

**CHEM 101 Exam 1****Page 1****September 21, 2001****Name** \_\_\_\_\_**Student ID #** \_\_\_\_\_

This exam consists of 7 pages. When the exam begins make sure you have one of each. Print your name at the top of each page now The last page is blank and you may tear it off and use it for scratch paper. Show your work on calculations, this is the only way partial credit can be given. Be sure to include units on calculations, and give answer to the correct number of significant figures. When a blank is not provided make sure you place a box around the correct answer. The exam is 100 points and 50 minutes.

**Page Points**

2	_____
3	_____
4	_____
5	_____
6	_____
7	_____

**If anything confuses you or is not clear, raise your hand and ask!****Total** \_\_\_\_\_**USEFUL INFORMATION**Avogadro's number =  $6.022 \times 10^{23} \text{ mol}^{-1}$

## Points

10 1) Complete the following table: (2 points each column, -1 for each mistake up to -2 per column)

Symbol	$^{11}_5\text{B}$	$^{54}_{26}\text{Fe}^{2+}$	$^{31}_{15}\text{P}^{3-}$	$^{196}_{79}\text{Au}$	$^{222}_{86}\text{Rn}$
Protons	5	26	15	79	86
Neutrons	6	28	16	117	136
Electrons	5	24	18	79	86
Net Charge	0	+2	-3	0	0

8 2) Name or provide the molecular formula for the following: 1 point each – all or nothing

- a) CuI            **copper(I) iodide**
- b) Na<sub>2</sub>CO<sub>3</sub>       **sodium carbonate**
- c) SF<sub>6</sub>            **sulfur hexafluoride**
- d) NH<sub>4</sub>NO<sub>3</sub>      **ammonium nitrate**
- e) sodium hydroxide    **NaOH**
- f) tin(II) fluoride       **SnF<sub>2</sub>**
- g) carbon tetrachloride   **CCl<sub>4</sub>**
- h) lithium nitride        **Li<sub>3</sub>N**

## Page 3

## Points

- 8 3) At a certain temperature the density of liquid water is  $1.00 \text{ g/cm}^3$ . At the same temperature the density of solid  $\beta$ -carotene,  $\text{C}_{40}\text{H}_{56}$ , the orange pigment in carrots food for vision is also  $1.00 \text{ g/cm}^3$ .

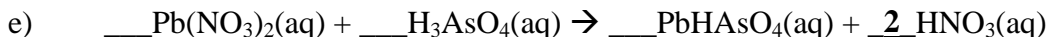
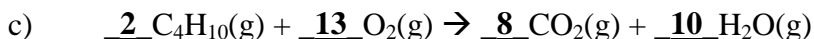
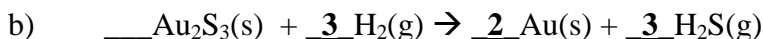
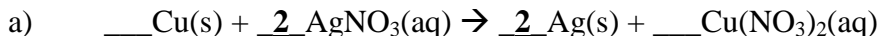
a) How many molecules of water are there in  $1.0 \text{ cm}^3$ ?

$$(1.0 \text{ g H}_2\text{O/cm}^3) \times (1 \text{ mol H}_2\text{O}/18.02 \text{ g H}_2\text{O}) \times (6.022 \times 10^{23} \text{ molec H}_2\text{O}/1 \text{ mol H}_2\text{O}) = \underline{3.34 \times 10^{22} \text{ molec H}_2\text{O/cm}^3}$$

b) How many molecules of  $\beta$ -carotene are there in  $1.0 \text{ cm}^3$ ?

$$(1.0 \text{ g } \beta\text{-c/ cm}^3) \times (1 \text{ mol } \beta\text{-c}/536.8 \text{ g } \beta\text{-c}) \times (6.022 \times 10^{23} \text{ molec } \beta\text{-c}/1 \text{ mol } \beta\text{-c}) = \underline{1.12 \times 10^{21} \text{ molec } \beta\text{-c/cm}^3}$$

10 4) Balance the following equations by filling in the provided blanks:



## Points

- 16 5) Caffeine is a central nervous stimulant found in coffee, tea, and cola nuts (and often consumed by students the night before exams!). Caffeine is found to be 49.48% C, 5.19% H, 28.85% N, and 16.48% O by mass.

a) What is the empirical formula for caffeine?

**Assume 100 g exactly**

$$49.48 \text{ g C} \times (1 \text{ mol C}/12.10 \text{ g C}) = 4.12 \text{ mol C} \quad 4.12 \text{ mol C}/1.03 \text{ mol O} \cong 4$$

$$5.19 \text{ g H} \times (1 \text{ mol H}/1.008 \text{ g H}) = 5.15 \text{ mol H} \quad 5.15 \text{ mol H}/1.03 \text{ mol O} \cong 5$$

$$28.85 \text{ g N} \times (1 \text{ mol N}/14.01 \text{ g N}) = 2.06 \text{ mol N} \quad 2.06 \text{ mol N}/1.03 \text{ mol O} \cong 2$$

$$16.48 \text{ g O} \times (1 \text{ mol O}/16.00 \text{ g O}) = 1.03 \text{ mol O} \quad 1.03 \text{ mol O}/1.03 \text{ mol O} \cong 1$$

**Empirical formula is C<sub>4</sub>H<sub>5</sub>N<sub>2</sub>O**

b) If the molar mass of caffeine is 194.2 g/mol what is the molecular formula?

**Find the empirical formula mass**

**Empirical formula mass = 97.10 g/mol**

**Divide molar mass by empirical formula mass**

$$(194.2 \text{ g/mol})/(97.10 \text{ g/mol}) \cong 2$$

**Molecular formula is C<sub>8</sub>H<sub>10</sub>N<sub>4</sub>O<sub>2</sub>**

- 10 6) (a) Calculate the atomic weight of the metal (X) that reacts with hydrochloric acid according to the following equation if 125 mL of 0.200 M HCl consumes 0.113 g of the metal.



$$0.125 \text{ L} \times (0.200 \text{ mol HCl/L}) = 0.0250 \text{ mol HCl}$$

$$0.0250 \text{ mol HCl} \times (1 \text{ mol X}/2 \text{ mol HCl}) = 0.0125 \text{ mol X}$$

$$\text{Atomic mass of X} = 0.113 \text{ g}/0.0125 \text{ mol} = 9.04 \text{ g/mol}$$

- (b) What metal is "X"? beryllium (Be) (name or atomic symbol)

## Points

- 8 7) Protoporphyrin IX is an important part of many naturally occurring biomolecules including hemoglobin, myoglobin, and most cytochromes. Zinc protoporphyrin IX has one bound Zn atom. The % mass of Zn in the complex is 10.44%. What is the molar mass of zinc protoporphyrin IX?

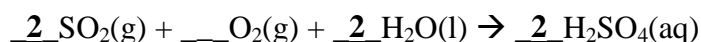
**Assume 100.0 g of Zinc protoporphyrin IX**

$$10.44 \text{ g Zn} \times (1 \text{ mol Zn}/65.39 \text{ g Zn}) = 0.1597 \text{ mol Zn}$$

$$\text{mol Zn} = \text{mol Zn protoporphyrin IX (ZnP IX)}$$

$$\text{molar mass of ZnP IX} = 100.0 \text{ g}/0.1597 \text{ mol} = 626.3 \text{ g/mol}$$

- 18 8) Sulfur dioxide is a major contributor to the environmental problem of acid rain. Below is the **unbalanced reaction** for acid rain production in the atmosphere:



- a) Fill in the blanks above to balance the reaction.
- b) 150.0 g of SO<sub>2</sub> and 100.0 g of O<sub>2</sub> and an excess of water are mixed. Which is the limiting reactant?

**Convert both numbers to moles**

$$150.0 \text{ g/mol SO}_2 \times (1 \text{ mol SO}_2/64.07 \text{ g SO}_2) = 2.341 \text{ mol SO}_2$$

$$100.0 \text{ g/mol O}_2 \times (1 \text{ mol O}_2/32.00 \text{ g O}_2) = 3.125 \text{ mol O}_2$$

**If SO<sub>2</sub> is limiting reagent then we need 2.341 mol SO<sub>2</sub> x (1 mol O<sub>2</sub>/2 mol SO<sub>2</sub>) = 1.171 mol O<sub>2</sub> which we have, therefore SO<sub>2</sub> is the limiting reagent.**

- c) How many grams of the excess reagent remains? Assume the reaction goes to completion.  
**Remaining mol O<sub>2</sub> = 3.125 mol - 1.171 mol O<sub>2</sub> = 1.954 mol O<sub>2</sub>**

$$\text{Mass of O}_2 \text{ remaining} = 1.954 \text{ mol O}_2 \times (32.00 \text{ g O}_2/1 \text{ mol O}_2) = 62.53 \text{ g O}_2$$

## Points

- d) Again, assuming the reaction goes to completion and the final volume of the solution is 3400. mL. What is the final concentration of  $\text{H}_2\text{SO}_4(\text{aq})$ ?

**4 points for getting final concentration of  $\text{H}_2\text{SO}_4$**

$$2.341 \text{ mol SO}_2 \times (2 \text{ mol H}_2\text{SO}_4/2 \text{ mol SO}_2) = 2.341 \text{ mol H}_2\text{SO}_4$$

$$[\text{H}_2\text{SO}_4] = 2.341 \text{ mol H}_2\text{SO}_4/(3.400 \text{ L}) = 0.6885 \text{ M H}_2\text{SO}_4$$

- 12 9) a) How many grams of  $\text{K}_2\text{Cr}_2\text{O}_7$  are needed to make 600. mL of a 0.0350 M solution?

$$0.600 \text{ L} \times (0.0350 \text{ mol K}_2\text{Cr}_2\text{O}_7/\text{L}) = 0.0210 \text{ mol K}_2\text{Cr}_2\text{O}_7$$

$$0.0210 \text{ mol K}_2\text{Cr}_2\text{O}_7 \times (294.2 \text{ g K}_2\text{Cr}_2\text{O}_7/\text{mol K}_2\text{Cr}_2\text{O}_7) = 6.18 \text{ g}$$

- b) How many milliliters of the solution made in a) are necessary to make 125 mL of a 0.00100 M solution of  $\text{K}_2\text{Cr}_2\text{O}_7$ ?

$$M_1V_1 = M_2V_2$$

$$(0.0350 \text{ M}) \times V_2 = (0.00100 \text{ M})(0.125\text{L}) \rightarrow V_2 = 0.00357 \text{ L} = 3.57 \text{ mL}$$

- c) What are the final concentrations of the ions in solution? (**in part b**) )

$$[\text{K}^+] = 2 \times 0.00100 \text{ M} = 0.00200 \text{ M}$$

$$[\text{Cr}_2\text{O}_7^{2-}] = 1 \times 0.00100 \text{ M} = 0.00100 \text{ M}$$