Pollution Prevention Sustainability Industrial Ecology and Green Engineering 2nd edition Dupont Solutions Manual

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PART II - ENGINEERING AND SCIENCE FUNDAMENTALS

Chapter 5 Units and Definitions

Problems and Solutions

PROBLEM 5.l. If a 250 cm^3 volume of liquid weighs 550 g, determine what volume of liquid will weigh 3.2 g.

SOLUTION: The information given provides a ratio of mass to volume for this liquid, which can be used in a dimensional calculation as follows:

$$(250\ cm^3/550\ g)\ (3.2\ g) = 1.45\ cm^3$$

Therefore, 1.45 cm^3 sample of the liquid will weigh 3.2 g.

PROBLEM 5.2. **If a manufacturing process yields 54 g of solid pollutant each day, determine the amount of pollutant in kg produced in 1 year considering the process is performed continuously 5 days per week.**

SOLUTION: The information given can be converted to weight per unit time as follows:

$$(54\ g/d)\ (5\ d/wk)\ (52\ wk/yr)\ (1\ kg/1{,}000\ g) = 14.04\ kg/yr$$

PROBLEM 5.3. If the density of carbon tetrachloride (CCl_4) is 99.2 1b/ft^3 at 68°F and atmospheric pressure, determine the density in g/cm^3 at the same conditions.

SOLUTION: The density of carbon tetrachloride can be converted from lb/ft^3 to g/cm^3 as follows:

$$(99.2\ 1b/ft^3)\ (453.6\ g/lb)\ (1\ ft^3/0.02832\ m^3)\ (1\ m^3/10^6\ cm^3) = 1.59\ g/cm^3$$

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PROBLEM 5.4. Thermal conductivity provides a measure of how fast (or how easily) heat flows through a substance and is defined as the amount of heat that flows per unit time through a unit area of unit thickness as a result of a unit difference in temperature. If the thermal conductivity of methanol is 0.0512 cal/m-s-°C at 60°F, convert this value to English engineering units (i.e., Btu, ft, hr, and °F).

SOLUTION: The thermal conductivity of methanol can be converted from cal/m-s-°C to Btu/ft-h-°F as follows:

(0.512 cal/m-s-°C) (l Btu/252 cal) (0.3048 m/1 ft) (3600 s/1 hr) (1 °C/1.8°F) =

0.124 Btu/ft-h-°F

NOTE: the usual engineering notation for thermal conductivity is k. To convert from cal/m-s-°C to Btu/ft-h-°F, a direct conversion factor of 2.419 can be used.

PROBLEM 5.5. The viscosity of a fluid provides a measure of the fluid's resistance to flow. If the viscosity of methanol is 0.64 cP at 60°F, convert this value to English engineering units (i.e., lb, ft and s).

SOLUTION: The viscosity of methanol can be converted from centipoise (cP) to lb/ft-s as follows:

(0.64 cP) (6.72 x $l0^{-4}$ lb/ft-s-cP) = 4.3 x $l0^{-4}$ lb/ft-s

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NOTE: The notation for viscosity is μ. The kinematic viscosity (γ) is defined as the ratio of the viscosity to density ($\gamma = \mu/\rho$) with units of length^2/time. Interestingly, the viscosity of gases increases, while the viscosity of liquids decreases with increasing temperature.

PROBLEM 5.6. Express the concentration 72 g of HCl in 128 cm^3 of water in terms of fraction and percentage by weight, ppm and molarity.

SOLUTION: The fraction by weight can be calculated as follows, by first determining the weight of water making up the solution.

(128 cm^3 of water) (1 g/cm^3 of water) = 128 g water

The weight fraction of this HCl solution is then:

(72 g/128 g) = 0.5625

The percentage by weight can be calculated from the fraction by weight as follows:

(0.5625) (100) = 56.25%

Then the ppm (parts per million) on a weight basis can be calculated as follows:

(72 g/128 g) (10^6) = 562,500 ppm

The Molarity (M) is moles of solute/volume of solution (L), and can be calculated as follows by first determining the number of moles of HCl in solution as:

MW of HCl = 1.0079 + 35.453 = 36.4609

M = [(72 g HCl)/(36.4609 g/gmol HCl)] / [(128 cm^3)/(1000 cm^3/L)]

M=(1.97 gmol HCL)/(0.128 L) = 15.43 mol/L

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