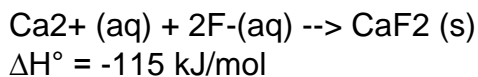


In the lab you mix 50.0 mL of 0.250 M Ca(NO₃)₂ with 50.0 mL of 0.500 M NaF in a coffee cup calorimeter to form a CaF₂ precipitate. The initial temperature of each solution is 23 degrees celsius. Assuming that the final solution has a total mass of 100.0 g and a specific heat of 4.18 J/g degrees celsius, calculate the final temperature you expect for the solution. Assume no heat is lost to the calorimeter.



Solution:

First you need to determine which reactant is the limiting one. That is, which reactant will run out first. It will determine how much heat is given off.

$$\begin{aligned} \text{moles Ca}^{2+} &= M \text{ Ca}^{2+} \times L \text{ Ca}^{2+} = (0.250)(0.0500) = 0.0125 \text{ moles Ca}^{2+} \\ \text{moles F}^{-} &= M \text{ F}^{-} \times L \text{ F}^{-} = (0.500)(0.0500) = 0.0250 \text{ moles F}^{-} \end{aligned}$$

The balanced equation tells us that it takes 2 moles of F⁻ to react with 1 mole of Ca²⁺, and that's exactly what we have: 0.0250 moles F⁻ / 0.0125 moles Ca²⁺ = 2/1. So both reactants will run out at the same time.

The equation also tells us that 1 mole of Ca²⁺ (or 2 moles of F⁻) will produce -11.5 kJ of heat. So how much heat will 0.0125 moles of Ca²⁺ produce?

$$0.0125 \text{ moles Ca}^{2+} \times (-11.5 \text{ kJ heat} / 1 \text{ mole Ca}^{2+}) = 0.144 \text{ kJ heat} = 144 \text{ J heat}$$

This amount of heat was absorbed by the water, causing the water temperature to increase.

$$\begin{aligned} \text{Heat gained by water} &= (\text{mass H}_2\text{O})(\text{specific heat H}_2\text{O})(T_f - T_i) \\ 144 \text{ J} &= (100 \text{ g H}_2\text{O})(4.18 \text{ J} / \text{g C})(T_f - 23.0) \\ 144 &= 418T_f - 9614 \\ 9844 &= 418T_f \\ T_f &= 23.55 \text{ C.} \end{aligned}$$

Answer: $T_f = 23.55 \text{ C.}$