

2016 AP® CHEMISTRY FREE-RESPONSE QUESTIONS



6. The polyatomic ion $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_8^{4-}$ 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 $\text{EDTA}^{4-}(aq)$ concentration of 0.30 M is mixed with 50.0 mL of 0.20 M $\text{Ba}(\text{NO}_3)_2$ to produce 100.0 mL of solution.
- (a) Considering the value of K for the reaction, determine the concentration of $\text{Ba(EDTA)}^{2-}(aq)$ in the 100.0 mL of solution. Justify your answer.
- (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 $\text{Ba}^{2+}(aq)$ present in the solution greater than, less than, or equal to the number of moles of $\text{Ba}^{2+}(aq)$ present in the original solution before it was diluted? Justify your answer.

**AP[®] CHEMISTRY
2016 SCORING GUIDELINES**

Question 6



The polyatomic ion $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_8^{4-}$ 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 $\text{EDTA}^{4-}(aq)$ concentration of 0.30 M is mixed with 50.0 mL of 0.20 M $\text{Ba}(\text{NO}_3)_2$ to produce 100.0 mL of solution.

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

<p>Based on the K value, the reaction goes essentially to completion. $\text{Ba}^{2+}(aq)$ is the limiting reactant.</p> <p>The concentration of Ba^{2+} when the solutions are first mixed but before any reaction takes place is $0.20 \text{ M}/2 = 0.10 \text{ M}$.</p> <p>Thus the equilibrium concentration of $\text{Ba(EDTA)}^{2-}(aq)$ is 0.10 M.</p>	<p>1 point is earned for indicating that the equilibrium concentration of $\text{Ba(EDTA)}^{2-}(aq)$ is the same as the original concentration of Ba^{2+} when the solutions are mixed.</p> <p>1 point is earned for the concentration with appropriate calculations.</p>
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- (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 $\text{Ba}^{2+}(aq)$ present in the solution greater than, less than, or equal to the number of moles of $\text{Ba}^{2+}(aq)$ present in the original solution before it was diluted? Justify your answer.

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