CHEMISTRY 101
Hour Exam II
March 30, 2021
McCarren

Name _____KEY_____

Signature _____

Section _____

"Adversity can be changed into opportunity. Embrace change and keep an open mind when it comes to learning." - Vanaja Bal

This exam contains 31 questions. 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. Please be sure to complete all questions.

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

+2 points each multiple-choice question

1. What is the sum of the coefficients when the equation below is balanced in standard form?

$$UO_2(s) + HF(aq) \rightarrow UF_4(aq) + H_2O(l)$$

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

2. Consider the balanced equation below between nitrogen and hydrogen to form ammonia. Which of the following is **<u>false</u>** about the reaction represented by this equation?

$$N_2 + 3H_2 \rightarrow 2NH_3$$

a. The arrow separates the reactants from the products.
b. <u>The term "$3H_2$" means that there are 6 hydrogen atoms connected to each other before the reaction.</u>
c. With sufficient hydrogen, this reaction can occur if only 0.50 moles of nitrogen are present in the container before the reaction.
d. There will be fewer molecules in the container after the reaction takes place.
e. The "3" subscript on NH_3 means that there are 3 hydrogen atoms connected to one nitrogen atom in each molecule of the substance.

3. Consider the equation below which has been balanced in standard form.

$$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

If 3.50 moles of aluminum react, assuming sufficient hydrochloric acid, how many moles of hydrogen gas will form?

a. 2.33 moles
b. 3.00 moles
c. <u>5.25 moles</u>
d. 7.00 moles
e. 10.5 moles

The balanced equation for the reaction between solid sulfur and aqueous sulfuric acid (H_2SO_4) to form sulfur dioxide and liquid water is shown below. 9.00 moles of sulfur and 8.00 moles of sulfuric acid react. Use this information to answer the next two questions.

$$\mathbf{S(\mathit{s}) + 2H_2SO_4(\mathit{aq}) \rightarrow 3SO_2(\mathit{g}) + 2H_2O(\mathit{l})}$$

4. What **mass** of water was formed as a result of this reaction?
   a. 8.00 grams
   b. 36.0 grams
   c. 72.0 grams
   d. 144 grams
   e. 288 grams

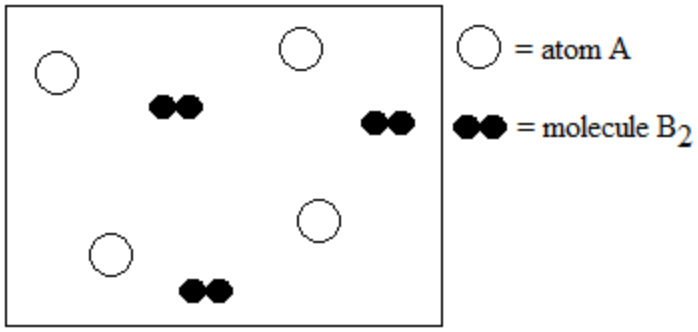
5. What **mass** of excess reactant was leftover after the reaction?
   a. 5.00 grams
   b. 64.0 grams
   c. 80.0 grams
   d. 128 grams
   e. 160. grams

6. 10.0 grams of unknown element X react with 15.0 grams of unknown element Y to form compound XY according to the balanced equation below.

   X(s) + Y(s) → XY(s)

   The mass of compound XY formed is 15.0 grams, and at least one of the reactants is completely consumed. What mass of excess reactant is leftover?
   a. 5.0 grams element X
   b. 10.0 grams element X
   c. 5.0 grams element Y
   d. 10.0 grams element Y
   e. There is no excess reactant; both reactants are completely consumed.

7-8. Unknown element A and a molecule containing unknown element with formula B_2 react to form some product containing both A and B. The diagram below represents the contents of a particular container before element A and molecule B_2 react. Use this information to answer questions 7 and 8.



7. After the A and B_2 react, one molecule of B_2 remains, and 4 molecules of products are formed. What is the formula of the product?
   a. <u>AB</u>
   b. A_2B
   c. AB_2
   d. A_2B_3
   e. AB_4

8. Assuming this reaction is carried out at a constant temperature and within a rigid container, will the pressure in the container increase, decrease, or remain constant after the reaction? Choose the best answer with correct explanation.
   a. *Increase:* Three molecules of B_2 are present in the container before the reaction, and four molecules of product are present after the reaction.
   b. *Increase:* The reaction causes the gas particles to move quicker, increasing the pressure on the container walls.
   c. *Remain constant:* The same number and type of atoms are present in the container before and after the reaction.
   d. <u>*Decrease:* Fewer particles are present in the container overall after the reaction.</u>
   e. *Decrease:* There were seven particles present in the container before the reaction but only four products in the container after the reaction.

9-10. Consider the table below which is similar to the one that you saw in the precipitation reactions video in which various combinations of reagents were mixed. Determine whether or not a precipitate was formed (yes or no) for each of the combinations below, and use this to answer questions 9 and 10. One example is already done for you.

	iron(III) nitrate	silver nitrate
potassium chromate	Yes	
potassium chloride		

9. For how many of the combinations (out of four) does a precipitate form?
   a. 1
   b. 2
   c. <u>3</u>
   d. 4
   e. Not enough information

10. A precipitate forms when iron(III) nitrate and potassium chromate mix, as shown above. What is the net ionic equation for this reaction?
   a. $Fe^{+2}(aq) + CrO_4^{-2}(aq) \rightarrow FeCrO_4(s)$
   b. <u>$2Fe^{+3}(aq) + 3CrO_4^{-2}(aq) \rightarrow Fe_2(CrO_4)_3(s)$</u>
   c. $Fe_2^{+3}(aq) + (CrO_4)_3^{-2}(aq) \rightarrow Fe_2(CrO_4)_3(s)$
   d. $2Fe^{+2}(aq) + 2CrO_4^{-2}(aq) \rightarrow Fe_3(CrO_4)_2(s)$
   e. $Fe_3^{+2}(aq) + (CrO_4)_2^{-2}(aq) \rightarrow Fe_3(CrO_4)_2(s)$

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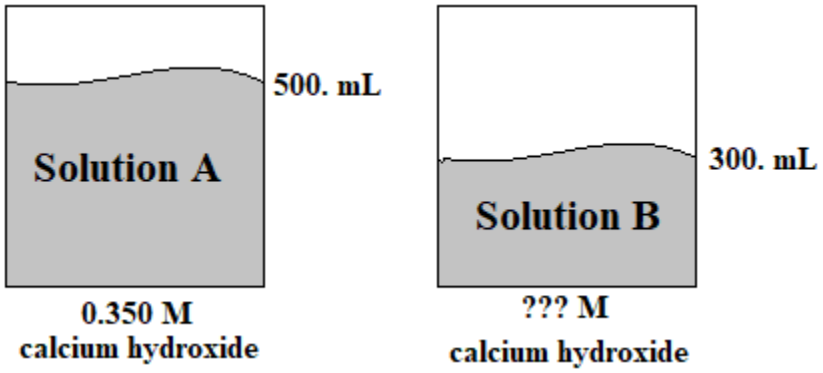
11. Consider the reaction between aqueous barium hydroxide and aqueous sulfuric acid (H_2SO_4). How many of the following statements are **<u>true</u>** about this reaction?
- This is a precipitation reaction.
- This is an acid-base reaction.
- Water is a product in this reaction.
- None of the ions in this reaction are spectator ions.

   a. 0 (None of the statements are true about this reaction.)
   b. 1
   c. 2
   d. 3
   e. <u>4 (All 4 statements are true regarding this reaction.)</u>

12-13. Use the images below to answer the following two questions about solutions A and B consisting of calcium hydroxide dissolved in water.



12. Solution A is a calcium hydroxide solution that has a concentration of 0.350 M and a volume of 500. mL. What mass of calcium hydroxide was dissolved to make this solution? (Note: The molar mass of calcium hydroxide is 74.093 g/mol.)

a. 0.175 g
b. 10.17 g
c. 12.97 g
d. 51.86 g
e. 105.94 g

13. You pour out 300. mL of solution A into a new container. This new 300 mL solution is solution B. How do the concentration and moles of solute in solution B compare to the concentration and moles of solute in the original solution A?

The concentration of solution B is _____ the concentration of solution A, and the number of moles of solute in solution B are _____ the number of moles of solute in solution A.

a. Equal to; less than
b. Equal to; equal to
c. Less than; less than
d. Less than; equal to
e. Greater than; greater than

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 a volume of 7.24 L at a temperature of 21.0°C and a pressure of 1.0 atm.

14. How many **moles** of sodium sulfate were produced along with this amount of carbon dioxide?
    a. **0.150 moles**
    b. 0.300 moles
    c. 0.450 moles
    d. 0.600 moles
    e. 1.00 moles

15. The concentration of sulfuric acid used in this reaction was 0.200 M. What volume of sulfuric acid must have been consumed to produce this amount of carbon dioxide? Choose the closest answer.
    a. 0.750 mL
    b. 200. mL
    c. 750. mL
    d. 1,330 mL
    e. 1,500 mL

Part 2: Free Response

Scenario 1:

In lecture, we saw a demonstration in which magnesium reacted with oxygen to produce magnesium oxide. It is also possible to react copper with oxygen in a similar manner to produce a copper oxide compound with one of two possible balanced equations, as shown below.

Reaction A: $2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

Reaction B: $4Cu(s) + O_2(g) \rightarrow 2Cu_2O(s)$

In the laboratory, a sample of copper was heated with sufficient oxygen over a Bunsen burner inside a beaker until a product formed and all copper was completely consumed. The following initial data was collected:

	Mass
Empty beaker	50.47 g
Copper sample	12.74 g

+2 computer graded

16. If reaction A was the one that took place, what mass of CuO product would have been expected to form? Give your answer to two decimal places.

15.95 g CuO

+2 computer graded

17. If reaction B was the one that took place, what mass of Cu_2O product have been expected to form? Give your answer to two decimal places.

14.34 g Cu_2O

The final mass of the beaker + the product formed was 66.42 grams. Use this information to answer the questions below.

+1 computer graded

18. Determine which reaction occurred (A or B).

Reaction A

19. For the reaction that you said occurred (A or B), show work or provide an explanation to show how you determined that this was the reaction occurring.

$$12.74\ g\ Cu \times \frac{1\ mol\ Cu}{63.55\ g\ Cu} \times \frac{2\ mol\ CuO}{2\ mol\ Cu} \times \frac{79.55\ g\ CuO}{1\ mol\ CuO} = 15.95\ g\ CuO$$

+3

66.42 grams - 50.47 grams for the beaker = 15.95 g product formed

(consistent with CuO)

Scenario 2:

In lab, we saw a reaction in which an acid (either H_2SO_4 or HCl) was combined with baking soda ($NaHCO_3$) in a flask to inflate a balloon full of carbon dioxide. Two possible reactions may have occurred which are shown below. Use the information provided to determine which reaction took place.

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

Reaction D: $HCl(aq) + NaHCO_3(s) \rightarrow H_2O(l) + NaCl(aq) + CO_2(g)$

In the laboratory, 0.100 mole samples of an acid labeled "Acid X" (which is either HCl or H_2SO_4) was mixed with two different amounts of baking soda. Carbon dioxide was produced which inflated a balloon. In trial #1, 0.100 moles of CO_2 were produced after the reaction occurred.

	Moles Acid X (mol)	Moles $NaHCO_3$ (mol)	Moles CO_2 (mol)
Trial 1	0.100	0.100	0.100
Trial 2	0.100	0.200	?

+2 computer graded

20. If reaction C was that one that took place, how many moles of carbon dioxide product would have been expected to form in trial #2? Give your answer to three decimal places.

0.200 moles CO_2

+2 computer graded

21. If reaction D was that one that took place, how many moles of carbon dioxide product would have been expected to form in trial #2? Give your answer to three decimal places.

0.100 moles CO_2

The balloons that were inflated in trials #1 and #2 were both the same size.

+1 computer graded

22. Use this information to determine which reaction occurred (C or D).

Reaction D

23. For the reaction that you said occurred (C or D), show work or provide an explanation to show how you determined that this was the reaction occurring.

+3

Reaction D produced 0.100 moles of carbon dioxide for trial #2 which is the same as the amount produced in trial #1. All the coefficients are 1, so the limiting reactant in this case was HCl, since 0.100 moles of it were used up, 0.100 moles of CO_2 were able to be formed.

Consider the two scenarios as described below. Determine the limiting reactant in each case, and identify the substances present in the container after the reaction.

Scenario 1:

Hydrogen gas and oxygen gas react in a closed container to form liquid water according to the equation below.

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

In one scenario, some oxygen gas reacts with 10.0 grams hydrogen gas and forms 71.2 grams liquid water.

24. What is present in the container after the reaction? Select all that are present.

+3 computer graded

- **Hydrogen gas**
- Oxygen gas
- **Water**

25. Explain your answer to #24 in the space below. Your answer should include a separate explanation for why hydrogen gas, oxygen gas, and water each are or are not present. Be sure to support your answers with relevant calculations.

+1 Water is a product.

Water is present in the container because it is formed as a result of the reaction and hydrogen is present because it is in excess.

+1 Oxygen is limiting and supporting work (lots of ways to show).

To form 71.2 grams of liquid water, fewer than 10.0 grams of hydrogen were required. Therefore, oxygen must have been the limiting reactant because more hydrogen was present than was used to produce the 71.2 grams water. Therefore there was no oxygen present in the container after the reaction.

71.2 g H_2O * 1 mol H_2O/18.02 g H_2O = 3.95 mol H_2O

3.95 mol H_2O * (2 mol H_2/2 mol H_2O) = 3.95 mol H_2 needed

+1 Hydrogen is excess.

3.95 mol H_2 * 2.02 g H_2/1 mol H_2 = 7.98 g H_2 required

Scenario 2

Lead(II) nitrate reacts with potassium chloride to form a lead(II) chloride precipitate according to the balanced molecular equation below.

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

In this scenario, 200.0 mL of a 0.100 M lead(II) nitrate solution is mixed with 200.0 mL of a 0.100 M sodium chloride solution.

26. Which ions are present in the solution after the reaction? Select all that are present.

+4 computer graded

- ☐ **Lead(II) ions**
- ☐ **Sodium ions**
- ☐ Chloride ions
- ☐ **Nitrate ions**

27. Explain your answer to #26 in the space below. Your answer should address each ion (lead(II), nitrate, sodium, and chloride) and explain why it was either present or not present in the solution after the reaction. Be sure to support your answers with relevant calculations.

+1 **Sodium and nitrate ions are present in the solution because they are spectators and not used in the reaction.**

+1 **Lead(II) ions are present in the solution because it is the excess reactant – some of them are used to form the product but others remain in the solution.**

+1 **Chloride ions were not present in the solution because they were limiting and completely used up in forming the precipitate.**

+1 supporting work for the limiting reactant

	$Pb(NO_3)_2(aq)$	+ $2NaCl(aq)$	→ $PbCl_2(s)$	+ $2NaNO_3(aq)$
B	**0.200 mol**	**0.200 mol**	**0**	**0**
C	**-0.100 mol**	**-0.200 mol**	**+0.100 mol**	**+0.200 mol**
A	**0.100 mol**	**0**	**0.100 mol**	**0.200 mol**

NaCl is limiting because the same number of moles of both are present before the reaction, but for every two moles of NaCl used, only one mole $Pb(NO_3)_2$ is used.