TEAM PROBLEM
Chapter 12

You have 100.0mL of NaCl solution that is 13.5% by mass (with a density of 1.12 g/mL). If you wanted the boiling point to be 104.4⁰C, you will need to add either NaCl or water. Which will you add and what mass is needed?

ANSWER:

Plan for how to solve
- Find out the molality needed to raise the BP to 104.4⁰C
- Find the molality of the current solution
- Decide if you need to add NaCl (b/c it the concentration is too low) or water (b/c the concentration is too high)
- Figure out how much to add

Step 1: Find the molality to raise the BP to 104.4⁰C
- $\Delta T_b = i \, K_b \, m$
  - i is the van't Hoff factor – because NaCl dissolves into 2 ions we use "2"
  - K_b is the boiling point elevation constant – look it up to get 0.52 ⁰C/m
- 4.4⁰C = (2) (0.52 ⁰C/m) m
  4.23m = m   this is the molality (moles of solute per kg of solvent) that is required

Step 2: Find the molality of the current solution
- molality is moles of solute per kg of solvent
  - need the moles of NaCl
  - need the kg of water
- 100.0mL (1.12 g/ 1mL) = 112 g of solution (not water)
- 13.5% by mass is NaCl
  - 112g (13.5gNaCl / 100g solution) = 15.12g NaCl is dissolved
  - That means 112g solution – 15.12g NaCl = 96.88g is water = 0.09688 kg H_2O
- 15.12g NaCl (1mol/58.5gNaCl) = 0.26mol NaCl
- 0.26mol NaCl / 0.09688kg H_2O = 2.68 m ← this is the molality of the current solution

Step 3: Decide if you need to add NaCl or water
- You need: 4.23m
- You have: 2.68m
  - the solution is not concentrated enough – you will need to add salt

Step 4: Figure out how much NaCl to add
- First figure out how much total NaCl you would need to add using the correct molality
  - 0.09688 kg H_2O (4.23 mol NaCl / 1kg H_2O) = 0.41mol NaCl
  - 0.41mol NaCl (58.5g/1mol) = 23.97g NaCl
- Decide how much you need to add
  - the solution already has 15.12g NaCl (from earlier calculation)
  - 23.97g – 15.12g = 8.85g of NaCl needs to be added!