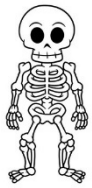
CHEMISTRY 101
Hour Exam II
October 29, 2024
McCarren/Formigao Gameiro

Name _____KEY_____

Signature _____

Section _____

Why don't skeletons like Halloween candy? They don't have the stomach for it.



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.

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).

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

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

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.

Section 1: Multiple Choice

1. Which of the following is **true** about the components of a balanced equation?

   A balanced equation tells us…
   a. the limiting reactant.
   b. the mole ratios of reactants required.
   c. the number of molecules present after the reaction.
   d. the number of moles needed to start a reaction.
   e. the masses of substances present before and after a reaction.

2. Consider the unbalanced equation below, showing the reaction between ethane (C_2H_6) and oxygen gas to form carbon dioxide and water.

   $$\mathbf{C_2H_6 + O_2 \rightarrow CO_2 + H_2O}$$

   What is the sum of the coefficients when this reaction has been balanced in standard form with lowest whole numbers?
   a. 4
   b. 9
   c. 10
   d. 18
   e. 19

Consider the balanced equation below showing the reaction between boron trifluoride and water. Use it to answer the next two questions.

$$\mathbf{2BF_3(g) + 3H_2O(g) \rightarrow B_2O_3(s) + 6HF(g)}$$

3. If 6.00 moles of B_2O_3 were formed in this reaction, how many moles of HF also formed?
   a. 1.00 mole
   b. 6.00 moles
   c. 9.00 moles
   d. 18.0 moles
   e. 36.0 moles

4. What mass of water is required to react with 100.0 grams of BF_3?
   (Note: molar mass BF_3 = 67.81 g)
   a. 2.212 g
   b. 17.71 g
   c. 26.56 g
   d. 39.83 g
   e. 2,212 g

5. Consider the combination of aqueous sodium phosphate and aqueous calcium nitrate similar to that observed in lab. What is the formula of the precipitate?
   a. $Ca_3(PO_4)_2$
   b. $CaPO_4$
   c. $Ca_2(PO4)_3$
   d. $NaNO_3$
   e. No precipitate forms when these two solutions are mixed.

6. Calcium hydroxide is mixed with another aqueous solution. A reaction occurs, but no precipitate forms. Which of the following could be the identity of the other aqueous solution?
   a. KCl
   b. HCl
   c. $AgNO_3$
   d. $NaNO_3$
   e. Na_2SO_4

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7. Enough sodium hydroxide is dissolved to make 200.0 mL of a 0.250 M solution. What mass of sodium hydroxide was needed to make this solution?
   a. 0.0500 g
   b. 2.00 g
   c. 20.0 g
   d. 32.0 g
   e. 50.0 g

8. Consider a solution of 1.0 M HCl. Which of the following will change when water is added to this solution?
   a. The moles of solute
   b. The total volume of the solution
   c. The concentration of the solution
   d. Options (b) and (c) will change.
   e. All three options (a), (b), and (c) will change.

9. What is the concentration of the resulting solution when 500.0 mL of 1.00 M HCl is mixed with 100.0 mL of an HCl solution with concentration 0.600 M?
   a. 0.733 M
   b. 0.800 M
   c. 0.933 M
   d. 1.00 M
   e. 1.60 M

Consider the precipitation reaction between aqueous copper(II) chloride and aqueous sodium hydroxide. The balanced molecular equation for this reaction is shown below. Use this equation to help answer questions 10-13.

$$CuCl_2(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + 2NaCl(aq)$$

10. Which is the balanced **net ionic** equation for this reaction?
    a. $Na^+(aq) + Cl^-(aq) \rightarrow NaCl(s)$
    b. $2Na^+(aq) + Cl_2^{-2}(aq) \rightarrow 2NaCl(s)$
    c. $Cu^{+2}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$
    d. $Cu^+(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$
    e. It is not possible to write a balanced net ionic equation for this reaction.

A solution of 1.00 M copper(II) chloride with volume of 500.0 mL is mixed with a 2.00 M solution of sodium hydroxide with volume of 200.0 mL.

11. Which two ions are spectator ions?
    a. Na^+ and Cl^-
    b. Cu^{+2} and OH^-
    c. Na^+ and OH^-
    d. Cu^{+2} and Cl^-
    e. Na^+ and Cu^{+2}

12. What is the concentration of **copper(II) ions** remaining in the solution after the reaction is complete?
    a. 0 M
    b. 0.143 M
    c. 0.429 M
    d. 0.600 M
    e. 1.50 M

13. What is the concentration of **hydroxide ions** remaining in the solution after the reaction is complete?
    a. 0 M
    b. 0.143 M
    c. 0.571 M
    d. 0.800 M
    e. 2.00 M

Consider the rection between sulfur dioxide and oxygen as shown below. Use this balanced equation to answer the next two questions.

$$\mathbf{2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)}$$

14. Six moles of SO_2 and two moles of O_2 combine in a rigid container. These react to form SO_3 gas. If the initial pressure in the container before a reaction is P, what is the pressure in the container after the reaction?

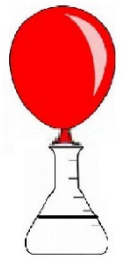
    a. 1/4P
    b. 1/2P
    c. 2/3P
    d. 3/4P
    e. P

15. In a separate scenario, if 8.00 grams of oxygen gas reacts with sufficient sulfur dioxide according to this same reaction, what volume of sulfur trioxide gas is formed? Assume the reaction occurs at a pressure of 1.0 atm and a temperature of 25.0°C.

    a. 1.03 L
    b. 3.06 L
    c. 6.11 L
    d. 12.2 L
    e. 22.4 L

Section 2: Free Response

16. Recall the laboratory activity in which you observed the combination of baking soda and sulfuric acid to form carbon dioxide, water, and sodium sulfate as shown in the balanced equation below. The carbon dioxide formed in these reactions inflated a balloon.



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

Consider both scenarios as shown below. For each, calculate the number of moles of carbon dioxide that can be formed with the given amounts of reactants. Show work for each scenario.

+4 total

+1 moles

+1 ratio

+2 answer

a. **Scenario 1:** 100.0 mL of 1.00 M sulfuric acid reacts with sufficient baking soda and inflates a balloon.

$$1.00\ M\ H_2SO_4 = \frac{x\ mol}{.100\ L} \qquad x = 0.100\ mol\ H_2SO_4$$

$$0.100\ mol\ H_2SO_4 \times \frac{2\ mol\ CO_2}{1\ mol\ H_2SO_4} = \boxed{0.200\ mol\ CO_2\ formed}$$

+4 total

+1 moles

+1 ratio

+2 answer

b. **Scenario 2:** 8.40 grams of baking soda reacts with sufficient sulfuric acid and inflates a balloon.

$$8.40\ g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.0\ g\ NaHCO_3} = 0.100\ mol\ NaHCO_3$$

$$0.100\ mol\ NaHCO_3 \times \frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3} = \boxed{0.100\ mol\ CO_2\ formed}$$

Please go on to the next page.

c. **Scenario 3:** 200.0 mL of 1.00 M sulfuric acid is mixed with 8.40 grams of baking soda and inflates a balloon.

+4 total

+1 moles baking soda

$$8.40\ g\ NaHCO_3 \times \frac{1\ mol\ \ NaHCO_3}{84.0\ g\ NaHCO_3} = 0.100\ mol\ NaHCO_3$$

+1 moles acid

$$1.00\ M\ H_2SO_4 = \frac{x\ mol}{.200\ L} \qquad x = 0.200\ mol\ H_2SO_4$$

+1 limiting reactant

	$2NaHCO_3(s) + H_2SO_4(aq) \rightarrow$		**$2CO_2(g) + Na_2SO_4(aq) + 2H_2O(l)$**		
B	0.100	0.200	0	0	0
C	-0.100	-0.050	+0.100	+0.050	+0.100
A	0	.150	0.100	0.050	0.100

+1 answer

0.100 moles carbon dioxide are formed.

d. Of the three scenarios, which balloon is the largest? If multiple balloons are equally large, you may state this. Explain your answer. Assume that all reactions occurred at the same temperature and pressure.

+3 total

+1 scenario 1

+2 explanation

The balloon is largest in <u>Scenario #1</u> because <u>the greatest number of moles of carbon dioxide were produced</u> (0.200 moles produced in scenario 1, versus only 0.100 moles produced in scenarios 2 and 3).

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17. Mass is conserved in all chemical reactions we have observed this semester. We can use this idea to solve stoichiometry problems in a variety of ways. For this problem, consider the idea of mass conservation and its applications to answer questions from both scenario 1 and scenario 2 below.

Scenario 1

Consider the reaction between nitrogen gas and hydrogen gas to produce ammonia (NH_3).

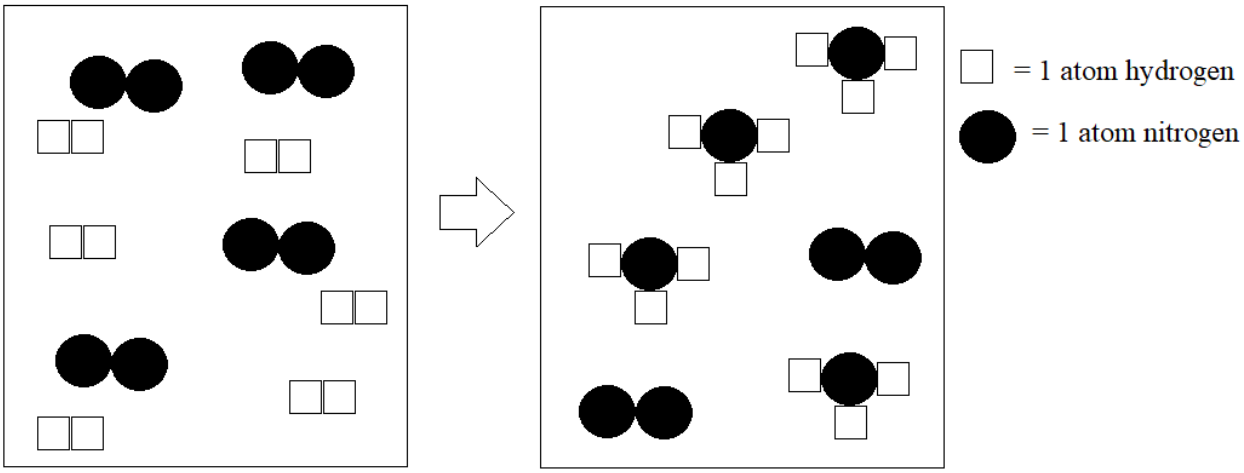
$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

+4 total

a. The diagram below shows the results of a reaction in a closed container between nitrogen gas and hydrogen gas. Fill in the box to the left to show the contents of the container before the reaction. Use the notation provided in the answer key to indicate hydrogen and nitrogen atoms.

+2 correct # nitrogen molecules

+2 correct # hydrogen molecules



+3 total

b. Explain how your answer to part a. demonstrates that mass has been conserved in this process. Include specific numerical information from your diagram to support your answer.

+1 explanation

+2 numerical support

We know that mass has been conserved because there are the same number and type of atoms before and after the reaction. For example, there are twelve atoms of hydrogen both before and after the reaction as well as eight atoms of nitrogen before and after the reaction.

Please go on to the next page.

Scenario 2

In a closed container, 8.40 grams of nitrogen gas and 4.20 grams of oxygen gas react to form 0.262 moles of a single product containing both nitrogen and oxygen. There is 1.06 g nitrogen gas leftover.

c. What mass of product is present after the reaction? Show your work.

+3 total

Mass conservation means that the total mass before the reaction is the same as the total mass after the reaction.

+1 mass before

Before: 8.40 g nitrogen gas + 4.20 g oxygen gas = 12.60 g total

+1 mass before

After: 1.06 g nitrogen gas + product mass = 12.60 g total

+1 answer

12.60 g – 1.06 g nitrogen gas = 11.54 g product formed

c. What is the balanced equation for the reaction? Show your work.

+5 total

Before: $8.40\ g\ N_2 \times \frac{1\ mol\ N_2}{28.01\ g\ N_2} = 0.300\ mol\ N_2$

+1 moles before

$$4.20\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g\ O_2} = 0.131\ mol\ O_2$$

+1 moles after

After: $1.06\ g\ N_2 \times \frac{1\ mol\ N_2}{28.01\ g\ N_2} = 0.038\ mol\ N_2$

	N_2 +	O_2 →	Product
B	0.300	0.131	0
C	-0.262	-0.131	+0.262
A	0.038	0	0.262

+1 some work to find coefficients

+1 correct coefficients

Based on the change row of the BCA table, the coefficients for the balanced equation must be 2:1:2. This means that the full balanced equation is:

$2N_2 + O_2 \rightarrow 2N_2O$

+1 correct product formula of N_2O