Lecture 3

Density and specific gravity

Density

Density is a derived quantity combining mass and volume. It is defined as mass per unit volume of a substance at a fixed temperature and pressure. It is usually expressed in CGS system, i.e., as grams per cubic centimeter (g/cm^3) or simply as grams per milliliter (g/mL). In SI units, it may be expressed as kilograms per cubic meter. It may also be expressed as number of grains per fluidounce, or the number of pounds per gallon.

Density may be calculated by dividing the mass of a substance by its volume. For example, if 100 mL of Lugol's solution weighs 120 g, its density is:

$$\frac{120\ (g)}{100\ (mL)} = 1.2\ g/mL$$

It is usually expressed as grams per cubic centimeter (g/cm^3).

1 mL = 1 cm^3.

At 4 ^oC one gram of water occupies 1 cm^3 (1 mL); hence the density of water is 1 g/cm^3 (1 g/mL). 13.6 g of mercury (Hg) occupies 1 cm^3 (1 mL); hence its density is 13.6g/mL.

$$Density(d) = \frac{Mass}{Volume}$$

Q: What is the density of sulfuric acid if 10 mL weighs 18 g?

$$Density = \frac{18(g)}{10(mL)}$$

= 1.8 g/mL

Specific Gravity

Specific gravity is the ratio of the density of a substance to the density of water, the values for both substances being determined at the same temperature or at another specified temperature. For practical purposes, it may be defined as the ratio of the mass of a substance to the mass of an equal volume of water at the similar temperature. The official pharmaceutical compendia uses 25°C to express specific gravity.

Specific gravity may be calculated by dividing the mass of a given substance by the weight of an equal volume of water. For example, if 100 mL of simple syrup, NF weighs 131.3, and 100 mL of water, at the same temperature, weighs 100 g, the specific gravity of the simple syrup is:

$$\frac{\text{Weight of 100 mL of simple syrup}}{\text{Weight of 100 mL of water}}$$

$$\frac{131.3}{100} = 1.313$$

$$Specific\ gravity = \frac{\text{Weight of substatance}}{\text{Weight of equal volume of water}}$$

Note: The values of density and specific gravity, in metric system, are numerically equal, i.e., when expressed in g/cc, the values of density and specific gravity are the same. For example, a density of 1.2 g/cc equals specific gravity of 1.2.

Q: What is the specific gravity of sulfuric acid if 10 mL of acid weighs 18g, and 10 mL of water weighs 10 g (assuming they are under the similar conditions)?

$$Specific gravity = \frac{18\,g}{10\,g}$$

= 1.8 (without unit)

Problems:

- **What is the weight of 4600 mL of alcohol with a specific gravity of 0.82?**

$$Specific\ gravity = \frac{\text{Weight of substatance}}{\text{Weight of equal volume of water}}$$

- 4600 mL of water weighs 4600 g

(because the definition of sp. gr. required that the two substances should have the equal volumes).

$$0.82 = \frac{\text{Weight of alcohol}}{4600\text{g}}$$

Weight of alcohol = 0.82 X 4600 = 3772 g

If 500 mL of ferric chloride solution weighs 650 g, what is its specific gravity?

If the specific gravity of the solution is known, interconversions between % w/v and % w/v are possible using the following expression:

$$\text{Percent weight-in-weight (\% w/w) of the solution} = \frac{\text{Percent weight-in-volume (\% w/v) of the solution}}{\text{Specific gravity of the solution}}$$

Example 1:

How many milliliters of 90% (w/w) sulfuric acid having a specific gravity of 1.788 should be used in preparing a liter of 8% (w/v) acid?

$$90\%\ \text{w/w} \times 1.788 = 160.92\%\ \text{w/v}$$

$$1000\ \text{mL} \times 8\%\ \text{w/v} = 160.92\%\ \text{w/v} \times X\ \text{mL}$$

answer: $X = 49.7$ or 50 mL

Example 3:

How many milliliters of a 64% (w/w) sorbitol solution having a specific gravity 1.26, should be used in preparing a liter of a 10% (w/v) solution?

$$64\%\ \text{w/w} \times 1.26 = 80.64\%\ \text{w/v}$$

$$1000\ \text{mL} \times 10\%\ \text{w/v} = X\ \text{mL} \times 80.64\%\ \text{w/v}$$

$$X = \frac{1000 \times 10}{80.64} = 124\ \text{mL}$$

answer: 124 mL

16. Calculate the weight, in grams, of 100 mL of each of the following:
    (a) acetone
    (b) liquid petrolatum
    (c) syrup
    (d) nitroglycerin
    (e) mercury

TABLE 5.1 SOME REPRESENTATIVE SPECIFIC GRAVITIES AT 25°C

AGENT	SP GR
Ether (at 20°C)	0.71
Isopropyl alcohol	0.78
Acetone	0.79
Alcohol	0.81
Liquid petrolatum	0.87
Peppermint oil	0.90
Olive oil	0.91
Peanut oil	0.92
Cod liver oil	0.92
Castor oil	0.96
Water	**1.00**
Propylene glycol	1.03
Clove oil	1.04
Liquefied phenol	1.07
Polysorbate 80	1.08
Polyethylene glycol 400	1.13
Glycerin	1.25
Syrup	1.31
Hydrochloric acid	1.37
Nitric acid	1.42
Chloroform	1.47
Nitroglycerin	1.59
Phosphoric acid	1.70
Mercury	13.6