Carol the brilliant laboratory technician, was asked to make up 5 litres of 2M solution of HCL from the concentrated solution. unfortuently she lost her preparation notes and cannot remember the volumes required. The label on the right was scanned from the concentration HCL bottle obtained from the European chemical company Scharlau.
The Two critical pieces of data are:
32% reagent grade which means the chemical has a minimum assay strength of 32% volume per volume
And D=1,15 g/cm3 means the chemical has a density of 1/15 grams per ml

Calculate the concentration of the moles per litre (molarity) of the concentrated solution?

Ps. im having trouble with the volume/ volume bit?

Solution

In this problem:

$$reagent\ grade = \frac{V_{reagent}}{V_{solution}}$$

We are given:

$$reagent\ grade = 32\% = 0.32$$

$$D_{solution} = 1.15 \frac{g}{cm^3}$$

As is it known , density of water is:

$$D_{water} = 1.00 \frac{g}{cm^3}$$

Density is defined as:

$$D = \frac{m}{V}$$

As solution consists of water and Hcl:

$$m_{solution} = m_{HCl} + m_{water}$$

So:

$$D_{solution} = \frac{m_{water} + m_{HCl}}{V_{solution}}$$

Thus:

$$m_{HCl} = D_{solution} * V_{solution} - m_{water}$$

Using definition of density:

$$m_{water} = D_{water} * V_{water} = D_{water} * (V_{solution} - V_{HCl})$$

$$m_{HCl} = D_{solution} * V_{solution} - m_{water} = D_{solution} * V_{solution} - D_{water} * (V_{solution} - V_{HCl})$$

$$m_{HCl} = D_{solution} * V_{solution} - D_{water} * V_{solution} * (1 - \frac{V_{HCl}}{V_{solution}}) = V_{solution} * (D_{solution} - D_{water} * (1 - \frac{V_{HCl}}{V_{solution}}))$$

Using definition of reagent grade get:

$$m_{HCl} = V_{solution} * (D_{solution} - D_{water} * (1 - reagent\ grade))$$

In chemistry, the **molar concentration or** molarity, c is defined as the amount of ac constituent divided by the volume of the mixture V:

$$c = n / V$$

Thus:

$$c_{HCl} = \frac{n_{HCl}}{V_{solution}}$$

Amount of substance can be calculated as:

$$n_{HCl} = m_{HCl} / Mr_{HCl}$$

Substituting all formulas into definition of molarity:

$$c_{HCl} = \frac{n_{HCl}}{V_{solution}} = \frac{m_{HCl}}{Mr_{HCl} * V_{Solution}} = \frac{V_{solution} * (D_{solution} - D_{water} * (1 - reagent\ grade))}{Mr_{HCl} * V_{Solution}} =$$

$$= \frac{D_{solution} - D_{water} * (1 - reagent\ grade)}{Mr_{HCl}}$$

Calculating:

$$c_{HCl} = \frac{D_{solution} - D_{water} * (1 - reagent\ grade)}{Mr_{HCl}} = \frac{1.15 - 1 * (1 - 0.32)}{(1 + 35.5)} = 0.47 / 36.5 = 0.01288 \frac{mol}{L}$$