Answer on Question #63254 - Chemistry - General Chemistry

Question: A small cube of lithium (density ρ = 0.535 g/cm^3) measuring 1.0 mm on each edge is added to 0.550 L of water. The following reaction occurs: 2Li(s)+2H_2O(l)→2LiOH(aq)+H_2(g) 1) What is the freezing point of the resultant solution, assuming that the reaction goes to completion?

Solution

1) Find the volume of the Li cube added: $V(Li) = a^3 = (1 * 10^{-1} cm)^3 = 10^{-3}\ cm^3$
2) Find the mass of Li added: $m(Li) = V(Li) * \rho(Li) = \ 10^{-3}\ cm^3 * 0{,}535 \frac{g}{cm^3} = 5{,}35 * 10^{-4}\ g$
3) Find the amount of substance of Li: $\nu(Li) = \frac{m(Li)}{M(Li)} = \frac{5{,}35*10^{-4} g}{6{,}941 g/mol} = 7{,}708 * 10^{-5} mol$
4) Find the mass of H_2O involved into the reaction according to the reaction equation

$$2Li + 2H_2O \rightarrow 2LiOH + H_2 \uparrow$$

$$m(H_2O) = m(Li) * \frac{2M(H_2O)}{2M(Li)} = 5{,}35 * 10^{-4} g * \frac{36 \frac{g}{mol}}{13{,}882 \frac{g}{mol}} = 1{,}39 * 10^{-3} g$$

As we can see, the mass of H_2O involved into the reaction is very small related to the total mass of H_2O and we can neglect the decrease in the total mass of water and assume that the volume and, respectively, the mass of water remained 0,550 L (kg).
5) The amount of substance of lithium hydroxide is equal to the amount of Li involved into the reaction, as we assume that the reaction goes to completion: $\nu(LiOH) = 7{,}708 * 10^{-5} mol$
6) Colligative properties of solutions depend only on the concentration of dissolved particles but not on their origin. LiOH is a strong base which in aqueous solutions undergoes complete dissociation to Li^+ and OH^-, so the amount of substance of ions (dissolved particles) is twice as big as the amount of substance of LiOH: $\nu(ions) = 1{,}5416 * 10^{-4} mol$
7) Now we can put all the necessary values into the equation for calculation of the decrease of the freezing point: $\Delta T_f = K_f * C_m * i$, where K_f is the cryoscopic constant of water (1,853 K*kg/mol), C_m is the molality of the solution, *i* is the van 't Hoff factor (2 for LiOH in our case).

$$\Delta T_f = K_f * C_m * i = 1{,}853 * \frac{1{,}5416 * 10^{-4}}{0{,}55} * 2 = 1{,}039 * 10^{-3} K$$

The decrease of the freezing temperature in Kelvin degrees is equal in its absolute value to the decrease in Celsius degrees, so the resulting freezing temperature of the solution in Celsius degrees is $T_f(°C) = 0 - 1{,}039 * 10^{-3} = -1{,}039 * 10^{-3}$°C
Answer: the freezing temperature of the resulting solution is $-1{,}039 * 10^{-3}$°C.