EQUILIBRIUM ASSIGNMENT

1. Write the equilibrium expression for each homogeneous reaction.
   a. The reaction between nitrogen gas and oxygen gas at high temperatures:
      $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$
   b. The reaction between hydrogen gas and oxygen gas to form water vapour:
      $2H_2(g) + O_2(g) \leftrightarrow 2H_2O(g)$
   c. The reduction-oxidation equilibrium of iron and iodine ions in aqueous solution:
      $2Fe^{+3}(aq) + 2I^{-1}(aq) \leftrightarrow 2Fe^{+2}(aq) + I_2(aq)$
   d. The oxidation of ammonia: $4NH_3(g) + 5O_2(g) \leftrightarrow 4NO(g) + 6H_2O(g)$

2. The following reaction took place in a sealed flask at 250°C.
   $PCl_5(g) \leftrightarrow PCl_3(g) + Cl_2(g)$. At equilibrium, the gases in the flask had the following concentrations: $[PCl_5] = 0.012$ mol/L, $[PCl_3] = 0.015$ mol/L and $[Cl_2] = 0.015$ mol/L. Calculate the value of Kc at 250°C.

3. Iodine and bromine react to form iodine monobromide, IBr.
   $I_2(g) + Br_2(g) \leftrightarrow 2IBr(g)$ At 150°C, an equilibrium mixture in a 2.0 L flask contained 0.024 mol of iodine, 0.050 mol of bromine and 0.38 mol of IBr(g). What is the value of Kc for the reaction at 150°C?

4. At high temperatures, carbon dioxide gas decomposes into carbon monoxide and oxygen gas. At equilibrium, the gases have the following concentrations: $[CO_2] = 1.2$ mol/L, $[CO] = 0.35$ mol/L and $[O_2] = 0.15$ mol/L. Determine Kc at the temperature of the reaction.

5. At 25°C, the value of Kc for the following reaction is 82.
   $I_2(g) + Cl_2(g) \leftrightarrow 2ICl(g)$. 0.83 mol of iodine and 0.83 mol of chlorine are placed in a 10 L container at 25°C. What are the concentrations of the three gases at equilibrium?

6. At a certain temperature, Kc = 4.0 for the following reaction:
   $2HF(g) \leftrightarrow H_2(g) + F_2(g)$. A 1.0 L reaction vessel contained 0.045 mol of fluorine at equilibrium. What was the initial amount of HF in the reaction vessel? Assume we only had HF at the beginning of the reaction.

7. A chemist was studying the following reaction:
   $SO_2(g) + NO_2(g) \leftrightarrow NO(g) + SO_3(g)$. In a 1.0 container, the chemist added 0.17 mol of sulfur dioxide to 0.11 mol of nitrogen dioxide. The value of Kc for the reaction at a certain temperature is 4.8. What is the equilibrium concentration of sulfur trioxide at this temperature?

8. Phosgene, $COCl_2(g)$, is an extremely toxic gas. It was used during World War I. Today it is used to manufacture pesticides, pharmaceuticals, dyes and polymers. It is prepared by mixing carbon monoxide and chlorine gas.

$CO(g) + Cl_2(g) \leftrightarrow COCl_2(g)$. 0.055 mol of CO(g) and 0.072 mol of chlorine gas are placed in a 5.0 L container. At 870 K, the equilibrium constant is 0.20. What are the equilibrium concentrations of the mixture at 870 K?

9. Hydrogen bromide decomposes at 700 K. $2HBr(g) \leftrightarrow H_2(g) + Br_2(g)$. $Kc = 4.2*10^{-9}$. If 0.09 mol of HBr(g) is placed in a 2.0 L reaction vessel and heated to 700 K. What is the equilibrium concentration of each gas?

10. Three reactions and their equilibrium constants are given below. Arrange these reactions in the order of their tendency to form products.
    a. $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$, $Kc = 4.7*10^{-31}$
    b. $2NO(g) + O_2(g) \leftrightarrow 2NO_2(g)$, $Kc = 1.8*10^{-6}$
    c. $N_2O_4(g) \leftrightarrow 2NO_2(g)$, $Kc = 0.025$

11. The following equation represents the equilibrium reaction for the dissociation of phosgene gas. $COCl_2(g) \leftrightarrow CO(g) + Cl_2(g)$. At 100°C, the value of Kc for this reaction is $2.2*10^{-8}$. The initial concentration of phosgene in a closed container at 100°C is 1.5 mol/L. What are the equilibrium concentrations of CO(g) and chlorine gas?

12. Hydrogen sulfide is a poisonous gas with a characteristic, offensive odour. It dissociates at 1400°C, with Kc equal to $2.4*10^{-4}$. $2H_2S(g) \leftrightarrow 2H_2(g) + S_2(g)$. If 4.0 mol of hydrogen sulfide is placed in a 3.0 L container, what is the equilibrium concentration of hydrogen at 1400°C?

13. At a certain temperature, the value of Kc for the following reaction is $3.3*10^{-12}$. $2NCl_3(g) \leftrightarrow N_2(g) + 3Cl_2(g)$. A certain amount of nitrogen trichloride is put in a 1.0 L reaction vessel at this temperature. At equilibrium, $4.6*10^{-6}$ mol of nitrogen gas is present. What amount of nitrogen trichloride was put in the reaction vessel?

14. At a certain temperature, the value of Kc for the following reaction is $4.2*10^{-8}$. $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$. If 0.45 mol of nitrogen gas and 0.26 mol of oxygen gas are put in a 6.0 L reaction vessel, what is the equilibrium concentration of NO(g) at this temperature?

15. At a particular temperature, Kc for the decomposition of carbon dioxide is $2.0*10^{-6}$. $2CO_2(g) \leftrightarrow 2CO(g) + O_2(g)$. 3.0 mol of carbon dioxide is put in a 5.0 L container. Calculate the equilibrium concentration of each gas.