

**City College, Chemistry Department  
Chemistry 10301, sections L and L2, Prof. T. Lazaridis  
First Midterm exam, Oct. 4, 2001**

**Name (last name first):** \_\_\_\_\_

**I.D. Number:** \_\_\_\_\_

**Workshop leader:** \_\_\_\_\_

**Note: There are 5 questions in this exam (check both sides of the sheet).  
Fill in your answer in the blank space provided immediately following each  
question. One point will be subtracted every time you report a numerical result  
with an incorrect number of significant figures. A copy of the periodic table is  
attached. Good luck!**

**Molar masses: C:12.01 , O:16.00 , H:1.008, Cl: 35.45 , Na: 22.99, F: 19.00**

1. a. (4) What is the formula of potassium nitrate?



- b. (4) What is the mass of one mole of carbon tetrachloride (CCl<sub>4</sub>) ?

**12.01 + 4 X 35.45 = 153.81**

- c. (4) How many protons and electrons does the Ca<sup>2+</sup> ion have?

**20 protons, 18 electrons**

- d. (4) Underline the substances below that are molecular compounds.

Diamond      Benzene(C<sub>6</sub>H<sub>6</sub>)      Potassium Chloride (KCl)

Ethanol(CH<sub>3</sub>CH<sub>2</sub>OH)

- e. (4) Write the atomic symbols of the elements:

Fluorine:      **F**

Magnesium:      **Mg**

Neon:      **Ne**

Mercury:      **Hg**

2. Write a balanced equation for each of the following reactions (it is not necessary to indicate the states of each substance):

a. (6) Complete combustion of octane (C<sub>8</sub>H<sub>18</sub>) in oxygen



b. (6)  $\text{C}_6\text{H}_{12}\text{O}_6$  ----->  $2 \text{C}_2\text{H}_5\text{OH} + 2 \text{CO}_2$   
(glucose) (ethanol)

c. (6) Reaction of magnesium with chlorine gas to give magnesium chloride



d. (6)  $2 \text{H}_2\text{O} + 2 \text{F}_2 \text{ -----} \rightarrow 4 \text{HF} + \text{O}_2$

3. Menthol (the substance we can smell in certain cough drops) is composed of C, H, and O. A 0.1005 g sample of menthol is combusted, producing 0.2829 g of CO<sub>2</sub> and 0.1159 g of H<sub>2</sub>O.

a. (10) What is the percent composition (by mass) of this substance?

$$0.2829 \text{ g CO}_2 \times \frac{12.01 \text{ g C}}{44.01 \text{ g CO}_2} = 0.07720 \text{ g C}$$

$$0.1159 \text{ g H}_2\text{O} \times \frac{2 \times 1.008 \text{ g H}}{18.02 \text{ g H}_2\text{O}} = 0.01297 \text{ g H}$$

$$0.1005 - 0.07720 - 0.01297 = 0.0103 \text{ g O}$$

$$\text{C} : \frac{0.07720}{0.1005} \times 100 \% = 76.82 \%$$

$$\text{H} : \frac{0.01297}{0.1005} \times 100 \% = 12.91 \%$$

$$\text{O} : \frac{0.0103}{0.1005} \times 100 \% = 10.25 \%$$

b. (10) What is the empirical formula of menthol?

$$0.07720 \text{ g C } \frac{1 \text{ mol}}{12.01 \text{ g}} = 64.28 \cdot 10^{-4} \text{ mol C}$$

$$0.01297 \text{ g H } \frac{1 \text{ mol}}{1.008 \text{ g}} = 128.7 \cdot 10^{-4} \text{ mol H}$$

$$0.0103 \text{ g O } \frac{1 \text{ mol}}{16.00 \text{ g}} = 6.46 \cdot 10^{-4} \text{ mol O}$$

**Divide by smallest:**

**O : 1**

**C :  $64.28 / 6.46 = 9.95 \approx 10$**

**H :  $128.7 / 6.46 = 19.9 \approx 20$**

**Empirical formula :  $\text{C}_{10}\text{H}_{20}\text{O}$**

c. (10) The molar mass of menthol is 156 g/mol. What is its molecular formula?

$$\text{Mass of empirical formula: } 10 \times 12.01 + 20 \times 1.008 + 16.00 = 156.3 \approx 156$$

**Therefore, molecular formula :  $\text{C}_{10}\text{H}_{20}\text{O}$**

4. (16) Sodium silicate reacts with hydrofluoric acid in the following way:



a. (5) A reacting mixture contains 3.0 moles of HF and 2.0 moles of  $\text{Na}_2\text{SiO}_3$ . Which one is the limiting reactant?

**2 moles  $\text{Na}_2\text{SiO}_3$  require 16 moles HF.**

**We only have 3 moles of HF.**

**Therefore: HF is the limiting reactant**

b. (11) How many grams of NaF will be produced by the above reacting mixture?

**All of HF will react.**

**Molar mass of NaF : 22.99 + 19.00 = 41.99 g/mol**

$$3.0 \text{ moles HF} \times \frac{2 \text{ moles NaF}}{8 \text{ moles HF}} \times \frac{41.99 \text{ g NaF}}{\text{mole NaF}} = 31 \text{ g NaF}$$

5. (10) Iron crystallizes in a cubic lattice and its density is 7.87 g/mL. The edge of a unit cell is 2.86 Å (1 Å = 10<sup>-10</sup> m). Avogadro's number is 6.022 × 10<sup>23</sup> mol<sup>-1</sup> and the molar mass of Fe is 55.847.

a. (8) What is the number of iron atoms per unit cell?

**Volume of unit cell: (2.86 Å)<sup>3</sup>**

$$\text{Mass of unit cell: } (2.86 \text{ Å})^3 \times 7.87 \frac{\text{g}}{\text{cm}^3} \left( \frac{10^{-8} \text{ cm}}{\text{Å}} \right)^3 = 1.84 \cdot 10^{-22} \text{ g/un.cell}$$

$$\text{Mass of one atom: } 55.847 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ mol}}{6.022 \cdot 10^{23} \text{ atoms}} = 9.274 \cdot 10^{-23} \text{ g/atom}$$

$$\text{Atoms per unit cell: } \frac{1.84 \cdot 10^{-22} \text{ g/un.cell}}{9.274 \cdot 10^{-23} \text{ g/atom}} = 1.98 \approx 2 \text{ atoms/un.cell}$$

b. (2) What type of cubic lattice is this (simple, BCC, or FCC)?

**2 atoms/un.cell -----> BCC**