

Name _____

#1 Math Skills

Quantitative Chemistry

Student Learning Map

Unit EQ: How do I perform measurements and conversions in Chemistry?

Key Learning: Understanding measurements and conversions is essential to solving chemistry problems.

UNIT CONCEPT:

1. Measurements	2. Dimensional Analysis	3. Density
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LESSON ESSENTIAL QUESTIONS:

a. What is Chemistry? b. Why do we use scientific notation? c. How does science differ from math when it comes to numbers?	How do I convert from one unit of measurement to another?	How do I determine density, and what factors are related to it?
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LESSON ESSENTIAL VOCABULARY:

Chemistry Scientific Notation Precision Accuracy Significant Figures Qualitative Quantitative	Dimensional Analysis (Fence-Posting) Metric System Mass Volume	Density
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1a. Introduction

EQ: What is Chemistry?

1b. Scientific Notation

EQ: Why do we use scientific notation?

Answer in your own words

Measurements:

- 1.
- 2.
- 3.
- 4.
- 5.

Scientific Notation Rules:

Problems:

1. Express each of the following numbers in standard scientific notation.

a. $0.0946 = 9.46 \times 10^{-2}$ c. $45,000,000,000,000 = 4.5 \times 10^{13}$

b. $6070 = 6.07 \times 10^3$ d. $0.00000890 = 8.90 \times 10^{-6}$

2. Express each of the following as an ordinary decimal number.

a. $3.44 \times 10^3 = 3440$ c. $1.0 \times 10^9 = 1\bar{0}00000000$

b. $2.7 \times 10^{-5} = 0.000027$ d. $3.888 \times 10^0 = 3.888$

1c. Significant Figures

EQ: How does science differ from math when it comes to numbers?

Answer in your own words

Math

vs.

Science

Significant figures deal with _____ in measurements.

* Counting Significant Figures

Rules:

Problems: How many significant figures are in each of the following numbers?

- | | |
|---|---|
| a. $0.0564 = 3$ (all non-zero) | g. $0.00020 = 2$ (trailing – decimal) |
| b. $450 = 2$ (trailing – no decimal) | h. $900 = 1$ (trailing – no decimal) |
| c. $98.05 = 4$ (captured) | i. $6,450. = 4$ (trailing – decimal) |
| d. $0.00001 = 1$ (leading) | j. $1200 = 2$ (trailing – no decimal) |
| e. $90,000 = 1$ (trailing – no decimal) | k. $59.00 = 4$ (trailing – decimal) |
| f. $90,000.00 = 7$ (trailing – decimal) | l. $7.82 \times 10^{-5} = 3$ (all non-zero) |

1c. Significant Figures (cont.)

* Multiplication & Division with Significant Figures

Rules:

1. Identify the term with the smallest number of _____.
This is the limiting term.
2. Solve for the answer and round it so it has as many _____
as the limiting term.

Problems: Solve the following problems and use the correct number of significant figures in your answer.

- | | |
|---|--|
| a. $0.12 \times 0.559 = 0.067$ (2 s.f.) | c. $3000 \times 0.298 = 900$ (1 s.f.) |
| b. $68 / 3.00 = 23$ (2 s.f.) | d. $(67.40 \times 0.322) / 5.30 = 4.09$ (3 s.f.) |
-

* Addition & Subtraction with Significant Figures

Rules:

1. Identify the term with the smallest number of _____.
This is the limiting term.
2. Solve for the answer and round it so it has as many _____
as the limiting term.

Problems: Solve the following problems and use the correct number of significant figures in your answer.

- | | |
|---|---|
| a. $99 + 1.01 = 100$. (units position) | c. $5.600 + 4.30 = 9.90$ (hundredths) |
| b. $4.56 - 3.2 = 1.4$ (tenths position) | d. $356.7 + 35.67 - 3.567 = 388.8$ (tenths) |
-

Mixed Review

Solve the following problems and use the correct number of significant figures in your answer.

- | | |
|---|--|
| a. $56.7 \times 3.225 = 183$ (3 s.f.) | e. $456.00 - 39.2 = 416.8$ (tenths) |
| b. $33.0 - 30.0 = 3.0$ (tenths) | f. $(3.45 \times 10^2) / (6.1 \times 10^3) = 0.057$ (2 s.f.) |
| c. $6.7 \times 8.9 \times 5 = 300$ (1 s.f.) | g. $(5.6 + 8.90) / 3.774 = 14.5 / 3.774 = 3.84$ (3s.f.) |
| d. $4.9999 + 5.111 = 10.111$ (thousandths) | h. $(5.6 \times 8.90) - 3.774 = 49.8 - 3.774 = 46$ (units.) |

2. Dimensional Analysis

EQ: How do I convert from one unit of measurement to another?

Answer in your own words

Steps of Fence Posting:

* Metric Conversions [Prefixes]

a. Convert 2.3 km to m

$$2.3 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} = 2300 \text{ m}$$

c. Convert 146,000 nm to m

$$146000 \text{ nm} \times \frac{1 \text{ m}}{1000000000 \text{ nm}} = 0.000146 \text{ m}$$

b. Convert 14.9 cL to L

$$14.9 \text{ cL} \times \frac{1 \text{ L}}{100 \text{ cL}} = 0.149 \text{ L}$$

d. Convert 12,900 mg to g

$$12900 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 12.9 \text{ g}$$

* English-Metric Conversions

Length

Convert 12 in to cm.

$$12 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 30. \text{ cm}$$

Convert 204 cm to ft.

$$204 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ ft}}{12 \text{ in}} = 6.69 \text{ ft}$$

Mass

Convert 3690 g to lb.

$$3690 \text{ g} \times \frac{1 \text{ lb}}{454 \text{ g}} = 8.13 \text{ lb}$$

Convert 0.0034 ton to g.

$$0.0034 \text{ ton} \times \frac{2000 \text{ lb}}{1 \text{ ton}} \times \frac{454 \text{ g}}{1 \text{ lb}} = 3100 \text{ g}$$

Volume

Convert 2.2 L to qt.

$$2.2 \text{ L} \times \frac{1.06 \text{ qt}}{1 \text{ L}} = 2.3 \text{ qt}$$

Convert 0.50 gal to L.

$$0.50 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{1 \text{ L}}{1.06 \text{ qt}} = 1.9 \text{ L}$$

2. Dimensional Analysis (cont.)

Demo Problems:

* Area and Volume Conversions

Examples:

Problems:

- a. Convert $320. \text{ cm}^2$ to in^2 .

$$320. \text{ cm}^2 \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 49.6 \text{ in}^2$$

- b. Convert $140. \text{ ft}^2$ to m^2 .

$$140. \text{ ft}^2 \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 13.0 \text{ m}^2$$

- c. Convert 2800 in^3 to ft^3 .

$$2800 \text{ in}^3 \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ ft}}{12 \text{ in}} = 1.6 \text{ ft}^3$$

2. Dimensional Analysis (cont.)

Solve the following problems using dimensional analysis (fence-posting). Show your work, and use significant figures!

1. An atom of gold has a diameter of 0.288 nm. What is its diameter in meters?

$$0.288 \text{ nm} \times \frac{1 \text{ m}}{100000000 \text{ nm}} = 0.00000000288 \text{ m}$$

2. Bill fills his car with 45 L of gas while in Mexico. How many gallons is this?

$$45 \text{ L} \times \frac{1.06 \text{ qt}}{1 \text{ L}} \times \frac{1 \text{ gal}}{4 \text{ qt}} = 12 \text{ gal}$$

3. A certain truck can safely carry 8.0 tons of material. It is scheduled to make a delivery next week of 3400 textbooks, each weighing 1.25 kg. Can the truck carry it?

$$3400 \text{ textbooks} \times \frac{1.25 \text{ kg}}{1 \text{ textbooks}} \times \frac{2.2 \text{ lb}}{1 \text{ kg}} \times \frac{1 \text{ ton}}{2000 \text{ lb}} = 4.675 \text{ tons} < 8.0 \text{ tons}; \text{ Yes.}$$

4. A plastic box has the dimensions 21.5 in x 20.0 in x 15.0 in.

- a. What is the volume of the box in cubic centimeters?

$$21.5 \text{ in} \times 20.0 \text{ in} \times 15.0 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 106000 \text{ cm}^3$$

- b. How many liters of water can it hold?

$$105697 \text{ cm}^3 \times \frac{1 \text{ mL}}{1 \text{ cm}^3} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 106 \text{ L}$$

5. What is the length of a football field (excluding end zones) in km?

$$100. \text{ yd} \times \frac{3 \text{ ft}}{1 \text{ yd}} \times \frac{1 \text{ mi}}{5280 \text{ ft}} \times \frac{1.609 \text{ km}}{1 \text{ mi}} = 0.0914 \text{ km}$$

6. A candy store clerk measures 2.65 lbs of peppermint candy for a customer. Each piece weighs approximately 5348 mg. About how many pieces of candy are in the bag?

$$2.65 \text{ lb} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \frac{1000 \text{ mg}}{1 \text{ g}} \times \frac{1 \text{ piece}}{5348 \text{ mg}} = 224 \text{ pieces (or 225 pieces if you are an optimist)}$$

7. An alien exchange student wants to buy your Cedar Cliff sweatshirt. He offers you 2000 dorfs. You want \$15 for the sweatshirt. Will you sell it or keep it until he has \$15? His currency goes like this: 4 dorfs = 2 fifs; 15 fifs = 3 gilts; \$1 = 7 gilts. (Prove it!)

$$2000 \text{ dorfs} \times \frac{2 \text{ fifs}}{4 \text{ dorfs}} \times \frac{3 \text{ gilts}}{15 \text{ fifs}} \times \frac{1 \text{ dollar}}{7 \text{ gilts}} = \$ 28.57 \text{ (SELL IT!)}$$

2. Dimensional Analysis (cont.)

* Multiple Variable Conversions

Types:

Problems: Show your work and use significant figures!

1. A car is traveling at 35 mi/hr. How fast is it traveling in km/min?

$$35 \frac{\text{mi}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1.609 \text{ km}}{1 \text{ mi}} = 0.94 \frac{\text{km}}{\text{min}}$$

2. In 2009, Usain Bolt set the world record for the 100. meter dash with a time of 9.58 s. What was his speed in miles per hour?

$$\frac{100 \text{ m}}{9.58 \text{ s}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{1 \text{ mi}}{1.609 \text{ km}} = 23.4 \frac{\text{mi}}{\text{hr}}$$

3. Your friend in Mexico just bought a new car that has a gas mileage rating of 12.4 km/L. What is this in mi/gal?

$$12.4 \frac{\text{km}}{\text{L}} \times \frac{1 \text{ L}}{1.06 \text{ qt}} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{1 \text{ mi}}{1.609 \text{ km}} = 29.1 \frac{\text{mi}}{\text{gal}}$$

4. A man is driving a European sports car on the PA turnpike. His speedometer reads 34.1 m/s. Is he speeding?

$$34.1 \frac{\text{m}}{\text{s}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{1 \text{ mi}}{1.609 \text{ km}} = 76.3 \frac{\text{mi}}{\text{hr}}$$

Practice Conversions:

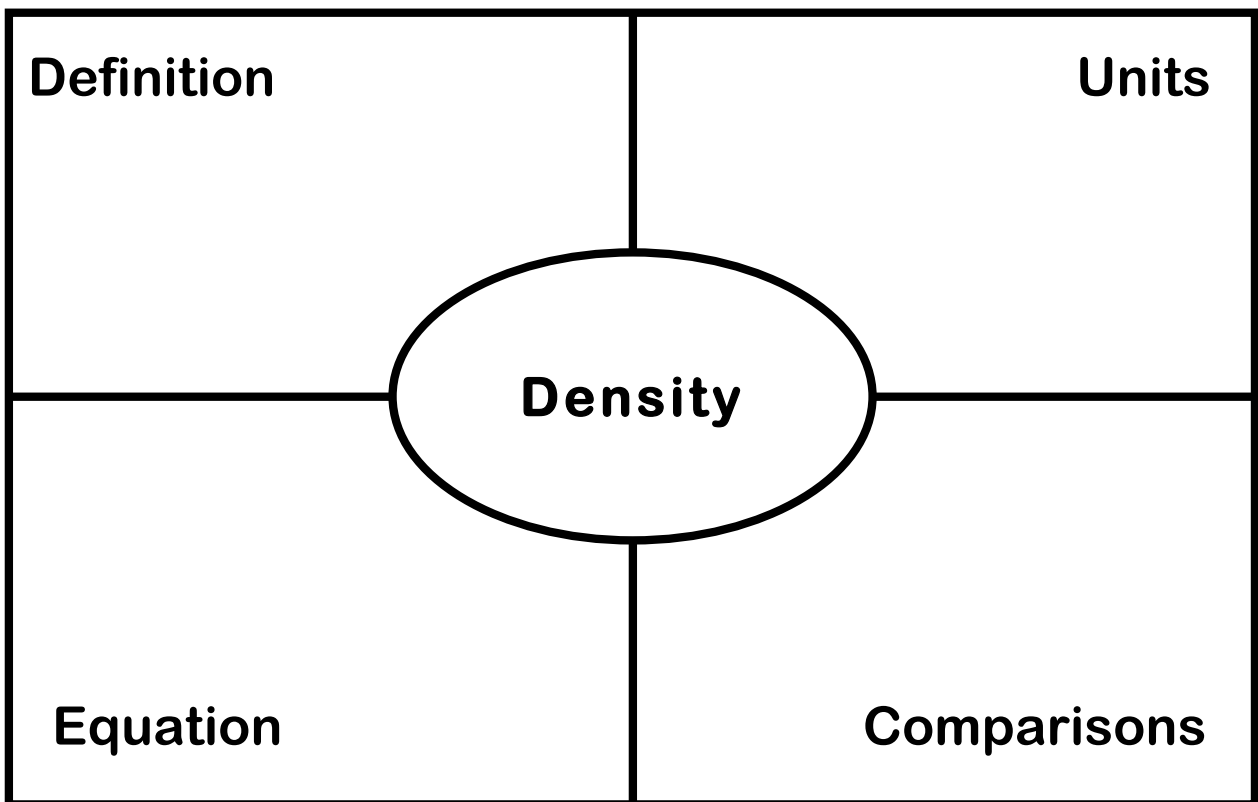
Date:

3. Density

EQ: How do I determine density, and what factors are related to it?

Answer in your own words

Demo:



3. Density (cont.)

*** Measurements**

Table 1 – Blocks

Block	Mass (g)	Volume (cm³)	Density (g/cm³)

How did you determine the volume? _____

Which block has the highest density? _____

Table 2 – Irregular Objects

Object	Mass (g)	Volume (mL)	Density (g/mL)

How did you determine the volume? _____

Which object has the highest density? _____

*** Density of Water**

What is the density of water? _____ g/mL

Which objects above would float in water?

Which would sink?

3. Density (cont.)

Problems: Show your work, and use significant figures!

1. A 216 cm^3 block of metal has a density of 17 g/cm^3 . What is its mass?

$$216 \text{ cm}^3 \times \frac{17 \text{ g}}{1 \text{ cm}^3} = 3670 \text{ g}$$

2. The density of a certain liquid is 0.787 g/mL . What is the volume of a 25.5 g sample?

$$25.5 \text{ g} \times \frac{1 \text{ mL}}{0.787 \text{ g}} = 32.4 \text{ mL}$$

3. What is the density in g/cm^3 of an object with a mass of 0.33 lbs and a volume of 37.2 cm^3 ?

$$D = \frac{\text{mass}}{\text{volume}} = \frac{0.33 \text{ lbs}}{37.2 \text{ cm}^3} \times \frac{454 \text{ g}}{1 \text{ lbs}} = 4.0 \text{ g/cm}^3$$

Use the data in the table below to answer questions 4-8.

Densities (g/cm^3)							
Magnesium	1.74	Iron	7.87	Silver	10.5	Mercury	13.6
Aluminum	2.70	Copper	8.96	Lead	11.34	Gold	19.32

4. A strip of metal has a mass of 6.8 g and a volume of 3.91 cm^3 . Calculate its density, and determine the identity of the metal.

$$D = \frac{\text{mass}}{\text{volume}} = \frac{6.8 \text{ g}}{3.91 \text{ cm}^3} = 1.7 \text{ g/cm}^3; \text{ Magnesium}$$

5. What is the mass of a sample of copper with a volume of 56.1 cm^3 ?

$$56.1 \text{ cm}^3 \times \frac{8.96 \text{ g}}{1 \text{ cm}^3} = 503 \text{ g}$$

6. What is the volume (cm^3) of 89.4 g of lead?

$$89.4 \text{ g} \times \frac{1 \text{ cm}^3}{11.35 \text{ g}} = 7.88 \text{ cm}^3$$

7. A metal sphere displaces 502 mL of water. It has a mass of 3.95 kg . What type of metal is it?

$$D = \frac{\text{mass}}{\text{volume}} = \frac{3.95 \text{ kg}}{502 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mL}}{1 \text{ cm}^3} = 7.87 \text{ g/cm}^3; \text{ Iron}$$

8. A metal cube has the dimensions $2.7 \text{ in} \times 2.7 \text{ in} \times 2.7 \text{ in}$. It has a mass of 870 grams . What type of metal is it?



$$D = \frac{\text{mass}}{\text{volume}} = \frac{870 \text{ g}}{2.7 \text{ in} \times 2.7 \text{ in} \times 2.7 \text{ in}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} = 2.7 \text{ g/cm}^3; \text{ Aluminum}$$

3. Density (cont.)

Gold Problem:

Extra Practice: Show your work, and use significant figures!

1. A graduated cylinder contains 20.0 mL of water. When 100.0 grams of brass shot were added to the cylinder, the water level read 32.6 mL. What is the density of the brass?

$$32.6 \text{ mL} - 20.0 \text{ mL} = 12.6 \text{ mL}; D = \frac{\text{mass}}{\text{volume}} = \frac{100.0 \text{ g}}{12.6 \text{ mL}} = 7.94 \text{ g/mL}$$

2. Diamonds are measured in carats, and a carat equals 0.200 grams. The density of diamond is 3.51 g/cm³. What is the volume of a 5.0 carat diamond?

$$5.0 \text{ carat} \times \frac{0.200 \text{ g}}{1 \text{ carat}} \times \frac{1 \text{ cm}^3}{3.51 \text{ g}} = 0.28 \text{ cm}^3$$

3. A 1.63-gram sheet of aluminum foil (D = 2.70 g/cm³) has a length of 27.9 cm and width of 23.3 cm. What is the thickness (height) of the foil?

$$1.63 \text{ g} \times \frac{1 \text{ cm}^3}{2.70 \text{ g}} \times \frac{1}{27.9 \text{ cm}} \times \frac{1}{23.3 \text{ cm}} = 0.000929 \text{ cm}$$

4. A sample of mercury (D = 13.6 g/cm³) with a mass of 500. grams was poured into a 100. mL graduated cylinder. How many mL of water would have to be added to bring the water up to the 100. mL mark?

$$500. \text{ g} \times \frac{1 \text{ cm}^3}{13.6 \text{ g}} \times \frac{1 \text{ mL}}{1 \text{ cm}^3} = 36.8 \text{ mL}; V_{\text{added}} = 100. \text{ mL} - 36.8 \text{ mL} = 63.2 \text{ mL} \rightarrow 63 \text{ mL (rounded to the units position)}$$

5. Vinegar contains 5.00% acetic acid by mass and has a density of 1.05 g/mL. What mass (in grams) of acetic acid is present in 10.0 L of vinegar?

Date:

$$10.0 \text{ L Vinegar} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1.05 \text{ g}}{1 \text{ mL}} \times \frac{5.00 \text{ parts Acetic Acid}}{100. \text{ parts Vinegar}} = 525 \text{ g Acetic Acid}$$