

## **SEAKING MASTERY OF MATTER**

UNIT 2 MODULE 1 SI UNITS & DENSITY

## Module Concepts

- Qualitative vs. Quantitative
- Units of Measurement
- Density

## Qualitative vs. Quantitative

- Unit 1 covered **qualitative descriptions** of matter. Qualitative descriptions of matter include:
  - Words to communicate the nature of matter, but they do not include numbers.
- This unit focuses on **quantitative descriptions** of matter. Quantitative descriptions of matter include:
  - Numbers to communicate measured quantities.

A example of a qualitative description is "Eevee is soft and fluffy." An example of a quantitative description is "Eevee has a mass of 4 kilograms."



## English System of Measurement

- Quantitative data can be reported using various units of measurement.
- English system of measurement:
  - Weight = pounds (lb), ounces (oz)
  - Volume = quarts (qt), pints (pt), cups (c), etc.
  - Temperature = degrees Fahrenheit (F)
  - Length = inches (in), feet (ft), yards (yd), miles (mi)



## Measurements in the Pokémon Go Universe

- However, scientists and Pokémon masters do NOT use the English system of measurement.
- Scientists and Pokémon masters use SI (International System) units of measurement, which are based on the metric system.
- SI base units of measurement used in Chemistry:
  - Time = seconds (s)
  - Amount of substance = moles (mol)
  - Length = meters (m)
  - Mass = kilogram (kg)
  - Temperature = Kelvin (K)

#### Visualizing SI Units Using Common Household Goods

Length	Volume	Mass
mm = about width of piece of yarn	mL = about $\frac{1}{4}$ teaspoon	g = 1 medium paper clip; 1 dollar bill
cm = about radius of nickel	L = about 1 quart; $\frac{1}{2}$ of 2 L bottle of	kg = almost 2 pounds; bag of brown
m = little longer than yard stick	soda	sugar
km = just over ½ mile	$*1 \text{ mL} = 1 \text{ cm}^3 = 1 \text{ cc}$	







### Measuring a Pokémon with Base SI Units



TABLE 1.4	Some Prefi	Some Prefixes for Multiples of SI Units			
Factor		Prefix	Symbol	Example	
1,00	$0,000 = 10^{6}$	mega	Μ	$1 \text{ megameter } (\text{Mm}) = 10^6 \text{ m}$	
	$1,000 = 10^3$	kilo	k	$1 \operatorname{kilogram} (\operatorname{kg}) = 10^3 \operatorname{g}$	
	$100 = 10^2$	hecto	h	1  hectogram (hg) = 100  g	
	$10 = 10^1$	deca	da	1 decagram $dag) = 10 g$	
	$0.1 = 10^{-1}$	deci	d	$1 \operatorname{decimeter} (\operatorname{dm}) = 0.1 \operatorname{m}$	
	$0.01 = 10^{-2}$	centi	С	1  centimeter  (cm) = 0.01  m	
	$0.001 = 10^{-3}$	milli	m	1  milligram (mg) = 0.001  g	
*0.00	$00001 = 10^{-6}$	micro	$\mu$	1 micrometer ( $\mu$ m) = 10 <sup>-6</sup> m	



WOW! That Onix has a mass of 1 Megagram (Mg)!

Note:

 $1 Mg = 10^6 g$ = 1,000,000 g

## SI Conversions

Metric prefixes are used with base units to indicate the scale of the number. Imagine a staircase where each step represents a unit prefix.



## **Derived Units**

- Derived units are defined by a combination of units.
  - Volume
    - Equation = (I) x (w) x (h)
    - Units =  $cm^3 (cc, mL) or dm^3 (L)$
    - In another words, 1 cm<sup>3</sup> = 1 cubic centimeter (cc) = 1 milliliters (mL) or 1 dm<sup>3</sup> = 1 liter (L)
  - Density
    - Density = mass/volume or D = m/V
    - Units = kg/m<sup>3</sup>, g/mL, or g/cm<sup>3</sup>



#### Density Practice Problem #1

## If a sample of copper has a mass of 4.23 g and has a measured volume of 1.31 mL, what is its density?

Step 1: List the known information

m = 4.23 g

V = 1.31 mL

Step 2: Identify the unknown

D = ?

Step 3: Write out the equation

D = m/V

Step 4: Rearrange the equation (if necessary) to solve for the unknown

D = m/V

Step 5: Plug numbers (with units) into the equation and solve for the unknown D = 4.23g/1.31mL

D = 3.23 g/mL

Step 6: Check your work, make sure you include units with your final answer! NO NAKED NUMBERS!

#2. A piece of metal with a mass of 147 g is placed in a50 mL graduated cylinder. The water level rises from 20 mL to 41 mL. What is the density of the metal?

Step 1: List the known information m = 147 g  $V_1 = 20 \text{ mL}$  $V_2 = 41 \text{ mL}$ Therefore,  $V_{metal} = 21 \text{ mL}$ Step 2: Identify the unknown D = ? *Step 3: Write out the equation* D = m/VStep 4: Rearrange the equation (if necessary) to solve for the unknown D = m/VStep 5: Plug numbers (with units) into the equation and solve for the unknown D = 147 g/21 mLD = 7.0 g/mLStep 6: Check your work, make sure you include units with your final answer!

NO NAKED NUMBERS!

#### Density Practice Problems - Cont'd

#3. What is the volume of a sample that has a mass of 20 g and a density of 4 g/mL?

- Step 1: List the known information
- m = 20 g
- D = 4 g/mL
- Step 2: Identify the unknown
- V = ?
- Step 3: Write out the equation
- D = m/V
- Step 4: Rearrange the equation (if necessary) to solve for the unknown
- V = m/D (See a teacher for an explanation if needed!)
- Step 5: Plug numbers (with units) into the equation and solve for the unknown V = 20 g / 4 g/mL
- V = 5 mL

Step 6: Check your work, make sure you include units with your final answer! NO NAKED NUMBERS!

#4. A metal cube with physical properties similar to those of aluminum has a mass of 20 g and a volume of 5 cm<sup>3</sup>. Is the cube made of pure aluminum ( $D_{AI} = 2.7 \text{ g/mL}$ )? Explain.

Step 1: List the known information

m = 20 g

 $V = 5 \text{ cm}^3$  (Remember,  $1 \text{ cm}^3 = 1 \text{ mL}$ , so this is also 5 mL)

Step 2: Identify the unknown

D = ?

Step 3: Write out the equation

D = m/V

Step 4: Rearrange the equation (if necessary) to solve for the unknown

D = m/V

Step 5: Plug numbers (with units) into the equation and solve for the unknown D = 20 g/5mL

D = 4 g/mL

This metal cube is not made of pure aluminum because its density (4 g/mL) is different from that of Aluminum (2.7 g/mL). Density is an intensive physical property. In order for this metal cube to be considered aluminum, it must have the same density as aluminum.

#### Density of Common Substances

Substance	Density $\rho$ (kg/m <sup>3</sup> )	Substance	Density $\rho$ (kg/m <sup>3</sup> )
Solids		Liquids	
Aluminum	2700	Blood	1060 806 13 600
Brass	8470	(whole, 37°C)	
Concrete	2200	Ethyl alcohol	
Copper	8890	Mercury	
Diamond	3520	Oil (hydraulic)	800
Gold	19.300	Water (4 <sup>0</sup> C)	1000
Ice (0°C)	917	Gases	
Iron (steel)	7860	Air	1.29
Lead	11 300	Carbon dioxide	1.98
Quartz	2660	Helium	0.179
Silver	10 500	Hydrogen	0.0899
Wood (vellow		Nitrogen	1.25
pine)	550	Oxygen	1.43

## Pokémon Activity

- Use data from your Pokémon Go Pokédex to calculate the densities of three different types of Pokémon.
- Prepare a "density column" of Pokémon.



Gastly

## Average Human







## Gastly

120 g

#### Basketball

56 g



 $\bigcirc$ 

 $\triangleleft$ 



Volume of a sphere =  $4/3*pi*r^3$ 





## **Gastly** 0.104 kg/m<sup>3</sup>



#### Air

1.225 kg/m<sup>3</sup>

How does the density of Gastly compare to the density of helium or air?

# Density









# Make a Pokémon Density Column!

