

**2016 AP<sup>®</sup> 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  $\text{EDTA}^{4-}$ . The ion can form complexes with metal ions in aqueous solutions. A complex of  $\text{EDTA}^{4-}$  with  $\text{Ba}^{2+}$  ion forms according to the equation above. A 50.0 mL volume of a solution that has an  $\text{EDTA}^{4-}(\text{aq})$  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  $\text{Ba}(\text{EDTA})^{2-}(\text{aq})$  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  $\text{Ba}^{2+}(\text{aq})$  present in the solution greater than, less than, or equal to the number of moles of  $\text{Ba}^{2+}(\text{aq})$  present in the original solution before it was diluted? Justify your answer.

# AP<sup>®</sup> CHEMISTRY

## 2016 SCORING GUIDELINES

### Question 6



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

Based on the  $K$  value, the reaction goes essentially to completion.  $\text{Ba}^{2+}(\text{aq})$  is the limiting reactant.

The concentration of  $\text{Ba}^{2+}$  when the solutions are first mixed but before any reaction takes place is  $0.20 \text{ M}/2 = 0.10 \text{ M}$ .

Thus the equilibrium concentration of  $\text{Ba}(\text{EDTA})^{2-}(\text{aq})$  is 0.10 M.

1 point is earned for indicating that the equilibrium concentration of  $\text{Ba}(\text{EDTA})^{2-}(\text{aq})$  is the same as the original concentration of  $\text{Ba}^{2+}$  when the solutions are mixed.

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  $\text{Ba}^{2+}(\text{aq})$  present in the solution greater than, less than, or equal to the number of moles of  $\text{Ba}^{2+}(\text{aq})$  present in the original solution before it was diluted? Justify your answer.

The number of moles of  $\text{Ba}^{2+}(\text{aq})$  increases because the percent dissociation of  $\text{Ba}(\text{EDTA})^{2-}(\text{aq})$  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.

Immediately after the dilution, the reaction quotient,  $Q$ , can be determined as shown below.

$$Q = \frac{\frac{1}{10}[\text{Ba}(\text{EDTA})^{2-}]}{\frac{1}{10}[\text{Ba}^{2+}] \times \frac{1}{10}[\text{EDTA}^{4-}]} = 10K$$

Because  $Q > K$ , the net reaction will produce more reactants to move toward equilibrium, so the number of moles of  $\text{Ba}^{2+}(\text{aq})$  will be greater than the number in the original solution.

1 point is earned for stating that the number of moles of  $\text{Ba}^{2+}(\text{aq})$  will increase.

1 point is earned for a valid justification.