CHEMISTRY 101
Hour Exam II
March 14, 2019
McCarren

Name _____KEY_______________________

Signature ____________________________

Section ______________________________

This exam contains 17 questions on 10 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·atm/mol·K ≈ 0.0821 L·atm/mol·K

K = °C + 273 $N_A = 6.022 \times 10^{23}$ = 1 mole

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

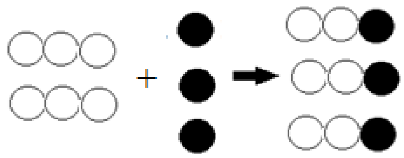
1. Balance the equation shown below. Which image shows the correct particle representation of the equation after it has been balanced? Assume that A and B each represent atoms of different elements.

$$A_3 + \quad B \rightarrow \quad A_2B$$

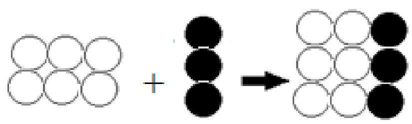
Key:

a.

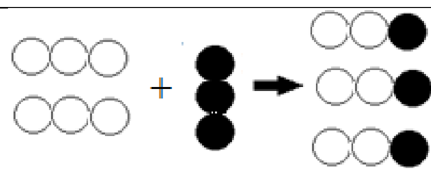
<u>b.</u>



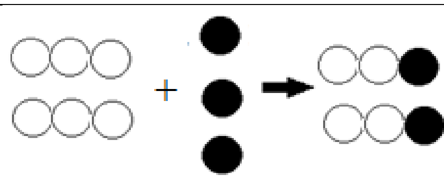
c.



d.



e.



2. The balanced equation for the reaction between hydrogen and phosphorus to make phosphine gas is shown below. Which statement is **<u>always true</u>** about this reaction?

$$3P_4 + 6H_2 \rightarrow 4PH_3$$

a. Hydrogen gas is limiting because it is used up twice as fast as phosphorus.
b. <u>Every time three molecules of hydrogen gas are used, two molecules of phosphine form.</u>
c. The reaction container holds four moles of phosphine gas after the reaction.
d. Before a reaction starts, there must be at least 3 moles of phosphorus and 6 moles of hydrogen present.
e. At least two of these statements are always true about this reaction.

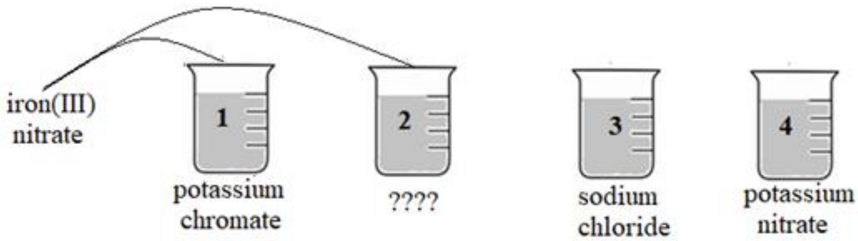
Consider the reaction between solid diphosphorus pentoxide and liquid water to form aqueous phosphoric acid (H_3PO_4). Write out and balance the equation. Then, use this equation to answer the next three questions.

3. Balance the equation and determine the sum of the coefficients when the equation is balanced in standard form (lowest whole number ratios).
   a. 3
   b. 5
   c. <u>6</u>
   d. 9
   e. 12

4. If 6.0 moles of phosphoric acid were formed as a result of this reaction, how many moles of water were needed to react?
   a. 1.0 mole
   b. 3.0 moles
   c. 6.0 moles
   d. <u>9.0 moles</u>
   e. 12 moles

5. If 6.0 moles of phosphoric acid were formed in this reaction, what mass of diphosphorus pentoxide was needed to react?
   a. 70.95 g
   b. 141.9 g
   c. 283.8 g
   d. <u>425.7 g</u>
   e. 851.4 g

Consider the four beakers below, each containing an aqueous salt dissolved in water as shown. Aqueous iron(III) nitrate has been added to beakers 1 and 2. Use this information to answer the next three questions.



6. Addition iron(III) nitrate to beaker 1 containing aqueous potassium chromate resulted in the formation of a precipitate. What is the formula of the precipitate that has formed in beaker 1?
   a. $Fe_2(CrO_4)_3$
   b. $FeCrO_4$
   c. $Fe_2(CO_3)_3$
   d. $FeCO_3$
   e. KNO_3

7. When iron(III) nitrate was added to the aqueous salt solution in beaker 2, no precipitate formed. Which of the following salts may have been present in beaker 2?
   a. K_2SO_4
   b. K_2CO_3
   c. KOH
   d. K_3PO_4
   e. At least two of these salts may have been the salt present in beaker 2.

8. When the iron(III) nitrate solution is poured into beakers 3 and 4, will any precipitates form?
   a. A precipitate will form in beaker 3 only.
   b. A precipitate will form in beaker 4 only.
   c. Precipitates will form in both beakers 3 and 4.
   d. Precipitates will form in neither beakers 3 nor 4.
   e. More information is needed to determine whether or not a precipitate will form in either of these beakers.

An aqueous solution of calcium chloride reacts with an aqueous solution of sodium phosphate. Use this reaction to answer the next several questions.

9. What is the **complete** ionic equation for this reaction?
   a. $3Ca^{+2}(aq) + 6Cl^{-}(aq) + 6Na^{+}(aq) + 2PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s) + 6Na^{+}(aq) + 6Cl^{-}(aq)$
   b. $3Ca^{+2}(aq) + 3Cl_2^{-}(aq) + 6Na^{+}(aq) + 2PO_4^{3-}(aq) \rightarrow 3Ca^{+2}(aq) + 2PO_4^{3-}(aq) + 6Na_3Cl_2(s)$
   c. $3Ca^{+2}(aq) + 6Cl^{-}(aq) + 6Na^{+}(aq) + 2PO_4^{3-}(aq) \rightarrow 3Ca^{+2}(aq) + 2PO_4^{3-}(aq) + 6NaCl(s)$
   d. $Ca^{+2}(aq) + Cl^{-}(aq) + Na^{+}(aq) + PO_4^{3-}(aq) \rightarrow CaPO_4(s) + Na^{+}(aq) + Cl^{-}(aq)$
   e. $2Ca^{+2}(aq) + 6Cl^{-}(aq) + 6Na^{+}(aq) + 3PO_4^{3-}(aq) \rightarrow Ca_2(PO_4)_3(s) + 6Na^{+}(aq) + 6Cl^{-}(aq)$

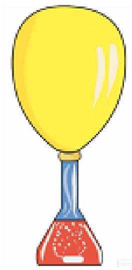
10. What is the **net ionic** equation for this reaction?
   a. $2Cl^{-}(aq) + 3Na^{+}(aq) \rightarrow Na_3Cl_2(s)$
   b. $Cl^{-}(aq) + Na^{+}(aq) \rightarrow NaCl(s)$
   c. $Ca^{+2}(aq) + PO_4^{3-}(aq) \rightarrow CaPO_4(s)$
   d. $2Ca^{+2}(aq) + 3PO_4^{3-}(aq) \rightarrow Ca_2(PO_4)_3(s)$
   e. $3Ca^{+2}(aq) + 2PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$

The solution of calcium chloride had a volume of 2.00 L and a concentration of 3.5 M. The sodium phosphate solution that it was mixed with had a volume of 2.00 L and a concentration of 2.0 M. Use this information as well as your equation above to answer the next two questions.

11. Which ions were present in the container after the reaction?
   a. Na^{+} and Cl^{-} only
   b. PO_4^{3-} and Cl^{-} only
   c. Na^{+}, PO_4^{3-}, and Cl^{-}
   d. Na^{+}, Ca^{+2}, and Cl^{-}
   e. Na^{+}, PO_4^{3-}, Ca^{+2}, and Cl^{-}

12. What is the concentration of sodium ions present in the container after the reaction? If these were not present in the container after the reaction, select 0 M.
   a. 0 M
   b. 1.0 M
   c. 2.0 M
   d. 3.0 M
   e. 6.0 M

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).



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

You have a flask containing sulfuric acid with a balloon holding baking soda on top of it. The baking soda is poured into the flask, the reaction occurs, and the balloon inflates. In the container, 42.0 grams of baking soda (molar mass 84.0 g/mol) combined with 500.0 mL of 1.00 M sulfuric acid, and the balloon filled with carbon dioxide at 1.10 atm and 25.0°C. Use this information to answer the next two questions.

13. What volume of carbon dioxide gas was produced in this reaction?
    a. 2.78 L
    b. 5.56 L
    c. <u>11.1 L</u>
    d. 16.7 L
    e. 22.2 L

14. How many moles of excess reactant were leftover after this reaction?
    a. 0.125 moles
    b. **<u>0.250 moles</u>**
    c. 0.500 moles
    d. 0.750 moles
    e. 1.00 moles

15. A second balloon contains 15.0 grams of baking soda reacting with 500.0 mL of 1.00 M sulfuric acid. These also react and fill the balloon with carbon dioxide. Will this balloon be larger, smaller, or equal to the size of the balloon in questions 12 and 13?
    a. <u>Larger:</u> More carbon dioxide is produced, so the balloon is larger.
    b. <u>Larger:</u> Due to less baking soda in the container, there is more room for the gas to expand, so the balloon is larger.
    c. <u>The same size:</u> The same amount of sulfuric acid is used up, so the same amount of carbon dioxide is produced and the balloons are the same size.
    d. <u>Smaller:</u> Less carbon dioxide is produced because the sulfuric acid is limiting, so the balloon is smaller.
    e. <u>Smaller: Less carbon dioxide is produced because the baking soda is limiting, so the balloon is smaller.</u>

Part 2: Free Response

Please write in your answers completely, showing all work and explaining as necessary.

16. Consider each of the pairs of solutions below and use them to answer question 16.

Set 1

- **Solution A** consists of 60.0 grams sodium hydroxide dissolved to make 500. mL of solution.
- **Solution B** consists of 0.25 moles sodium hydroxide dissolved to make 250. mL of solution.

a. Which solution has a greater overall molarity? Show work and/or explain your answer.

Solution A:

$$60.0\ g\ NaOH \times \frac{1\ mol\ NaOH}{40.0\ g\ NaOH} = 1.50\ mol\ NaOH$$ +1

+3 total

$$\frac{1.50\ mol\ NaOH}{.500\ L\ NaOH} = 3.00\ M\ NaOH$$

Solution B:

$$\frac{0.25\ mol\ NaOH}{.250\ L\ NaOH} = 1.00\ M\ NaOH$$ +1

Solution A has a greater concentration. +1

b. For the solution in part a. that you said has the greater concentration, what volume of water (in mL) would you need to add to that solution to result in both solutions A and B having the same concentration? Show work.

+3 total

To reduce the concentration of solution A to 1.00 M, <u>1,000. mL of</u> water would need to be added. +1

Want a 1.00 M solution:

$$\mathbf{1.00\ M = \frac{1.50\ mol}{x\ L}}$$ **x = 1.50 L** +1

1.50 L – 0.50 L of solution present before adding water = 1.00 liters of water need to be added

1.00 L is equivalent to 1000. mL. +1 converting L to mL

Please go on to the next page.

Set 2

- **Solution C** consists of a 1.0 L aqueous solution of calcium hydroxide.
- **Solution D** consists of a 1.0 L aqueous solution of hydrochloric acid (HCl)

Solutions C and D are combined together.

c. Give the balanced molecular equation for this reaction, showing all phases.

$$Ca(OH)_2(aq) + 2HCl_{(aq)} \rightarrow 2H_2O_{(l)} + CaCl_{2(aq)}$$

+1 reactants

+1 products

+3 total

+1 balance and phases

d. When these solutions reacted, they reacted in a perfectly stoichiometric ratio; neither reactant was in excess and both reactants ran out at the same time. Which solution had a higher concentration, solution C or D? Explain your answer.

+1

<u>Solution D had a greater concentration.</u> Every time 1 mole of calcium hydroxide was used up, according to the balanced equation, twice as many moles of hydrochloric acid were used up. Therefore, if adding two solutions of volumes 1.0 L together resulted in a perfect stoichiometric ratio reaction, this means that there must have been twice as many moles of HCl present in the 1.0 L container as calcium hydroxide moles present. This means that the HCl solution had a higher concentration.

+3 total

+2 for coherent explanation

Please go on to the next page.

17. Consider the unbalanced equation between some unknown element X and fluorine gas (F_2) to form some compound XF_n containing both X and fluorine, where n represents some unknown whole number.

$$X + F_2 \rightarrow XF_n$$

Before the reaction, six moles of X and six moles of fluorine gas are present in a sealed container. These later react to form the XF_n compound.

After the reaction:

- All six moles of fluorine gas have been consumed.
- Four moles of element X remain unreacted.
- Two moles of XF_n product have been formed.

a. Even without having a balanced equation, this is enough information to complete a BCA table for the reaction. Use the information above to completely fill out each blank in the BCA table below:

+3 total

	X	F_2	XF_n	
B	**6**	**6**	**0**	+1 each row of BCA table
C	**-2**	**-6**	**2**	+1
A	**4**	**0**	**2**	+1

b. Using information from your BCA table, give the lowest whole number coefficients for each of the substances in this reaction. Explain how your BCA table displays this information.

+1 each coefficient (+3 possible)

+4 total

Coefficient of X: **1** Coefficient of F_2: **3** Coefficient of XF_n: **1**

The "change" row of the BCA tables shows the coefficient ratios. So, in this case, if the change row shows 2, 6, and 2, these would simplify to 1, 3, and 1 as coefficients.

+1 explanation

c. What is the value of "n" in XF_n? Show work and/or explain. **6**

+1

+3 total

The equation is $X + 3F_2 \rightarrow XF_n$. The only way for this equation to balance because there are 6 F atoms on the left side is for to be 6. This also makes 6 F atoms on the right side.

+2 work or explanation

d. What was the mass of the six moles of F_2 present before the reaction?

+1

$$6\, mol\, F_2 \times \frac{38.0\, g\, F_2}{1\, mol\, F_2} = \mathbf{228\, g\, F_2}$$

e. If the total mass in the container before the reaction was 1,016 total grams of X and F_2 combined, what was the total mass of the six moles of X present?

+1

1,016 grams total – 228 g F_2 = **788 g X**

f. Use your answer to part e. to determine the identity of X.

+2 total

$$\frac{788\, g\, X}{6.0\, moles\, X} = 131 \frac{g}{mol}$$ +1

X is Xe, xenon +1

g. We have seen in chemical reactions that mass is often conserved and therefore is not created or destroyed as a result of a chemical reaction. You now have all the information you need to demonstrate that mass was conserved in this reaction. To do this, fill in the table below by giving the masses of X, F_2, and XF_n present before and after the reaction. Show all work in the space below the table.

	X	F_2	XF_n product	**Total**
Before reaction	**788 g**	**228 g**	**0 grams**	**1,016 grams**
After reaction	**525.2 g**	**0 g**	**490.6 g**	**1,016 grams**

+0.5 each blank

(+3 total possible)

+4 total

$$4\, mol\, Xe \times \frac{131.3\, g\, Xe}{1\, mol\, Xe} = \mathbf{525.2\, g\, Xe}$$

$$2\, mol\, XeF_6 \times \frac{245.3\, g\, XeF_6}{1\, mol\, XeF_6} = \mathbf{490.6\, g\, XeF_6}$$

Or…1,016 grams total – 525.2 g = 490.8 g XeF_6 +1 work

STOP **This is the end of the exam. Nothing written after this page will be graded.**