Question 6

$$Ba^{2+}(aq) + EDTA^{4-}(aq) \rightleftarrows Ba(EDTA)^{2-}(aq) \qquad\qquad K = 7.7 \times 10^7$$

The polyatomic ion $C_{10}H_{12}N_2O_8{}^{4-}$ is commonly abbreviated as $EDTA^{4-}$. The ion can form complexes with metal ions in aqueous solutions. A complex of $EDTA^{4-}$ with Ba^{2+} ion forms according to the equation above. A 50.0 mL volume of a solution that has an $EDTA^{4-}(aq)$ concentration of 0.30 M is mixed with 50.0 mL of 0.20 M $Ba(NO_3)_2$ to produce 100.0 mL of solution.

(a) Considering the value of K for the reaction, determine the concentration of $Ba(EDTA)^{2-}(aq)$ in the 100.0 mL of solution. Justify your answer.

Based on the K value, the reaction goes essentially to completion. $Ba^{2+}(aq)$ is the limiting reactant.	1 point is earned for indicating that the equilibrium concentration of $Ba(EDTA)^{2-}(aq)$ is the same as the original concentration of Ba^{2+} when the solutions are mixed.
The concentration of Ba^{2+} when the solutions are first mixed but before any reaction takes place is 0.20 $M/2 = 0.10$ M.	
Thus the equilibrium concentration of $Ba(EDTA)^{2-}(aq)$ is 0.10 M.	1 point is earned for the concentration with appropriate calculations.

(b) The solution is diluted with distilled water to a total volume of 1.00 L. After equilibrium has been reestablished, is the number of moles of $Ba^{2+}(aq)$ present in the solution greater than, less than, or equal to the number of moles of $Ba^{2+}(aq)$ present in the original solution before it was diluted? Justify your answer.

The number of moles of $Ba^{2+}(aq)$ increases because the percent dissociation of $Ba(EDTA)^{2-}(aq)$ increases as the solution is diluted.	
OR	
A mathematical justification such as the following:	
The dilution from 100.0 mL to 1.00 L reduces the concentrations of all species to one tenth of their original values.	1 point is earned for stating that the number of moles of $Ba^{2+}(aq)$ will increase.
Immediately after the dilution, the reaction quotient, Q, can be determined as shown below. $$Q = \dfrac{\frac{1}{10}[Ba(EDTA)^{2-}]}{\frac{1}{10}[Ba^{2+}] \times \frac{1}{10}[EDTA^{4-}]} = 10K$$	1 point is earned for a valid justification.
Because $Q > K$, the net reaction will produce more reactants to move toward equilibrium, so the number of moles of $Ba^{2+}(aq)$ will be greater than the number in the original solution.	