Set #1

1. Urea (H$_2$NCONH$_2$) is used extensively as a nitrogen source in fertilizers. It is produced commercially from the reaction of ammonia and carbon dioxide.

   \[
   2 \text{NH}_3(g) + \text{CO}_2(g) \rightarrow \text{H}_2\text{NCONH}_2(s) + \text{H}_2\text{O}(g)
   \]

   Ammonia is added to an evacuated 5.0-L flask, to a pressure of 8.0 atm, at a temperature of 20°C. Carbon dioxide is added to the ammonia, to give a total pressure of 11 atm. The flask is then heated. What mass of urea is produced in this reaction, assuming 100% yield?

2. A compound consists of 37.5% C, 3.15% H, and 59.3% F by mass. When 0.298 g of the compound is heated to 50°C in an evacuated 125-mL flask, the pressure is observed to be 750 mm Hg. What is the molar mass, empirical formula, and molecular formula of the compound?

3. Write net ionic equations for the following reactions:
   a. HNO$_3(aq)$ + NaHCO$_3(aq)$ → NaNO$_3(aq)$ + CO$_2(g)$ + H$_2$O$(l)$
   b. HCl$_{(aq)}$ + KOH$_{(aq)}$ → KCl$_{(aq)}$ + H$_2$O$_{(l)}$
   c. NH$_4$Cl$_{(aq)}$ + NaOH$_{(aq)}$ → NaCl$_{(aq)}$ + NH$_3(g)$ + H$_2$O$_{(l)}$

4. A solution is made by mixing 200 mL 0.20 M NaOH with 100 mL 0.10 M HNO$_3$. Find the number of moles of each ion and its concentration in the solution after reaction is complete.

5. The three quantum numbers for an electron in a hydrogen atom in a certain state are $n=4$, $l=1$, $m_l=1$. The electron is located in what type of orbital?

6. Write the ground-state electron configuration of Sc.

7. Which of the following has the smallest atomic radius?
   (a) S  (b) P  (c) Si  (d) Al  (e) Cl

8. A balloon is filled to a volume of $6.00 \times 10^2$ mL at a temperature of 20.0°C. The balloon is then cooled to a temperature of $1.0 \times 10^2$ K. What is the final volume?

9. Determine the oxidation number of lead in the following oxides:
   a. PbO  
   b. PbO$_2$  
   c. Pb$_2$O$_3$  
   d. Pb$_2$O$_4$

10. Iron can react with oxygen to give iron(III) oxide. What is the enthalpy of the reaction if 5.58 g of Fe is heated in pure O$_2$?  
     \[
     4 \text{Fe}(s) + 3 \text{O}_2(g) \rightarrow 2 \text{Fe}_2\text{O}_3(s) \quad \Delta H = -1648.4 \text{ kJ}
     \]

Set #2

1. It is found that 22.3 mL of 0.240 M NaOH is required to completely react with a 50.0-mL sample of vinegar, a solution of acetic acid in water. The net ionic equation for the reaction is

   \[
   \text{HC}_2\text{H}_3\text{O}_2(aq) + \text{OH}^-\_{(aq)} \rightarrow \text{C}_2\text{H}_3\text{O}_2^-\_{(aq)} + \text{H}_2\text{O}(l)
   \]

   Calculate the concentration of acetic acid in the vinegar.

2. If the air we breathe is 78% N$_2$ and 22% O$_2$ on a mole basis, what is the mole fraction of O$_2$? What is the partial pressure of O$_2$ if the total pressure is 0.947 atm?

3. What volume of each of the following acids will react completely with 50.00 mL of 0.200 M NaOH?
   a. 0.100 M HCl  
   b. 0.0598 M HNO$_3$  
   c. 1.23 M H$_2$SO$_4$
4. Given the following elements and three values of possible first ionization energies:
   Cl, Ge, K and 418, 1255, 784 kJ mol\(^{-1}\), match the atoms with their first ionization energies.

5. Identify the atom with ground-state electron configuration [Ne]3s\(^2\)3p\(^4\).

6. Identify the following reactions as either dissolution, precipitation, redox, or acid-base:
   a. \( \text{N}_2\text{O}_5(g) + 2 \text{NaOH}(aq) \rightarrow 2 \text{NaNO}_3(aq) + \text{H}_2\text{O}(l) \)
   b. \( \text{P}_4\text{O}_{10}(s) + 5 \text{C}(s) \rightarrow \text{P}_4(g) + 5 \text{CO}_2(g) \)
   c. \( 3 \text{Ca(NO}_3)_2(2aq) + 2 \text{K}_2\text{PO}_4(4aq) \rightarrow \text{Ca}_3(\text{PO}_4)_2(2s) + 6 \text{KNO}_3(aq) \)
   d. \( (\text{NH}_4)_2\text{SO}_4(2aq) + \text{Ba(OH)}_2(2aq) \rightarrow \text{BaSO}_4(4s) + 2 \text{NH}_3(g) + 2 \text{H}_2\text{O}(l) \)
   e. \( 2 \text{KMnO}_4(s) \rightarrow \text{K}_2\text{MnO}_4(4s) + \text{MnO}_2(s) + \text{O}_2(g) \)

7. Write net ionic equations for each of the reactions in #6.

8. Consider the two flasks in the diagram below. Once the stopcock (valve) connecting the two flasks is opened, what is the partial pressure of each gas and the total pressure in the resulting system? Assume the connecting tubes have negligible volume.

Set 1 - KEY

1. 37 g urea  
2. Molar mass = 64.0 g mol\(^{-1}\), Empirical Formula = CHF, Molecular Formula = C\(_2\)H\(_2\)F\(_2\)
3. a. \( \text{H}^+(aq) + \text{HCO}_3^-(aq) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(l) \)
   b. \( \text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l) \)
   c. \( \text{NH}_4^+(aq) + \text{OH}^-(aq) \rightarrow \text{NH}_3(g) + \text{H}_2\text{O}(l) \)
4. 0.010 mol \text{NO}_3^- in sol’n, [\text{NO}_3^-] = 0.033 M; 0.040 mol \text{Na}^+ in sol’n, [\text{Na}^+] = 0.13 M; 0.030 mol \text{OH}^- in sol’n, [\text{OH}^-] = 0.10 M
5. 4p  
6. 1s\(^2\) 2s\(^2\) 2p\(^6\) 3s\(^2\) 3p\(^\qquad\) 4s\(^2\) 3d\(^\downarrow\)  
7. (e) Cl  
8. \( V_l = 2.0 \times 10^4 \text{ mL or } 0.20 \text{ L} \)
9. a. +2  
   b. +4  
   c. +3  
   d. +4  
   10. \( \Delta H = -41.2 \text{ kJ} \)

Set 2 - KEY

1. [\text{HC}_2\text{H}_2\text{O}_2] = 0.107 M  
2. X: O\(_2\) = 0.22, P\(_{O_2}\) = 0.21 atm  
3. a. \( V_{\text{HCl}} = 0.100 \text{ L} \)  
   b. \( V_{\text{HNO}_3} = 0.167 \text{ L} \)  
   c. \( V_{\text{HBr}} = .00407 \text{ L} \)
4. Cl = 1255 kJ, Ge = 784 kJ, K = 418 kJ  
5. S
6. a. acid-base  
   b. redox  
   c. precipitation  
   d. acid-base  
   e. redox
7. a. \( \text{N}_2\text{O}_5(g) + 2 \text{OH}^-(aq) \rightarrow 2 \text{NO}_3^-(aq) + \text{H}_2\text{O}(l) \)
   b. & e. As written originally
   c. \( 3 \text{Ca}^{2+}(aq) + 2 \text{PO}_4^{3-}(aq) \rightarrow \text{Ca}_3(\text{PO}_4)_2(2s) \)
   d. \( 2 \text{NH}_4^+(aq) + \text{SO}_4^{2-}(aq) + \text{Ba}^{2+}(aq) + 2 \text{OH}^-(aq) \rightarrow \text{BaSO}_4(4s) + 2 \text{NH}_3(g) + 2 \text{H}_2\text{O}(l) \)
8. \( P_{\text{Ar}} = 0.11 \text{ atm} \)  
   \( P_{\text{O}_2} = 0.59 \text{ atm} \)  
   \( P_{\text{tot}} = 0.70 \text{ atm} \)
9. When ice melts it is endothermic with respect to the ice. When water freezes it is exothermic with respect to the liquid.