WKS
Equilibrium Constants

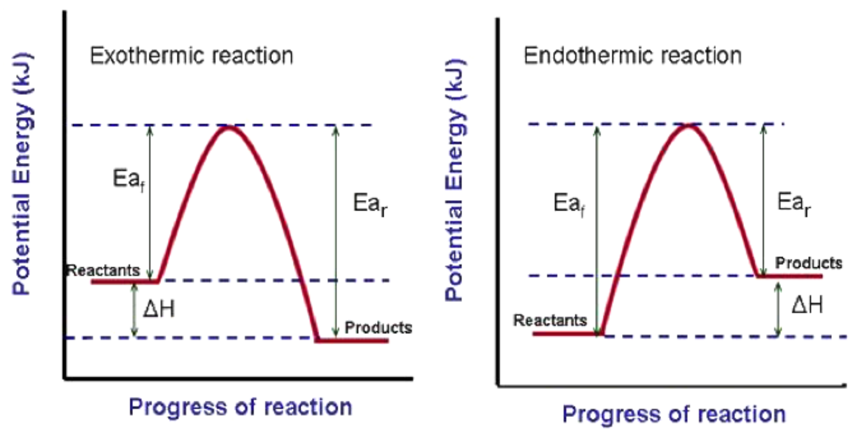
Name Answer Key
Period __________ Date ______________

1) Explain what is incorrect about the following statements:
   a) At equilibrium no more reactants are transformed into products.
   In dynamic equilibrium, reactants and products are continually reacting to form the other.

   b) At equilibrium there are equal amounts of reactants and products.
   While the forward and reverse rates are equal, the concentrations of reactants and products are ***constant***. While they may be equal, this is not required.

2) A flask contains a saturated aqueous NaCl solution that is in contact with 10.0 g of undissolved **NaCl powder**. The flask is stoppered and left undisturbed. A year later it is observed that the system contains a **single, large 10.0 g crystal of NaCl** in contact with the solution.
Explain how this observation can be used to support the notion that equilibrium is a ***dynamic*** *process.*
In a saturated solution, dissolving and crystallizing are continually occurring: NaCl (s) $\rightleftharpoons$ NaCl (aq). The powder dissolves more quickly than larger crystals (surface area!), so during equilibrium the larger crystals will tend to grow until only a single large crystal remains.

3) Look at the two energy diagrams at the right (one is exothermic and the other is endothermic). Which reaction would favor reactants at equilibrium? Why?
Endothermic. The $E_{a,f}$ is larger than $E_{a,r}$ so $k_r > k_f$, so reactants are formed faster than products.



4) Write the K_{eq} expressions for the following reactions. *Remember:* $K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$ *No numbers!!!*

   a) $N_2\,(g) + O_2\,(g) \rightleftharpoons 2\,NO\,(g)$

   $$K_{eq} = \frac{[NO]^2}{[N_2][O_2]}$$

   b) $2\,N_2O_5\,(g) \rightleftharpoons 4\,NO_2\,(g) + O_2\,(g)$

   $$K_{eq} = \frac{[NO_2]^4[O_2]}{[N_2O_5]^2}$$

   c) $4\,H_3O^+\,(aq) + 2\,Cl^-\,(aq) + MnO_2\,(s) \rightleftharpoons Mn^{2+}\,(aq) + 6\,H_2O\,(l) + Cl_2\,(g)$

   $$K_{eq} = \frac{[Mn^{2+}][Cl_2]}{[H_3O^+]^4[Cl^-]^2}$$

   d) $2\,PbO\,(s) + 3\,O_2\,(g) + C\,(s) \rightleftharpoons 2\,Pb\,(l) + CO_2\,(g) + 2\,SO_2\,(g)$

   $$K_{eq} = \frac{[CO_2][SO_2]^2}{[O_2]^3}$$

5) A system is described by the equation: 2 $SO_2(g)$ + O_2 (g) $\rightleftharpoons$ 2 SO_3 (g)
At equilibrium, the concentrations of reactants and products are as follows:
$[SO_2]$ = 0.75 M $[O_2]$ = 0.30 M $[SO_3]$ = 0.15 M
Write the K_{eq} expression and then solve for the value of K_{eq} for this reaction.

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(0.15)^2}{(0.75)^2(0.30)} = \boxed{0.13}$$

6) A system is described by this equation: PCl_5 (g) $\rightleftarrows$ PCl_3 (g) + Cl_2 (g)
The equilibrium constant (K_{eq}) for this reaction is 0.0896
If at one equilibrium position, $[PCl_5]$ = 0.015 M and $[PCl_3]$ = 0.78, what must be the concentration of Cl_2?

$$K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]} \Rightarrow [Cl_2] = \frac{K_{eq}[PCl_5]}{[PCl_3]} = \frac{(0.0896)(0.015)}{(0.78)} = \boxed{0.0017\ \text{M}}$$