

Q: What is the concentration by mass percent of a hydrochloric acid solution whose density is 1.18 g/cm³ and whose pH is 2.12?

A: First, let us calculate the concentration of HCl in the solution. From the definition of pH and the fact that HCl is a strong monoprotic acid, we have

$$\text{pH} = -\log[\text{HCl}]$$

$$[\text{HCl}] = 10^{-2.12} \approx 0.00759 \text{ M}$$

The mass of the solute in one liter of solution can be computed by multiplying this number by the molar mass of HCl

$$0.00759 \text{ mol/L} \cdot (36.46 \text{ g/mol}) = 0.277 \text{ g/L}$$

We can suppose without loss of generality that our solution contains exactly 1.0 L = 1000 cm³. In this case, the mass of the solute would be 0.277 g. Meanwhile, the mass of the solution as a whole would be simply its volume times its density:

$$m_{\text{solution}} = (1000 \text{ mL})(1.18 \text{ g/L}) = 1180 \text{ g}$$

Therefore the final answer given by

$$\% \text{ mass} = \frac{m_{\text{HCl}}}{m_{\text{solution}}} = \frac{0.277 \text{ g}}{1180 \text{ g}} \approx 2.3 \times 10^{-4} = \boxed{0.23 \%}$$