Converting Concentration.

Molarity, $M = \frac{n_{solute}}{L_{soln}}$ molality, $m = \frac{n_{solute}}{Kg_{solvent}}$ mole fraction, $\chi_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$

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3 M $HCl_{(aq)}$, $D_{HCl} = 1.050$ g/ml

↳ solute : HCl ⇒ molar mass ($m.m_{HCl}$) = 36.46 g/mol

solvent : H_2O ⇒ molar mass ($m.m_{H_2O}$) = 18.02 g/mol

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1. 3 M ⟶ ??? m.

a. start w/ M, assume 1 L solution ⇒ $n_{solute} = M \times L_{soln} = 3\ (\frac{mol}{L}) \times 1\ L = 3$ mole

b. calculate $Kg_{solvent}$, ⇒ $Kg_{,solvent} = Kg_{,soln} - Kg_{,solute} = \boxed{D_{soln} \times L_{soln}} - \boxed{m.m_{solute} \cdot n_{solute}}$

$= 1.050\ (\frac{g}{ml}) \times 1L\ (\frac{1000\ ml}{L}) - 36.46\ (\frac{g}{mol}) \times 3\ mol$

$= 1050\ g - 109.38\ g = 940.62\ g = 0.94062\ Kg$

c. calculate molality, m ⇒ $m = \frac{n_{solute}}{Kg_{,solvent}} = \frac{3\ mole}{0.94062\ Kg} = \boxed{3.189\ m}$

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2. 3.189 m ⟶ χ_{solute}

a. start w/ m, assume 1 Kg solvent ⇒ $n_{solute} = m \times Kg_{,solvent} = 3.189\ (\frac{mole}{Kg}) \times 1Kg = 3.189$ m

b. calculate $n_{solvent}$ ⇒ $n_{solvent} = \frac{Mass_{,solvent}}{m.m_{,solvent}} = \frac{1Kg \times (\frac{1000g}{Kg})}{18.02\ g/mol} = 55.494$ mole

c. calculate χ_{solute} ⇒ $\chi_{solute} = \frac{n_{solute}}{n_{solute} + n_{solvent}} = \frac{3.189}{3.189 + 55.494} = \boxed{0.0543}$

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3. χ_{solute} of 0.0543 ⟶ ??? M

a. start w/ χ_{solute}, assume 1 mole in total ⇒ $n_{solute} = 0.0543$

$n_{solvent} = 1 - n_{solute} = 1 - 0.0543 = 0.9457$

b. calculate $L_{solution}$ w $D_{solution}$ and $Mass_{,solution}$ ⇒ $L_{solution} = \frac{Mass_{,solution}}{D_{solution}}$

$Mass_{,solution} = Mass_{,solute} + Mass_{,solvent} = n_{solute} \cdot m.m_{solute} + n_{solvent} \cdot m.m_{solvent}$

$= 0.0543\ mol \cdot 36.46\ (\frac{g}{mol}) + 0.9457\ mole \cdot 18.02\ (\frac{g}{mol})$

$= 19.021\ g$

$L_{solution} = \frac{Mass_{,solution}}{D_{solution}} = \frac{19.021\ g}{1.050\ g/ml} = 18.115\ ml = 0.018115\ L$

c. calculate molarity, M ⇒ $M = \frac{n_{solute}}{L_{,solution}} = \frac{0.0543}{0.018115} = \boxed{3\ M}$