General Chemistry I
Chem 101 Midterm #1
Fall 2010

Name Key

ID# 10/22/10

There are four questions to this exam.
A periodic chart is found on the last page of this exam.
If you have questions raise your hand.
If additional room is needed use the back of the facing page and note such on the facing page.

Question	Your Points	Total Points
1.		65
2.		40
3.		20
4.		25
Midterm Grade		150

1. The Composition of Molecules

a. Decaborane, $B_{10}H_{18}$, was used as a fuel for the Redstone rockets of the 1950s. Decaborane reacts violently with oxygen according to the following equation:

$$B_{10}H_{18} + 12\,O_2 \text{ ----------> } 5\,B_2O_3 + 9\,H_2O$$

The two starting materials are stored in separate containers. When mixed, they ignite spontaneously, releasing large amounts of energy. If one fuel tank of a rocket contains 1.3×10^5 kg of decaborane and the second tank contains 6.5×10^4 kg of liquid oxygen, which tank will empty first, and how much of the second reactant will be left over? How much B_2O_3 will be produced? (35 points)

$B_{10}H_{18} + 12\,O_2 \rightarrow 5\,B_2O_3 + 9\,H_2O$

(mol)	$B_{10}H_{18}$	O_2	B_2O_3
sm	1031746	2031250	0
change	−1184704	−2031250	846754
fa	846754	0	846754

$(1.3\times10^5\text{ kg } B_{10}H_{18})\left(\frac{10^3\text{ g}}{1\text{ kg}}\right)\left(\frac{1\text{ mole } B_{10}H_{18}}{126\text{ g } B_{10}H_{18}}\right) = 1031746\text{ mol } B_{10}H_{18}$

$(6.5\times10^4\text{ kg } O_2)\left(\frac{10^3\text{ g}}{1\text{ kg}}\right)\left(\frac{1\text{ mole } O_2}{32\text{ g } O_2}\right) = 2031250\text{ mol } O_2$

divide by 12 $\frac{2031250}{12} = 169271$ mole O_2; so O_2 is L.R.

$(2031250\text{ mole } O_2)\left(\frac{1\text{ mole } B_{10}H_{18}}{12\text{ mole } O_2}\right)\left(\frac{126\text{ g } B_{10}H_{18}}{1\text{ mole } B_{10}H_{18}}\right) = 21329125\text{ g } B_{10}H_{18}$ used up

$(846754\text{ mole } B_{10}H_{18})\left(\frac{126\text{ g } B_{10}H_{18}}{1\text{ mole } B_{10}H_{18}}\right) = 106710510\text{ g } B_{10}H_{18}$

$= 1.1\times10^5\text{ kg } B_{10}H_{18}$ remaining

The O_2 tank, since it is the L.R., will empty first.

$(2031250\text{ mole } O_2)\left(\frac{5\text{ mol } B_2O_3}{12\text{ mol } O_2}\right)\left(\frac{68.6\text{ g } B_2O_3}{1\text{ mole } B_2O_3}\right) = 58906250\text{ g } B_2O_3$

$= 5.9\times10^4\text{ kg } B_2O_3$ produced

1. **The Composition of Molecules (continued)**
   b. A sample of mass 0.150 g and containing only C, H, N, O and Cl is burned yielding 0.138 g of CO_2 and 0.0566 g of H_2O. In a separate experiment a sample of mass 0.200 g was burned and the nitrogen converted to 0.0238 g of NH_3. The chlorine in a 0.500 g sample was then converted to Cl^- and precipitated as AgCl with mass 1.0004 g. Find the empirical formula of the compound. (30 points)

$(0.138\text{ g } CO_2)\left(\frac{12.01\text{ g C}}{44.01\text{ g } CO_2}\right) = 0.0377\text{ g C}$

$(0.0566\text{ g } H_2O)\left(\frac{2(1.008\text{ g H})}{18.02\text{ g } H_2O}\right) = 0.00633\text{ g H}$

$(0.0238\text{ g } NH_3)\left(\frac{14.01\text{ g N}}{17.03\text{ g } NH_3}\right) = 0.0196\text{ g N}$

$(1.0004\text{ g AgCl})\left(\frac{35.45\text{ g Cl}}{143.32\text{ g AgCl}}\right) = 0.2483\text{ g Cl}$

$\%\text{C} = \left(\frac{0.0377\text{ g}}{0.150\text{ g sample}}\right)(100\%) = 25.1\%$

$\%\text{H} = \left(\frac{0.00633\text{ g H}}{0.150\text{ g sample}}\right)(100\%) = 4.19\%$

$\%\text{N} = \left(\frac{0.0196\text{ g N}}{0.200\text{ g sample}}\right)(100\%) = 9.80\%$

$\%\text{Cl} = \left(\frac{0.2483\text{ g Cl}}{0.500\text{ g sample}}\right)(100\%) = 49.7\%$

$\%\text{O} = 100\% - 25.1\%\text{C} - 4.22\%\text{H} - 9.80\%\text{N} - 49.7\%\text{Cl} = 11.2\%$

$\frac{25.1\text{ g C}}{12.01\text{ g/mole}} = 2.08\text{ mole C} \quad \frac{2.08}{0.7} = 3 \qquad \frac{4.22\text{ g H}}{1.008\text{ g/mole H}} = 4.19\text{ mole H} \quad \frac{4.19}{0.7} = 6$

$\frac{49.7\text{ g Cl}}{35.45\text{ g/mole Cl}} = 1.40\text{ mole Cl} \quad \frac{1.40}{0.7} = 2 \qquad \frac{11.2\text{ g O}}{16.00\text{ g/mole O}} = 0.700\text{ mole O} \quad \frac{0.700}{0.7} = 1$

$\frac{9.80\text{ g N}}{14.01\text{ g/mole N}} = 0.700\text{ mole N} \quad \frac{0.700}{0.7} = 1$

Divide by 0.7

$\boxed{C_3H_6Cl_2NO}$

2. Chemical Nomenclature

a. Give the formula for each of the following compounds: (4 points each)

1. lithium perbromate

$LiBrO_4$

2. copper(II) nitrate hexahydrate

$Cu(NO_3)_2 \cdot 6H_2O$

3. iron(II) phosphate

$Fe_3(PO_4)_2$

b. Please balance the following equations: (4 points each)

1. $Al + Fe_3O_4 \text{ ----------> } Fe + Al_2O_3$

8 3 9 4

2. $C_9H_4O_3 + O_2 \text{ ----------> } CO_2 + H_2O$

2 17 18 4

3. $Na_2CO_3 + Fe(NO_3)_3 \text{ ----------> } NaNO_3 + Fe_2(CO_3)_3$

3 2 6 1

c. Name each of the following compounds: (4 points each)

1. TiO_2

titanium (IV) oxide

2. V_2O_3

Vanadium (III) oxide

3. $Fe(NH_4)_2(SO_4)_2$

iron (II) ammonium sulfate

4. N_2O_5

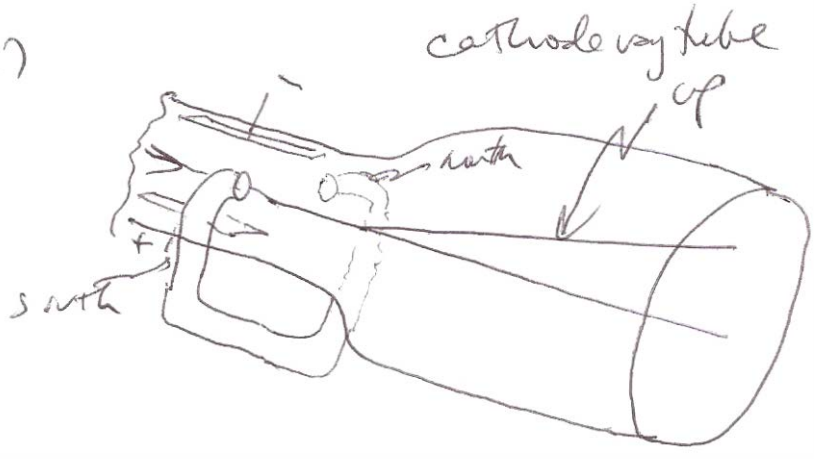
dinitrogen pentoxide

3. The Atomic Nature of Matter

a. Draw a sketch (include appropriate signs for the electric plates) for a cathode ray tube in which **positive** ions are accelerated into a deflection region. I like pictures. (10 points)

b. In a Millikan type of experiment, an oil droplet with a mass of 1.2 μg and carrying three extra electrons is held motionless by an electrical force, F_{el}. In which direction is a droplet of mass 1.2 μg and carrying four electrons moving? In which direction is a droplet of mass 2.0 μg and carrying three extra electrons moving? Please explain. I like pictures. (10 points)

a)



b) Upwards for first quarter, towards the positively charged plate

Downwards for second quarter, pulled by the force of gravity

4. Chemical Potpourri

a. When an unknown compound is burned completely in O_2, 1.23 g of CO_2 and 1.02 g of H_2O are recovered. What additional information is needed before the molecular formula of the unknown compound can be determined? (10 points)

In addition to the atomic weights of C, O and H and the molecular weight of the sample burned, one would also need to know if any elements other than H, C and, possibly, O, are present and what the approx. molecular mass is before the molecular formula can be determined.

b. Please draw a structural formula for each of the following compounds: (5 points each)

1. 1,1,2,2,3,3,4,4-octamethylcyclobutane

2. 3-methyl-4-ethyl-1-heptene

3. 2-methyl-1-pentyne

impossible structure!