CHEMISTRY 101
Hour Exam I
February 13, 2024
McCarren

Name _____KEY_____

Signature _____

Section _____

"Stay open to learning new things, and never stop growing." – Ray T. Bennett

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	(12 pts.)	_____
17	(18 pts.)	_____
Total	(60 pts)	_____

Useful Information:

PV = nRT

K = °C + 273

R = 0.08206 L•atm/mol•K

Density = mass / volume

Avogadro's number = 6.022×10^{23}

1 L = 1000 mL

1 atm = 760. torr

Assume atmospheric pressure is 1.00 atm (unless explicitly told otherwise).

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

Section 1: Multiple Choice

1. Measurements for three different lengths are shown below, each in a different unit. Which option ranks the lengths from shortest to longest? (Note: 1 mile = 5820 feet, 1 foot = 12 inches)

6.0×10^4 inches 1 mile 6,000 feet

a. 1 mile < 6,000 feet < 6.0×10^4 inches

b. 6.0×10^4 inches < 1 mile < 6,000 feet

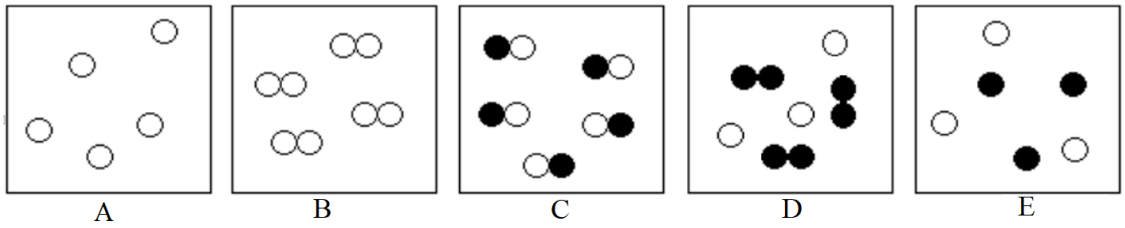
c. 1 mile < 6.0×10^4 inches < 6,000 feet

d. 6,000 feet < 6.0×10^4 inches < 1 mile

e. 6,000 feet < 1 mile < 6.0×10^4 inches

The five images below each represent substances. The white circles represent atoms of one element, and the black circles represent atoms of a different element.

2. Which of the five images below represents a substance which is a compound?



a. A
b. B
c. C
d. D
e. E

3. How many images contain at least one substance which is a molecular element?
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5 (All five images contains at least one molecular element.)

4. Consider the ionic compound $NiSO_4$. What is the charge of the **cation** in this compound?
   a. +3
   b. +2
   c. +1
   d. -1
   e. -2

5. How many of the anions named below have a charge of -1?

   - Nitrate
   - Carbonate
   - Chloride
   - Hydroxide

   a. 0 (None of the anions have a -1 charge.)
   b. 1
   c. 2
   d. 3
   e. 4 (All four of the anions have a -1 charge.)

6. What is the percent by mass of **sulfur** in sodium sulfide?
   a. 22.6%
   b. 26.9%
   c. 41.0%
   d. 58.2%
   e. 73.6%

7. Which sample below has the greatest mass in grams?
   a. 1.0 mole helium gas
   b. 1.0 mole neon gas
   c. 1.0 mole argon gas
   d. 1.0 mole krypton gas
   e. All have the same mass because they are all 1.0 mole samples.

8. Which of the following is **true** related to protons, neutrons, and electrons for the atom or ion of a given element?
   a. The number of protons in a given species can always identify the element.
   b. The number of electrons in a given species can always identify the element.
   c. The number of neutrons in a given species can always identify the element.
   d. Two of the above (a. – c.) are true.
   e. All three of the above (a. – c.) are true.

You have containers holding samples of two different substances. The first container holds 18.02 grams of liquid water. The second container holds 4.003 grams of helium gas. Compare these samples to answer the next two questions.

9. How do the number of moles of water compare to the number of moles of helium?

   The number of moles of water is approximately _____ the number of moles of helium.

   a. one-third
   b. half
   c. <u>equal to</u>
   d. double
   e. three times

10. How do the number of atoms in the water sample compare to the number of atoms in the helium sample?

    The number of atoms in the sample of water is approximately _____ the number of atoms in the sample of helium.

    a. one-third
    b. half
    c. equal to
    d. double
    e. <u>three times</u>

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11. What is the volume of 2.50 moles of helium gas with a pressure of 1.0 atm and temperature of 298 K?
    a. 0.0163 L
    b. 5.13 L
    c. 23.0 L
    d. <u>61.1 L</u>
    e. 244 L

12. A gas at constant temperature occupies a volume of 2.25 L and exerts a pressure of 895 torr. What volume (in L) will the gas occupy at a pressure of 647 torr?
    a. 1.61 L
    b. <u>3.11 L</u>
    c. 1,610 L
    d. 2,010 L
    e. 3,110 L

13. Recall the lecture demonstration in which you saw the volume of a balloon decrease when liquid nitrogen was poured over it. Which of the following explains **why** this occurred?

As the liquid nitrogen was poured over the balloon…

a. the particles inside the balloon collided with the balloon walls less often.
b. the particles inside the balloon became smaller and less massive.
c. the pressure of the air outside the balloon increased.
d. some gas particles which were inside the balloon left the balloon.
e. the gas inside the balloon changed from mostly oxygen to mostly nitrogen.

14. A rigid container holds 44.0 grams of carbon dioxide gas and an unknown mass of neon gas. The partial pressure of the neon gas is twice as great as the partial pressure of the carbon dioxide. What is **true** about the mass of the neon gas present?

The mass of the neon gas present…

a. may be greater than or less than the mass of the carbon dioxide present based on the temperature of the container.
b. may be greater than or less than the mass of the carbon dioxide present based on the volume of the container.
c. must be less than the mass of the carbon dioxide present.
d. must be equal to the mass of the carbon dioxide present.
e. must be greater than the mass of carbon dioxide present.

15. We have a container containing a mixture of two different gases which behave ideally. Which is **not** an assumption we make about the individual gas particles in this mixture?

Individual gas particles…

a. have no volume.
b. have large spaces between them.
c. have no interactions with one another.
d. are in constant motion.
e. with greater masses exert greater pressure.

Section 2: Free Response

16. This question contains missing information for three different chemical compounds. Fill in the chart for each compound in part a, b, and c to provide the missing information about each compound.

+4 points total

a. A compound has a molar mass of 110.9 grams per mole. It consists of an alkaline earth metal cation combining with one or more ions of chlorine.

+1 i. Give the formula for this compound. **$CaCl_2$**

+1 ii. Give the name of this compound. **calcium chloride**

Show your work for determining the formula in the space below.

+1 use of charges

An alkaline earth metal has a +2 charge. Chlorine has a -1 charge. This means that the compound can be considered to be XCl_2. X + Cl + Cl has a molar mass of 110.9 grams per mole. If we take 110.9 g/mol – 2(35.45 g/mol), we are left with the molar mass of X, which is around 40.0 g/mol. This means that X is chlorine.

+1 subtraction

+4 points total

b. Consider a compound with the empirical formula SO_2 and molar mass of 192.18 g/mol.

+1 i. Give the molecular formula for this compound. **S_3O_6**

+1 ii. Give the name of the compound. **trisulfur hexoxide**

Show your work for determining the molecular formula in the space below.

+1 **Molar mass of SO_2 is 64.04 g/mol.**

+1 **192.18 g/mol ÷ 64.04g/mol = 3**

$(SO_2)*3 = S_3O_6$

+4 points total

c. Consider an ionic compound containing just iron and oxygen which is 69.9% iron by mass.

+1 i. Give the formula for this compound. **Fe_2O_3**

+1 ii. Give the name of the compound. **iron(III) oxide**

Show your work for determining the formula of the compound in the space below.

Assume 100.0 grams.

+1 convert to moles

100.0 grams compound – 69.9 g iron = 30.1 g oxygen.

$$69.9\ g\ Fe * \frac{1\ mol\ Fe}{55.845\ g\ Fe} = 1.25\ mol\ Fe \times \frac{1}{1.25} = 1 \times 2 = 2$$

+1 correct simplification

$$30.1\ g\ O * \frac{1\ mol\ O}{16.00\ g\ O} = 1.88\ mol\ O \times \frac{1}{1.25} = 1.504 \times 2 = 3$$

The formula is Fe_2O_3.

Please go on to the next page.

17. For parts a. and b. below, consider two balloons, both at the same pressure. One balloon contains 1.0 mole of hydrogen gas at 50.0° C, and the other contains 1.0 mole of helium gas at 25.0° C.

+4 points total

a. How do the masses of gas in the balloons compare? Select the answer which best completes the statement below and show work to support your answer.

+2 ***The mass of gas in the hydrogen balloon is _____half_____ the mass of gas in the helium balloon.***

Select one of the five options below and then explain your answer:

- ☐ one quarter (1/4)
- ☐ **half (1/2)**
- ☐ equal to
- ☐ greater than, but less than double
- ☐ double

+1 $\mathbf{1.0\ mol\ He \times \frac{4.003\ g\ He}{1\ mol\ He} = 4.003\ g\ He}$

+1 $\mathbf{1.0\ mol\ H_2 \times \frac{2.02\ g\ H_2}{1\ mol\ H_2} = 2.02\ g\ H_2}$

+5 points total

b. How do the volumes of gas in the balloons compare? Select the answer which best completes the statement below and explain your answer in words. It may be helpful to show mathematical support for your explanation.

+2 ***The volume of the hydrogen balloon is __greater than, but less than double__ the volume of the helium balloon.***

Select one of the five options below and then explain your answer:

- ☐ one quarter (1/4)
- ☐ half (1/2)
- ☐ equal to
- ☐ **greater than, but less than double**
- ☐ double

+1 V & T relationship **If balloon temperature goes up, the volume goes up. Everything is equal** except the temperatures of the balloons. If we convert these to Kelvin, we **see that the hydrogen balloon is at a temperature of 50.0°C + 273 = 323 K. The helium balloon is at a temperature of 25.0°C + 273 = 298 K. We can see in this case that the Kelvin temperature for the hydrogen balloon is greater than that of the helium balloon, but it is less than double. So, the volume of the hydrogen balloon is larger than the helium balloon, but still less than double the size.**

+1 K

+1 coherent explanation

*** They can get up to 1 out of 3 points for the explanation to part b. if there are formulas provided but no words.***

+4 points total

For parts c. and d. below, you are holding two balloons, both at the same temperature. One balloon contains 10.0 g argon, and the other balloon contains 10.0 g neon.

c. How do the pressures of gas in the balloons compare? Select the answer which best completes the statement below and explain your answer in words.

+2

The pressure of gas in the argon balloon is ____equal to_____ the pressure of gas in the neon balloon.

Select one of the five options below and then explain your answer:

- ☐ one-quarter (1/4)
- ☐ half (1/2)
- ☐ **equal to**
- ☐ greater than, but less than double
- ☐ double

+2

Because both balloons are in the same room, they are at the same pressure. The balloons adjust their size so that the pressure inside and outside of the room is the same. Because the balloons are not getting any bigger or smaller, they both have the same room pressure.

+5 points total

d. How do the volumes of gas in the balloons compare? Select the answer which best completes the statement below and explain your answer. It may be helpful to show mathematical support for your explanation.

+2

The volume of gas in the argon balloon is ____half_____ the volume of gas in the neon balloon.

Select one of the five options below and then explain your answer:

- ☐ One-quarter (1/4)
- ☐ **half (1/2)**
- ☐ equal to
- ☐ greater than, but less than double
- ☐ double

+1 V & n relationship

+1 find moles

+1 coherent explanation

Using PV = nRT, P and T are constant, meaning that only V and n vary. Larger numbers of moles mean a larger balloon. 10.0 grams of argon is about 0.25 moles, and 10.0 grams of neon is about 0.50 moles. Because the neon balloon has double the moles with everything else constant, it is predicted to have double the volume.

*** They can get up to 1 out of 3 points for the explanation to part d. if there are formulas provided but no words.***