City College, Chemistry Department
Chemistry 10301, sections L and L2, Prof. T. Lazaridis
First Midterm exam, Sep. 26, 2000
Name (last name first): _____
I.D. Number: _____
Workshop leader: _____

Note: There are 6 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. For some questions you may need to consult the periodic table posted in the classroom. Good luck!

Molar masses (in g/mol): C: 12.01, H: 1.008 , O: 16.00 Al: 26.98

1. a. (4) What is the formula of ammonium sulfate?

$(NH_4)_2\ SO_4$

b. (4) What is the mass of one mole of ethyl alcohol (C_2H_6O) ?

2 X 12.01 + 6 X 1.008 + 16.00 = 46.07 g/mol

c. (4) How many protons and electrons does the Fe(III) ion have?

26 protons, 23 electrons

d. (4) An element has been found to have a molar mass of about 40 g/mol. Write the name and the symbol of that element.

Calcium (Ca) or Argon (Ar)

e. (4) Write the atomic symbols of the elements Chlorine, Phosphorus, Copper, and Sodium.

Cl, P, Cu, Na

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

a. (6) Burning of benzene (C_6H_6) in excess oxygen

$2\ C_6H_6 + 15\ O_2$ ------> $12\ CO_2 + 6\ H_2O$

b. (6) Reduction of iron(III) oxide by carbon monoxide to give iron metal and carbon dioxide.

$Fe_2O_3 + 3\ CO$ --------> $2Fe + 3CO_2$

c. (6) Potassium dissolves in water to give potassium hydroxide and hydrogen gas.

$2K + 2H_2O$ ---------> $2KOH + H_2$

d. (6) Nitrogen gas and hydrogen gas react to form ammonia (NH_3).

$N_2 + 3H_2$ ---------> $2NH_3$

3. (16) A substance that contains C, H, and O is subjected to combustion analysis. 50.0 g of the substance is burned to produce 61.4 g of carbon dioxide and 22.6 g of water. What is the percent composition (by mass) of this substance?

Molar mass of CO_2 : 12.01 + 2 X 16.00 = 44.01 g/mol
Molar mass of H_2O : 16.00 + 2 X 1.008 = 18.02 g/mol
61.4 g CO2 X (12.01 g C)/(44.01 g CO2) = 16.8 g C
22.6 g H2O X (2.016 g H)/(18.02 g H2O) = 2.53 g H
Oxygen : 50.0 - 16.8 -2.53 = 30.7 g O
Percent composition:
C : 16.8/50.0 X 100% = 33.6 %
H : 2.53/50.0 X 100% = 5.06 %
O : 30.7/50.0 X 100% = 61.4 %

4. The percentage composition (by mass) of glucose is 40.0 % C, 6.7 % H, and 53.3 % O.

a. (10) What is the empirical formula of glucose?

Consider 100 g of sample. In this we have 40.0 g C, 6.7 g H, and 53.3 g O
Find number of moles:
C: 40.0 g /(12.01 g/mol) = 3.33 mol
H: 6.7 g / (1.008 g/mol) = 6.65 mol
O: 53.3 g/ (16.00 g/mol) = 3.33 mol

Divide by the smallest: The whole-number ratio is C:H:O = 1:2:1

Therefore empirical formula is CH_2O

b. (10) The molar mass of glucose is 180.16 g/mol. What is its molecular formula?

Molar mass of CH_2O unit is 12.01 + 2 X 1.008 + 16.00 = 30.03 g/mol

180.16/30.03 = 6

Therefore, molecular formula is $C_6H_{12}O_6$

5. (10) You are given a sample of metal A and a sample of metal B of equal masses. A has a density of 3.2 g/mL and B has a density of 9.6 g/mL. If the sample of metal A has a volume of 7.5 mL, what is the volume of the sample of metal B?

mass = density X volume = 3.2 g/mL X 7.5 mL

Volume of B = mass/density = 3.2 X 7.5 g / (9.6 g/mL) = 2.5 mL

6. (10) Aluminum crystallizes in the Face Centered Cubic lattice and its density is 2.70 g/mL Calculate the radius of an aluminum atom in Angstroms ($1Å=10^{-10}$ m). (Avogadro's number is 6.022×10^{23} mol^{-1})

Divide the molar mass by Avogadro's number to get the mass of one atom:

26.98 g/mol / (6.022×10^{23} atoms/mol) = 4.480×10^{-23} g/atom

Divide by the density to get the volume per atom and then multiply by the number of atoms per unit cell (4 for FCC) to get the volume of the unit cell and convert mL to $Å^3$ ($1mL = 1cm^3 = (10^8 Å)^3 = 10^{24} Å^3$) :

4.480×10^{-23} g/atom / (2.70 g/mL) $\times 10^{24}$ $Å^3$/mL X 4 atoms/unit cell = 66.4 $Å^3$ /unit cell

For FCC, edge = $2\sqrt{2}$ r (where r is the atomic radius)

and edge^3 = Volume of unit cell = 66.4 $Å^3$ => edge = $\sqrt[3]{66.4}$ Å = 4.05 Å

r = $\frac{\text{edge}}{2\sqrt{2}}$ = 1.43 Å