PRINCIPLES OF PHARMACY PRACTICE

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DENSITY, SPECIFIC GRAVITY, AND SPECIFIC VOLUME

Density (D) Is Mass Per Unit Volume Of A Substance. It Is Usually Expressed As Grams Per Cubic Centimeter **(G/Cc).** Because The Gram Is Defined As The Mass Of 1 Cc Of Water At 4°c, The Density Of Water Is 1 G/Cc.

For Our Purposes, Because The United States Pharmacopeia1 States That 1 mL May Be Used As The Equivalent Of 1 Cc, The Density Of Water May Be Expressed As 1 g/mL

Density May Be Calculated By Dividing Mass By Volume, That Is:

- **THUS, IF 10 ML OF SULFURIC ACID WEIGHS 18 G, ITS DENSITY IS:**

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{18\ (\text{g})}{10\ (\text{mL})} = 1.8 \text{ grams per milliliter}$$

SPECIFIC GRAVITY

Specific Gravity (Sp Gr) Is A Ratio, Expressed Decimally, Of The Weight Of A Substance To The Weight Of An Equal Volume Of A Substance Chosen As A Standard, Both Substances At The Same Temperature Or The Temperature Of Each Being Known.

Water Is Used As The Standard For The Specific Gravities Of Liquids And Solids; The Most Useful Standard For Gases Is Hydrogen.

Specific Gravity May Be Calculated By Dividing The Weight Of A Given Substance By The Weight Of An Equal Volume Of Water, That Is:

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

- Thus, If 10 mL Of Sulfuric Acid Weighs 18 g, And 10 mL Of Water, Under Similar Conditions, Weighs 10 g, The Specific Gravity Of The Acid Is:

$$\text{Specific gravity} = \frac{18\ (\text{g})}{10\ (\text{g})} = 1.8$$

- Substances That Have A Specific Gravity Less Than 1 Are Lighter Than Water.
- Substances That Have A Specific Gravity Greater Than 1 Are Heavier Than Water

* **If 54.96 mL Of Oil Weighs 52.78 g, What Is The Specific Gravity Of The Oil?**

54.96 mL Of Water Weighs 54.96 g

Specific Gravity Of Oil= 52.78 (g)/ 54.96 (g)

= 0.9603, Answer.

* **If A Pint Of A Certain Liquid Weighs 601 g, What Is The Specific Gravity Of The Liquid?**

1 Pint =473 mL.

473 mL Of Water Weighs 473 g

Specific Gravity Of Liquid= 601 (g) /473 (g)

= 1.27, Answer.

Pycnometer Or Specific Gravity Bottle

A **Pycnometer** Is A Special Glass Bottle Used To Determine Specific Gravity. Pycnometers Are Generally Available For Laboratory Use In Volumes Ranging From 1 mL To 50 mL.

Pycnometers Have Fitted Glass Stoppers With A Capillary Opening To Allow Trapped Air And Excess Fluid To Escape. Some Pycnometers Have Thermometers Affixed, Because Temperature Is A Factor In Specific Gravity Determinations.

Example:

A 50 mL Pycnometer Is Found To Weigh 120 g When Empty, 171 g When Filled With Water, And 160 g When Filled With An Unknown Liquid. Calculate The Specific Gravity Of The Unknown Liquid.

Weight Of Water: 171 g - 120 g = 51 g

Weight Of Unknown Liquid: 160 g - 120 g = 40 g

Specific Gravity= Weight Of Substance/ Weight Of Equal Volume Of Water

Specific Gravity Of Unknown Liquid = 40 (G)/ 51 (G)

= 0.78, Answer.

CALCULATING WEIGHT, KNOWING THE VOLUME AND SPECIFIC GRAVITY

Grams = Milliliters × Specific Gravity

Grams (Other Liquid)= Grams (Of Equal Volume Of Water) × Specific Gravity (Other Liquid)

Example:

What Is The Weight, In grams, Of 2 Fl. Oz. Of A Liquid Having A Specific Gravity Of 1.118?

2 × 29.57 mL =59.14 mL

59.14 mL of Water Weigh 59.14 g

59.14 g × 1.118 =66.12 g, Answer.

What is The Cost Of 1000 mL Of Glycerin, Specific Gravity 1.25, purchased At $54.25 Per Pound?

1000 mL Of Water Weigh 1000 g

Weight Of 1000 mL Of Glycerin =1000 g × 1.25 =1250 g

1 lb =454 g

454 (g) /1250 (g) = ($) 54.25 ($) /X

X = $149.37, Answer

CALCULATIONS CAPSULE

Specific Gravity

The specific gravity (sp gr) of a substance or a pharmaceutical preparation may be determined by the following equation:

$$\textit{Specific gravity} = \frac{\textit{Weight of substance (g)}}{\textit{Weight of equal volume of water (g)}}$$

The following equation may be used to convert the volume of a substance or pharmaceutical preparation to its weight:*

$$\textit{Weight of substance} = \textit{Volume of substance} \times \textit{Specific gravity}$$

Or simply,

$$\mathbf{g = mL \times sp\ gr}$$

The following equation may be used to convert the weight of a substance or pharmaceutical preparation to its volume:*

$$\textit{Volume of substance} = \frac{\textit{Weight of substance}}{\textit{Specific gravity}}$$

Or simply,

$$\mathbf{mL} = \frac{\mathbf{g}}{\mathbf{sp\ gr}}$$

* The full explanation on why these equations work may be found in the section "Use of Specific Gravity in Calculations of Weight and Volume," on page 73.

What is the volume, in milliliters, of 492 g of nitric acid with a specific gravity of 1.40?

492 g of water measure 492 mL

$$\frac{492 \text{ mL}}{1.40} = 351 \text{ mL, } \textit{answer.}$$

What is the volume, in milliliters, of 1 lb of methyl salicylate with a specific gravity of 1.185?

1 lb = 454 g
454 g of water measure 454 mL

$$\frac{454 \text{ mL}}{1.185} = 383.1 \text{ mL, } \textit{answer.}$$

What is the volume, in pints, of 50 lb of glycerin having a specific gravity of 1.25?

50 lb = 454 g × 50 = 22,700 g
22,700 g of water measure 22,700 mL and 1 pint = 473 mL

$$\frac{22{,}700 \text{ mL}}{1.25} = 18{,}160 \text{ mL} \div 473 \text{ mL} = 38.4 \text{ pints, } \textit{answer.}$$

What is the cost of 1 pint of chloroform, specific gravity 1.475, bought at $25.25 per pound?

1 pint = 473 mL
473 mL of water weigh 473 g
Weight of 473 mL of chloroform = 473 g × 1.475 = 697.7 g
1 lb = 454 g

$$\frac{454\ (g)}{697.7\ (g)} = \frac{(\$)\ 25.25}{(\$)\ x}$$

$$x = \$38.80, \textit{answer.}$$

PHARMACEUTICAL APPLICATIONS

1. The Purpose Of A Conversion Is Either To Measure The Volume Of A Material When A Formula Is Expressed In Units Of Weight Or To Weigh An Equivalent Amount Of A Material When A Formula Is Expressed In Units Of Volume.

2. Another Application Of Specific Gravity Is In Automated Pharmaceutical Equipment Used By Pharmacists To Prepare Total Parenteral Nutrition (TPN) Admixtures. In These Automated Compounders, The Purpose Of The Specific Gravity Of The Large-volume Liquids Being Mixed Is To Determine The Weights Of Components (E.G., Dextrose, Amino Acids, And Water).

Calculating Specific Volume

Specific Volume, In Pharmaceutical Practice, Is Usually Defined As An Abstract Number Representing The Ratio, Expressed Decimally, Of The *Volume Of A Substance* To The *Volume Of An Equal Weight Of Another Substance* Taken As A Standard, Both Having The Same Temperature. Water Is The Standard.

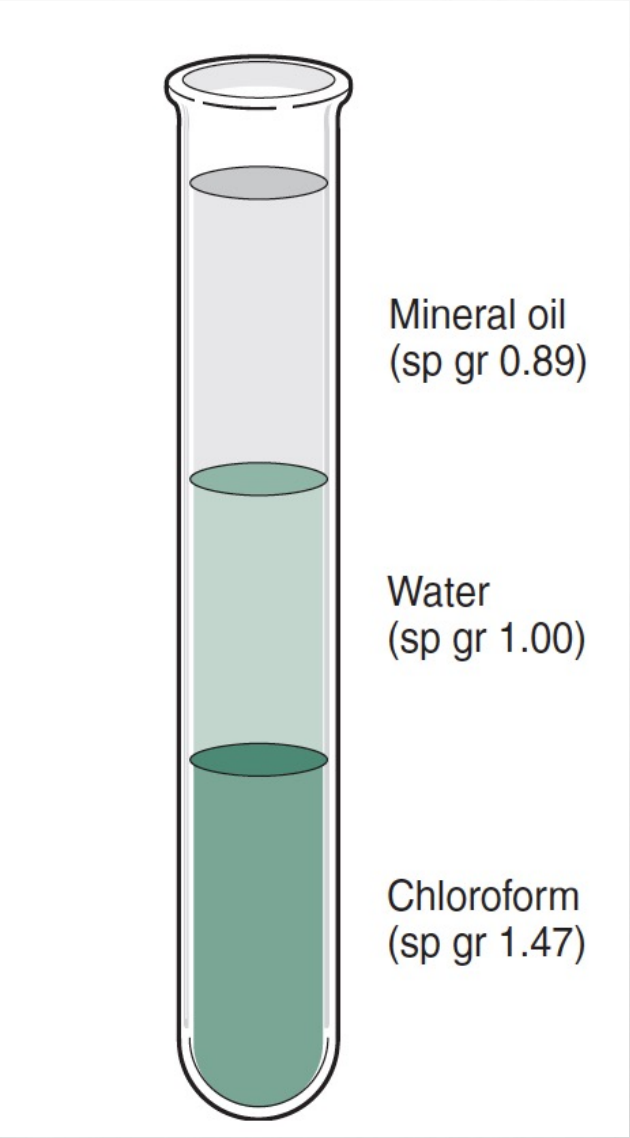
Example:

Calculate The Specific Volume Of A Syrup, 91.0 mL Of Which Weighs 107.16 g.

107.16 g Of Water Measures= 107.16 mL

Specific Volume Of Syrup = 91.0 (mL) /107.16 (mL)

= 0.849, Answer


Mineral oil
(sp gr 0.89)
Water
(sp gr 1.00)
Chloroform
(sp gr 1.47)

Because Specific Gravity And Specific Volume Are Reciprocals, A Substance That Is Heavier Than Water Will Have A Higher Specific Gravity And A Lower Specific Volume,

Whereas A Substance That Is Lighter Than Water Will Have A Lower Specific Gravity And A Higher Specific Volume.

It Follows, Therefore, That We May Determine The Specific Volume Of A Substance By Dividing 1 By Its Specific Gravity, And We May Determine The Specific Gravity Of A Substance By Dividing 1 By Its Specific Volume.

Examples:

What is the specific volume of phosphoric acid having a specific gravity of 1.71?

$$\frac{1}{1.71} = 0.585, \textit{ answer.}$$

If a liquid has a specific volume of 1.396, what is its specific gravity?

$$\frac{1}{1.396} = 0.716, \textit{ answer.}$$

11. A modified Ringer's Irrigation has the following formula:

Sodium chloride		8.6	g
Potassium chloride		0.3	g
Calcium chloride		0.33	g
PEG 3350		60	g
Water for injection	ad	1000	mL

Assuming that 980 mL of water is used in preparing the irrigation, calculate its specific gravity.

27. If fifty glycerin suppositories are made from the following formula, how many milliliters of glycerin, having a specific gravity of 1.25, would be used in the preparation of 96 suppositories?

Glycerin	91 g
Sodium stearate	9 g
Purified water	5 g

33. The formula for 1000 g of polyethylene glycol ointment calls for 600 g polyethylene glycol 400. At $19.15 per pint, what is the cost of the polyethylene glycol 400, specific gravity 1.140, needed to prepare 4000 g of the ointment?

32. A transdermal patch for smoking cessation contains 30 mg of liquid nicotine per patch. If nicotine has a specific gravity of 1.01, how many milliliters of the agent are required to manufacture 1 million patches?