Equilibrium

1. Balance the following reactions if they are not balanced already and then write the equilibrium constant expression for each reaction:

   $Ni(s) + CO_2(g) \leftrightarrow CO(g) + NiO(s)$ no solids in K_c expressions

   $K_c = \frac{[CO]}{[CO_2]}$

   $2\,SO_2(g) + O_2(g) \leftrightarrow 2\,SO_3(g)$

   $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

   $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \leftrightarrow BaSO_4(s) + 2\,NaNO_3(aq)$

   $K_c = \frac{[NaNO_3]^2}{[Ba(NO_3)_2][Na_2SO_4]}$

2. For the system, if we start with 0.100 mol/L of CO_2 and H_2, what are the concentrations of the reactants and products at equilibrium given that $K_{eq} = 0.64$ at 900K:

R	$CO_2 + H_2 \rightleftharpoons CO + H_2O$			
I	0.100M	0.100M	0	0
C	−x	−x	+x	+x
E	0.100−x	0.100−x	x	x

$K_{eq} = \frac{[CO][H_2O]}{[CO_2][H_2]} = \frac{(x)(x)}{(0.100-x)^2}$

$0.64 = \sqrt{\frac{x^2}{(0.100-x)^2}}$

$0.80 = \frac{x}{0.100-x}$

$0.080 - 0.80x = 1x$

$1.80x = 0.080$

$x = 0.0444$

$[CO] = [H_2O] = 0.0444\,M$

$[CO_2] = [H_2] = 0.0556\,M$

3. Calculate the equilibrium constant for the following hypothetical reactions. Assume that all components of the reactions are gaseous:

   a) $A \leftrightarrow C + D$ $K_{eq} = \frac{[C][D]}{[A]}$

At equilibrium, the concentration of A is 2.24×10^{-2} M and the concentrations of both C and D are 6.41×10^{-3} M:

$$K_{eq} = \frac{[6.41 \times 10^{-3}][6.41 \times 10^{-3}]}{[2.24 \times 10^{-2}]} = \frac{(6.41 \times 10^{-3})^2}{(2.24 \times 10^{-2})}$$

$$K_{eq} = 1.83 \times 10^{-3}$$

b) $A + B \leftrightarrow C + D$

$$K_{eq} = \frac{[C][D]}{[A][B]}$$

At equilibrium, the concentrations of both A and B are 3.23×10^{-5} M and the concentrations of both C and D are 1.27×10^{-2} M:

$$K_{eq} = \frac{[1.27 \times 10^{-2}][1.27 \times 10^{-2}]}{[3.23 \times 10^{-5}][3.23 \times 10^{-5}]}$$

$$= \frac{(1.27 \times 10^{-2})^2}{(3.23 \times 10^{-5})^2}$$

$$K_{eq} = 1.55 \times 10^{5}$$