Question #59430, Chemistry / General Chemistry

Question:
What is the final temperature of a solution formed when 0.75 g of KMnO4 is added to 85.5 g of water at 13.2 °C in a calorimeter?
$KMnO_4$ (s) -> K+ (aq) + MnO_4 (aq) ΔH = +42.1 kJ/mol

Solution:

One should note that the enthalpy of reaction is positive. This means that the heat is absorbed during the reaction. Let's calculate the number of the heat absorbed by the solution:

$$Q = \Delta H \cdot n(KMnO_4)$$

To calculate the number of the moles of potassium permanganate, we should divide the mass by molar mass (158.034 g/mol for $KMnO_4$):

$$n(KMnO_4) = \frac{m}{M} = \frac{0.75\ g}{158.034\ g/mol} = 0.0047(5)\ mol$$

Then, the quantity of the heat is:

$$Q = 42.1 \cdot 0.00475 = 0.20\ kJ$$

Let's assume, that there is no loose of energy during the process and all heat absorbed by potassium permanganate is due to its dissolvation. Then, final temperature can be calculated through specific heat capacity. Also, let's assume that the heat capacity of pure water is the same as the heat capacity of the solution (4.186 J/g·°C)

$$Q + cm_{solution}(T_2 - T_1) = 0$$

$$T_2 = \frac{-Q}{cm_{solution}} + T_1$$

$$T_2 = \frac{-0.20 \cdot 10^3 J}{4.186(J/g \cdot °C) \cdot 86.26(g)} + 13.2 = 12.7°C$$

Answer: 12.7 °C