Colligative Mole Fraction and Vapor Pressure

Consider the following problem:

What would be the vapor pressure of water at 70°C above a solution made by dissolving 37.840 g of sodium nitrate, $NaNO_3$, in 281.52 g of water? The vapor pressure of pure water at this temperature is 233.70 mmHg. Assume complete dissociation of solute.

Solution: when we see problems that have vapor pressure and salts dissolved into a solvent, we should think of colligative properties with ionic solutions in particular in this case Raoult's law; your book tells you to use: $P_A = i \cdot P_A^o \cdot X_A$. These problems were written to take into account the total number of particles in another way and you should use the following instead to solve the problems.

$$P_A = P_A^o \cdot X_{A,c} \text{ where } X_{A,c} = \text{colligative mole fraction.}$$

$$X_{A,c} = \frac{n_A}{n_A + i \cdot n_B} \text{ where I = van't Hoff factor.}$$

1. Determine colligative mole fraction:
n_A = mol water = 281.52/18.01 = 15.63 mol
n_B = mol $NaNO_3$ = 37.840/85.00 = 0.445 mol
i = 2

$$X_{A,c} = \frac{15.63}{15.63 + 2 \cdot 0.445} = 0.946$$

2. Substitute into above equation and determine answer:

$$P_A = 233.70 \cdot 0.946 = 221.1 \text{ torr}$$ Q.E.D.