James Madison HIGH SCHOOL

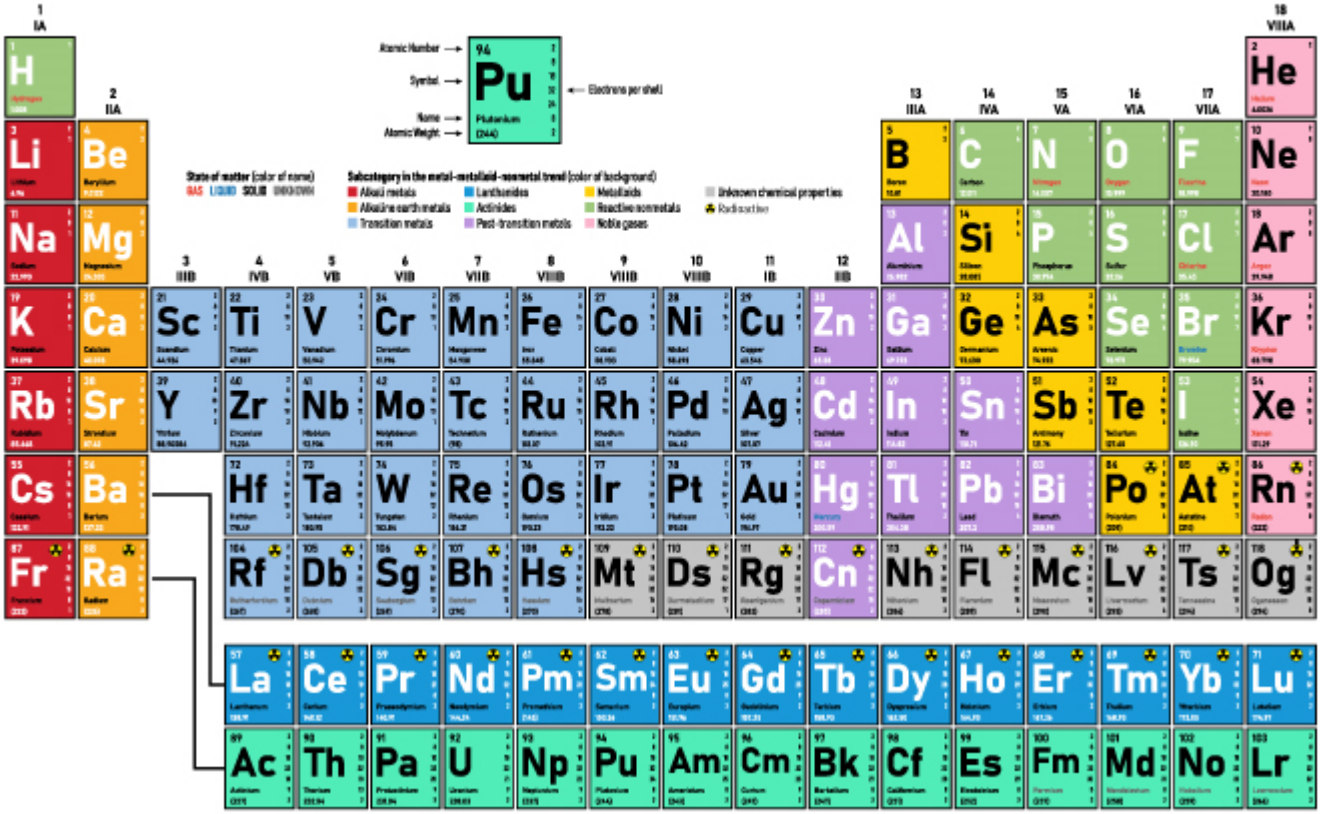
Chemistry Semester 2 Exam

Student Name: _____

Student Number: _____

Materials needed for this exam include a scientific calculator and a periodic table. If you don't have a scientific calculator, you can use the calculator available at desmos.com (https://www.desmos.com/scientific). A periodic table from your course is included below for you to use. You can also reference an interactive version (https://www.rsc.org/periodic-table) from the Royal Society of Chemistry website.

Periodic Table of the Elements



1. Solids, liquids, and gases are the three most commonly accepted phases of matter. Explain the properties of each phase, including their relative energy.

2. Explain the differences between an ideal gas and a real gas.

3. Explain the process of sublimation. Name one substance that sublimes at room temperature and pressure.

4. The **mole** is a counting number that allows scientists to describe how individual molecules and atoms react. If one mole of atoms or molecules is equal to 6.022×10^{23} atoms or molecules, how many molecules are in a 23.45 g sample of copper (II) hydroxide, $Cu(OH)_2$? Express your answer to the correct number of significant figures. (MM of $Cu(OH)_2$ is 97.562 g/mol). Be sure to show all steps completed to arrive at the answer.

5. The density of water at 4.00°C is 0.967 g/mL. How many molecules of water are present in a 499.8 mL bottle of water? Express your answer to the correct number of significant figures. Be sure to show all steps completed to arrive at the answer.

6. A manufacturing company is trying to produce a lightweight but strong cart for use by home gardeners. Explain which metal—titanium (Ti), iron (Fe), or zinc (Zn)—would be the best for this application and why?

7. Combustion reactions are a notable source of carbon dioxide in the environment. Using the following balanced equation, how many grams of carbon dioxide are formed when 100.00 g of propane (C_3H_8) is burned? Express your answer to the correct number of significant figures. Be sure to show all steps completed to arrive at the answer.

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

8. To obtain pure lead, lead (II) sulfide is burned in an atmosphere of pure oxygen. The products of the reaction are lead and sulfur trioxide (SO_3). Write a balanced chemical equation for this process. How many grams of lead will be produced if 2.54 grams of PbS is burned with 1.88 g of O_2? Express your answer to the correct number of significant figures. Be sure to show all steps completed to arrive at the answer. (Hint: be sure to work the problem with both PbS and O_2).

9. Using the Ideal Gas Law, $PV = nRT$, where $R = 0.0821$ L atm/mol K, calculate the volume in liters of oxygen produced by the catalytic decomposition of 25.5 g potassium chlorate according to the following reaction. The oxygen is collected at 2.22 atm and 25.44°C. Express your answer to the correct number of significant figures. Be sure to show all steps completed to arrive at the answer.

$$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$$

10. Ammonia (NH_3) is an example of a Brønsted-Lowry Base.

    i. Define the **Brønsted-Lowry acid-base theory**.

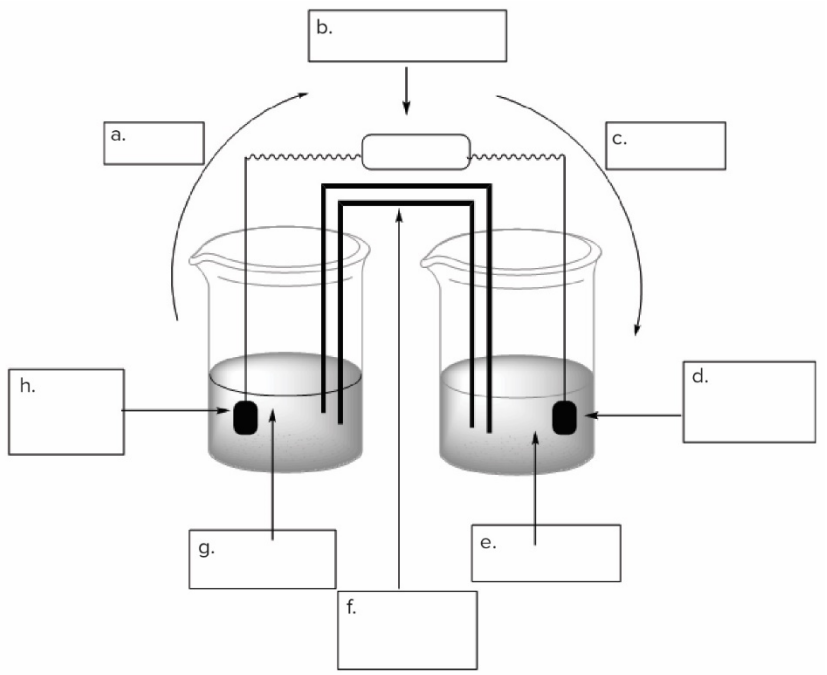
    ii. What's the pH of a solution of ammonia that has a concentration of 0.335 M? The K_b of ammonia is 1.8×10^{-5}.

11. Electrochemistry is important in many aspects of daily life.

    i. Define **voltaic cell**.

    ii. Fill in the blanks for the drawing of a voltaic cell that's made with copper/copper (II) nitrate ($E° = 0.34$ V) and zinc/zinc (II) nitrate ($E° = -0.76$ V). Briefly explain the role of the salt bridge.

    iii. Using the equation $E°_{cell} = E°_{cathode} - E°_{anode}$, calculate the overall cell potential for the cell in step b. Be sure to show all steps completed to arrive at the answer.



a. _____
b. _____
c. _____
d. _____
e. _____
f. _____
g. _____
h. _____

12. Compare and contrast an electrolytic cell with a voltaic cell. Provide one example where both are present in daily life.

For chemical drawings, you can use the Chemical Equation editor in the submission box for the assignment. You can also download a program called Marvin Sketch (https://chemaxon.com/products/marvin).

13. Acid catalyzed dehydration-condensation reactions of carboxylic acids and alcohols produce chemicals called **esters**.

    i. Using carbon skeletal notation, write the dehydration-condensation reaction that occurs between ethanol and butanoic acid.

    ii. What is the name of this ester?

14. Respiration is a three-step process that breaks down glucose and produces ATP. Describe each of the three steps.

15. The equation $E = mc^2$ is one of the lasting symbols of science and nuclear chemistry in general.

    i. Explain what each term in this equation means and what energy is being calculated. What are the derived units for E?

    ii. Compare a nuclear reaction, such as uranium's alpha particle emission, with a nonnuclear reaction, such as the reaction of sodium with chlorine. What's the fundamental difference between these two types of reactions?