Appendix A - Solutions to Starred Problems of *Exercise 1*

Review of General Chemistry (answers to questions with *)

A. Scientific Notation, Significant Figures, Accuracy and Precision, Unit Conversions

1. a. $8.20x10^{-2}$

3. Determine the answers to the following calculations without using a calculator:

   a. $1.5x10^{20}$ g. $7.0x10^{-4}$
   c. $9.0x10^{-3}$ i. $4.04x10^{4}$
   e. 17.4 or $1.74x10^{1}$

4. 0.956 g/mL

6. $3.5x10^{4}$ g

8. $9.10x10^{-28}$ g

B. Atomic Structure: Protons, Neutrons, Electrons and Isotopes

Answer the following using only a periodic table as a source of information. Give as much information as possible using only the atomic number and atomic mass.

1. a. F has 9 protons, an average of 10 neutrons and probably is predominately 1 isotope with 10 neutrons and 9 electrons (only one isotope of fluorine occurs naturally).

2. a. Cl has 17 protons, an average of 18.45 neutrons and at least 2 isotopes must occur naturally and 17 electrons. (actually, Cl has 2 naturally occurring isotopes, about 75% have 18 neutrons and 25% have 20 neutrons but this information cannot be determine from the atomic mass alone).

3. a. H has 1 proton, an average of 0 neutrons (and probably is predominately 1 isotope with 0 neutrons) and 1 electron (actually there are 2 naturally occurring stable isotopes of H, 99.98% have 0 neutrons and 0.02% have 1 neutron but this information cannot be determined from the atomic mass alone).

4. a. Cu^{2+} has 29 protons, an average of 34.55 neutrons and at least 2 isotopes must occur naturally and 27 electrons.

6. a. ${}^{3}_{1}H$ or tritium deviates by 2 neutrons from the average number calculated from the atomic mass and number (0). Early in the chart a deviation of 2 indicates that the nucleus is probably (and is) unstable.

8. a. 6.935

C. Inorganic Nomenclature, Formulas and Balancing Equations

3. Write balanced equations and net ionic equations for each of the following:

   a. $Mg(s) + H_2SO_4(aq) = MgSO_4(aq) + H_2(g)$

   $Mg + 2 H^+ = Mg^{2+} + H_2$

D. Electronic Structure, Bonding and Intermolecular Attractions (For Lewis structures and polarities of molecules, see *Exercise 2*)

1. a. Li $1s^2 2s^1$

2. a. n, l, m, s for a 2s electron n = 2, l = 0, m = 0

5. a. The number of unpaired electrons in Ca is 0.

E. Chemical Calculations: the Mole, Molarity, Formulas and Stoichiometry

1. (230 g)(1mole/18.0g) = 13 moles (13 moles)(6.022×10^{23}molecules/1mole) = 7.7×10^{24} molecules

2. (1 atom)(1 mole/6.022×10^{23} atoms)(39.95 g/1 mol) = 6.634×10^{-23} g

3. 0.331g/3.45×10^{-3} moles = 95.9 g/mole. The element is probably Mo

4. (1×10^{-6} g)(1mole/55.8g)(6.022×10^{23} atoms/1 mol) = 1×10^{16} atoms

5. a. Assume 100.0 g of compound.

$$87.41 \text{ g N} \times \frac{1 \text{ mol N}}{14.007 \text{ g N}} = 6.240 \text{ mol N} \qquad 6.240/6.240 = 1$$

$$12.58 \text{ g H} \times \frac{1 \text{ mol H}}{1.0079 \text{ g H}} = 12.48 \text{ mol H} \qquad 12.48/6.240 = 2 \qquad NH_2$$

32/16 x $NH_2 \rightarrow N_2H_4$

b. A Lewis structure can be drawn for N_2H_4 that satisfies all the guidelines for Lewis structures.

6. 2 Na(s) + 2 $H_2O(\ell)$ = 2 NaOH(aq) + H_2(g)

(2.3 g Na)(1 mol Na/23.0 g Na)(1 mol H_2/2 moles Na)(2.02 g H_2/1 mol H_2) = 0.10 g H_2 (theoretical yield)

(0.080 g/0.10 g)100% = 8.0×10^1%

7. 2 H_2(g) + O_2(g) = 2 H_2O(g)

(5.0 g H_2)(1 mol H_2/2.02 g H_2)(2 moles H_2O/2 moles H_2)(18.0 g H_2O/1 mol H_2O) = 45 g H_2O

(8.00×10^1 g O_2)(1 mol H_2/32.0 g O_2)(2 moles H_2O/1 mole O_2)(18.0 g H_2O/1 mol H_2O) = 90 g H_2O

Theoretical yield = 45 g H_2O since hydrogen was limiting reagent.

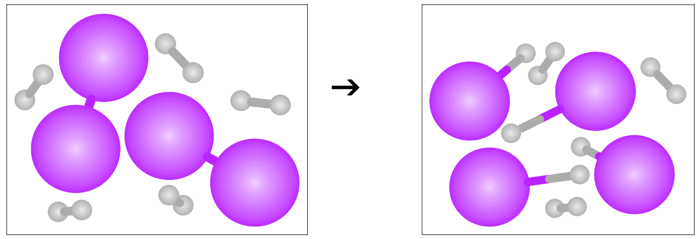
(25 g/45 g)100% = 56% yield

8. (0.25 L)(0.10 mole/L)(58.5 g NaCl/mole NaCl) = 1.5 g NaCl
Dilute 1.5 g NaCl to 250 mL with water.

9. $M_1V_1 = M_2V_2$ (0.050)(500)/(6.0) = 4.2 mL

Dilute 4.2 mL of 6.0 M HCl to 500 mL with water.

13. The chemical equation for the reaction to the right is:



a. $5\ I_2 + 2\ I_2 = 4\ HI + 3\ H_2$
b. $\mathbf{H_2 + I_2 = 2\ HI}$
c. $5\ H_2 + 2\ O_2 = 4\ H_2O + 3\ H_2$
d. $N_2 + O_2 = 2\ NO$
e. none of the above

d can be eliminated because N_2 and O_2 have multiple bonds and neither of the reactants has a multiple bonds. c can be eliminated because H_2O has 3 atoms and none of the products has 3 atoms. While a does demonstrate the reaction that occurs, reactions are always written in their most simplified forms with the lowest whole number coefficients.

F. Equilibrium

Write the correct equilibrium expression for the following reactions:

1. $2NO_2(g) = N_2O_4(g)$ $K_{eq} = [N_2O_4]/[NO_2]^2$

The answers for the questions below are: a. left b. right c. no change

Assume an aqueous HF solution (#3 above) is at equilibrium. In which direction will the system shift to reachieve equilibrium if:

7. If HCl is added to the system, the system will shift to the left as this adds H^+ to the system.

G. Acids, Bases and pH

For each reaction, label each reactant and product as: Brönsted acid, Brönsted base, conjugate acid, conjugate base.

1.* $HNO_3(aq)$ + $H_2O(l)$ = H_3O^+ + NO_3^-
BA BB CA CB

9. Fill in the blanks in the following table:

	pH	$[H^+]_{(mol/L)}$	$[OH^-]_{(mol/L)}$	pOH
a.	4.7	$2x10^{-5}$	$5.0x10^{-10}$	9.3

13. Let KHP = potassium hydrogen phthalate

KHP(aq) + NaOH(aq) = KNaP(aq) + $H_2O(\ell)$

$$\frac{0.6530\text{ g KHP}}{23.32\text{ mL NaOH}} \times \frac{1\text{ mol KHP}}{204.23\text{ g KHP}} \times \frac{1\text{ mol NaOH}}{1\text{ mol KHP}} \times \frac{10^3\text{ mL NaOH}}{1\text{ L NaOH}} = 0.1371\text{ mol NaOH/L}$$

14. $$\frac{0.0160\text{ L NaOH}}{0.0250\text{ L HCl}} \times \frac{0.120\text{ mol NaOH}}{1\text{ L NaOH}} \times \frac{1\text{ mol HCl}}{1\text{ mol NaOH}} = 0.0768\text{ mol HCl/L}$$

15. $0.0213\ L\ NaOH \times \frac{0.120\ mol\ NaOH}{1\ L\ NaOH} \times \frac{1\ mol\ HA}{1\ mol\ NaOH} = 2.56x10^{-3}\ moles\ HA$

$\frac{0.400\ g}{2.56x10^{-3}\ mol\ HA} = 156\ g\ HA/mol$

H. Thermodynamics

solution	concentration (mol/L)	heat of formation (kJ/mol)
hydrochloric acid	1.00	-164.4
sodium hydroxide	1.00	-469.6
sodium chloride	1.00	-407.1
water		-285.9
nitric acid	1.00	-206.6
sodium nitrate	1.00	-446.2

3. -407.1 - 285.9 - (-164.4 - 469.6) = -59.0 kJ/mol

J. Oxidation-Reduction

1. What is the oxidation number of the element indicated in the problems below?

   a. iron in Fe_2O_3 = +3

2. For the reactions below that are redox reactions, label the reactant that is undergoing oxidation with a capital O and the reactant that is undergoing reduction with a capital R. Label the oxidizing agent with OA and the reducing agent with RA.

a. $Mg_{(s)}$ + $ZnCl_{2(aq)}$ = $MgCl_{2(aq)}$ + Zn(s)

Mg + Zn^{2+} = Mg^{2+} + $Zn_{(s)}$

O, RA   R, OA

b. 2 $AgNO_{3(aq)}$ + $CaCl_{2(aq)}$ = 2 $AgCl_{(s)}$ + $Ca(NO_3)_{2(aq)}$

Ag^+ + Cl^- = $AgCl_{(s)}$

not a redox reaction