

**Minnesota Science Olympiad  
Division C  
University of Minnesota Regional  
Saturday, February 3, 2007**

**Chemistry Lab**

General information:

1. No reference material is allowed.
2. Calculators will be provided by the event supervisor. No other calculators are allowed.
3. Goggles and aprons/lab coats are expected to be worn by participants.
4. A periodic table will be provided.
5. All answers must be transferred to the answer sheet in order to be scored.

Scoring: Nuclear chemistry and gases are each valued at 50% for this event. Tie-breaker questions will be announced. Time may be limited for a portion of the exam, however, time will not be used as a tiebreaker.

Part 1: Nuclear Chemistry

Laboratory Data and Analysis Questions

Section 1: Shielding

	Counts per Minute			
Radiation Source	No Shielding	Cardboard	Glass	Lead
Alpha	<b>311</b>	<b>11</b>	<b>0</b>	<b>0</b>
Beta	<b>882</b>	<b>541</b>	<b>132</b>	<b>0</b>
Gamma	<b>1350</b>	<b>1115</b>	<b>1087</b>	<b>322</b>

1. Rate the three types of radiation from greatest to least in their ability to penetrate materials.

(a) \_\_\_\_\_ (b) \_\_\_\_\_ (c) \_\_\_\_\_

2. Rate the three types of shielding materials from least to greatest in their ability to block radiation.

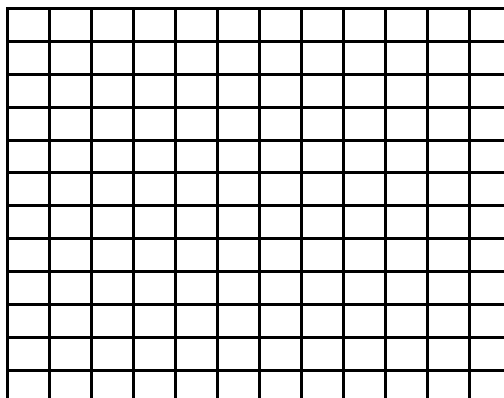
(a) \_\_\_\_\_ (b) \_\_\_\_\_ (c) \_\_\_\_\_

3. Which type of radiation is most dangerous to humans? Explain.

Section 2: Radiation intensity

Distance (cm)	Intensity (cpm)
<b>4</b>	<b>455</b>
<b>8</b>	<b>149</b>
<b>12</b>	<b>98</b>
<b>16</b>	<b>53</b>
<b>20</b>	<b>47</b>
<b>24</b>	<b>32</b>

4. Graph the Radiation Intensity versus Distance. Make sure to transfer your graph on to the answer sheet.



5. By what factor did the radiation intensity change when the distance was doubled?
6. By what factor did the intensity change when the distance was tripled?
7. In general, what is the relationship between the radiation intensity and the distance to the source?

#### Short Answer

8. Give 2 benefits to irradiating food.
9. Complete the following nuclear reactions:
- a.  $?\alpha \rightarrow {}_{96}^{243}\text{Cm} + {}_0^1n$
- b. Thorium-232 decays to Protactinium-232
- c.  ${}_{92}^{235}\text{U} + {}_0^1n \rightarrow ? + {}_{36}^{92}\text{Kr} + 2{}_0^1n$
10. Write balanced nuclear equations for radioactive decay of:
- a. Hafnium-174 with alpha emission
- b. Technitium-98 with beta emission

#### Multiple Choice

11. Which of these is NOT a factor that determines the extent of biological damage caused by radiation?
- a. The area exposed to the source
- b. The exposure time
- c. The type of tissue exposed
- d. Material in the container holding the source

12. The spontaneous process of an atom changing into another atom, emitting a particle and energy is defined as:
- radioactive decay
  - bombardment
  - fission
  - fusion
13. If a 500 gram sample of a radioisotope has half-life of 3.0 days, what mass of the original isotope will still be in the present in 18 days?
- 3.9 g
  - 7.8 g
  - 15.6 g
  - 31.3 g
  - 62.5 g
14. If you start with 259 pounds of a new element, with a half-life of 13 hours, how many hours have passed when only 16.2 pounds remains of the original sample?
- 52 hours
  - 39 hours
  - 3 hours
  - 4 hours

## Part 2: Gases

Ideal Gas Constants and other true statements:

$$R = 0.0821 \frac{L \cdot atm}{mol \cdot K} = 62.4 \frac{L \cdot mmHg}{mol \cdot K} = 82.1 \frac{mL \cdot atm}{mol \cdot K}$$

$$1.0 atm = 101325 Pa = 101325 Pa = 760 mmHg = 760 Torr$$

True or False

- The absolute temperature and volume of a gas are directly related.
- The pressure and absolute temperature of a gas are inversely related.
- The volume and pressure of a gas are inversely related.
- The volume and number of moles of a gas are directly related.
- The pressure and number of moles of a gas are inversely related.
- The coldest temperature possible is -273 K.
- Molar volumes of gases are about 1000 times greater than those of liquids or solids.
- The rate of effusion is directly proportional to the square root of its molar mass.

Multiple Choice

9. An instrument used to measure gas pressure is:
- Calorimeter
  - Thermometer
  - Hygrometer
  - Speedometer
  - Barometer
10. A sample of gas with an initial pressure of 1.2 atm is compressed from 2.8 L to 1.75 L. What is the new pressure?
- 1.9 atm
  - 4.1 atm
  - 0.75 atm
  - 0.24 atm
11. Calculate the volume occupied by 25 g of nitrogen gas,  $N_2$ , at STP.
- 25 L
  - 20 L
  - 0.9 L
  - 4.4 L
12. According to the ideal gas law, if other factors are constant, the volume of a sample gas is:
- Directly proportional to the absolute temperature.
  - Inversely proportional to pressure.
  - Directly proportional to the number of moles of gas.
  - All of the above
13. The density of liquid oxygen,  $O_2$ , is  $1.144 \text{ g/cm}^3$  at  $-183^\circ\text{C}$ . An insulated flask designed to contain 1.00 mole of liquid oxygen at  $-183^\circ\text{C}$  must have which of the following volumes?
- $14.0 \text{ cm}^3$
  - $18.3 \text{ cm}^3$
  - $23.6 \text{ cm}^3$
  - $28.0 \text{ cm}^3$
  - $36.6 \text{ cm}^3$
14. A 6.1 liter sample of gas, measured at  $25.0^\circ\text{C}$  and 1.00 atm, was found to have a mass of 7.0 grams. The molar mass of the gas is:
- 7.0 g/mole
  - 14 g/mole
  - 28 g/mole
  - 32 g/mole
  - 35 g/mole

15. Chlorine ( $\text{Cl}_2$ ) is a gas at room temperature. What volume, in liters, would a 3.55 g sample of chlorine gas occupy at  $0.00^\circ\text{C}$  and 1.00 atm pressure?
- 1.12 liters
  - 2.24 liters
  - 22.4 liters
  - 1.23 liters
  - 2.45 liters
16. A container of gas at  $20.0^\circ\text{C}$  is heated. What temperature must be reached if the gas pressure is to be doubled?
- $586^\circ\text{C}$
  - $313^\circ\text{C}$
  - $273^\circ\text{C}$
  - $40.0^\circ\text{C}$
  - $10.0^\circ\text{C}$
17. In order for 2.00 moles of a gas to occupy a volume of 10.0 liters at  $227^\circ\text{C}$ , the pressure, in atm, must be which of the following?
- $P=8.21$  atm
  - $P=2830$  atm
  - $P=3.73$  atm
  - $P=3730$  atm
  - $P=8210$  atm
18. A 10.0 mL sample of nitrogen gas ( $\text{N}_2$ ) is heated from  $25.0^\circ\text{C}$  to  $50.0^\circ\text{C}$ . The new volume will be:
- 20.0 mL
  - 5.00 mL
  - 9.23 mL
  - 10.8 mL
19. Hydrogen gas is collected in gas collecting tube by displacement of water. The total pressure is 762 mm Hg and the vapor pressure of water is 18.0 mm Hg at the temperature of the experiment. What is the partial pressure of the hydrogen?
- 762 mm Hg
  - 780 mm Hg
  - 744 mm Hg
  - 760 mm Hg
  - 42.0 mm Hg
20. Which statement is NOT TRUE?
- In a gas mixture, each gas contributes to the total pressure.
  - The volume occupied by an ideal gas is essentially the volume of the container.
  - The collisions of the gas molecules with the walls of the container account for the observed pressure.
  - There are large intermolecular forces between molecules in an ideal gas.

21. At what temperature in Celsius, °C, will 19.4 g of oxygen gas, O<sub>2</sub>, exert a pressure of 1820 mm Hg in a 5.12 liter cylinder?
- 246 °C
  - 519 °C
  - 27 °C
  - 7.7 °C
22. If a mixture of gases at 740 mm Hg contains 0.500 mol of N<sub>2</sub>, 3.00 mol of O<sub>2</sub>, and 6.50 mol of CO<sub>2</sub>, what is the partial pressure of O<sub>2</sub> in the mixture?
- 222 mm Hg
  - 317 mm Hg
  - 37 mm Hg
  - 481 mm Hg
23. The kinetic molecular theory of gases assumes:
- Molecular motion without any collisions
  - Molecular kinetic energy is directly proportional to the absolute temperature
  - Molecules slow down with they hit each other
  - Attractive forces between molecules have an effect on their behavior
24. At constant temperature, the behavior of a sample of a real gas more closely approximates that of an ideal gas as its volume is increased because the:
- Collisions with the walls of the container become less frequent
  - Average molecular speed decreases
  - Average distance between molecules becomes greater
  - Average molecular kinetic energy decreases

Tie-breaker questions

25. If it takes a certain amount of helium atoms 10 seconds to effuse through a porous barrier, how long does it take the same amount of methane molecules, CH<sub>4</sub> under the same conditions?
26. Write balanced nuclear equations for:
- Krypton-74 with positron emission
  - Calcium-41 with electron capture
27. List the greenhouse gases.

Other tie-breaker questions will be used as needed.

**Chemistry Lab**

**Team Number** \_\_\_\_\_  
**School** \_\_\_\_\_

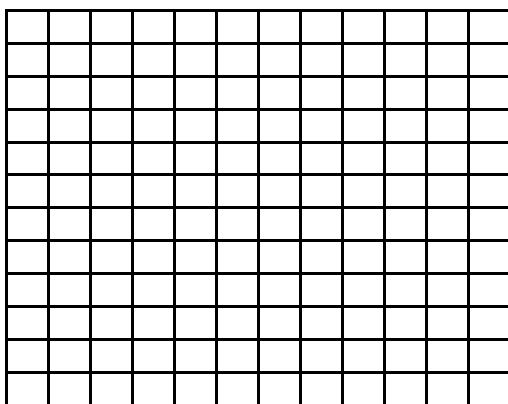
Part 1: Nuclear

- 1. a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

- 2. a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

3.

4.



5. \_\_\_\_\_

6. \_\_\_\_\_

7.

- 8. a. \_\_\_\_\_
- b. \_\_\_\_\_

- 9. a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

- 10. a. \_\_\_\_\_
- b. \_\_\_\_\_

11. \_\_\_\_\_

12. \_\_\_\_\_

13. \_\_\_\_\_

14. \_\_\_\_\_

Part 2: Gases

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
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Tie-breakers

- 25.
26. a. \_\_\_\_\_  
b. \_\_\_\_\_
- 27.