problem using a BCA table.

$$1.20\ g\ C \times \frac{1\ mol\ C}{12.011\ g\ C} = 0.100\ mol\ C$$

$$10.14\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} = 0.230\ mol\ CO_2$$

+7 points

	2Mg(s) +	CO_2(s) →	2MgO(s)	+ C(s)
B	0.200	0.230	0	0
C	-0.200	-.100	+0.200	+0.100
A	0	0.130	0.200	0.100

$$0.200\ mol\ Mg \times \frac{24.31\ g\ Mg}{1\ mol\ Mg} = 4.68\ g\ Mg$$

$$0.130\ mol\ CO_2 \times \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = 5.74\ g\ CO_2$$

$$0.200\ mol\ MgO \times \frac{40.31\ g\ MgO}{1\ mol\ MgO} = 8.06\ g\ MgO$$

<u>Point breakdown for intermediate steps:</u>

+1 moles C after reaction
+1 moles CO_2 before reaction

+1 using a mole ratio to find moles MgO
+1 using a mole ratio to find moles Mg before reaction

+1 moles Mg before reaction
+1 moles CO_2 after reaction
+1 moles MgO after reaction

c. Explain how your table above demonstrates that mass has been conserved in this process.

+1 point

This demonstrates that mass has been conserved because the total mass present both before and after the reaction is 15.0 grams.

Before reaction: 4.68 g Mg + 10.14 g CO2 = 15.00 g

After reaction: 5.74 g CO2 + 8.06 g MgO + 1.20 g C = 15.00 g