Density

Density is a physical property of matter. Density refers to how closely "packed" or "crowded" the materials are.

Many substances can be identified based on their density. Different substances have different densities as shown in Table 1.

Density is the amount of matter per unit volume of that matter. Density cannot be measured directly.

In order to determine density, you must measure **mass (g, kg)** and **volume (cm^3 or mL, L)**. The units for density are **g/cm^3** or **kg/m^3** for a solid or **g/mL** for a liquid

The equation for density is:

density = $\frac{mass}{volume}$ or **d = $\frac{m}{v}$**

It can be rearranged to solve for mass or volume:

mass = volume x density or **m = v d**

$volume = \frac{mass}{density}$ or **v = $\frac{m}{d}$**

Example 1:

Calculate the density of a metal sample that has a volume of 798 cm^3 with a mass of 14 250g. What is the identity of the metal?

G: v = 798 cm^3
m = 14 250g

R: d

A: d = $\frac{m}{v}$

S: d = $\frac{m}{v}$

= $\frac{14\ 250\ g}{798\ cm^3}$

= 19.3089 g/cm^3

= 19.3 g/cm^3

S: The metal's density is 19.3 g/cm^3 and it is gold.

GRASS Example 2

Calculate the density of a piece of silver that has a volume of 2.0 cm^3 and a mass of 21.0 g.

G: $V = 2.0 cm^3$

$m = 21.0 g$

R: $d = ?$

A: $d = \frac{m}{V}$

S: $d = \frac{21.0 g}{2.0 cm^3}$

S: $d = 10.5 g/cm^3$

GRASS Example 3

What is the volume occupied by 40 000 kg of water? *(Hint: use Table 1)*

G: $m = 40000 kg \longrightarrow 40{,}000 \text{ kg} \times \frac{1000 g}{1 kg} = 40{,}000{,}000 g$

$d_{water} = 1.00 g/cm^3$

R: $V = ?$

A: $V = \frac{m}{d}$

S: $V = \frac{40{,}000{,}000 g}{1.00 g/cm^3}$

S: $V = 40{,}000{,}000 cm^3$

GRASS Example 4

An empty beaker with a mass of 53.5 g is filled with 65 mL of an unknown liquid. The mass of the beaker with the liquid is now 104.85 g. What is the density of the liquid? What is the liquid? *(Hint: use different subscripts to differentiate between measurements of the same unit)*

$1g = 1mL = 1cm^3$

G: $m_i = 53.5g$

$V = 65mL$

$m_f = 104.85g$

R: $d = ?$

A: $d = \frac{m}{V}$

S: $d = \frac{m_f - m_i}{V}$

$d = \frac{104.85 - 53.5}{65} = \frac{51.08g}{65mL} \longrightarrow d = 0.7858\ g/mL$

S: ∴ the density is 0.786 and the substance is isopropanol

GRASS Example 5

A graduated cylinder is filled with 20mL of water. When 250g of lead is added to the water, the volume rises to 42mL. What is the density of lead? *(Hint: use different subscripts to differentiate between measurements of the same unit)*

G: $V_i = 20mL$

$m = 250g$

$V_f = 42mL$

R: $d = ?$

A: $d = \frac{m}{V}$

S: $d = \frac{250}{42-20} = \frac{250}{22} \longrightarrow d = 11.36\ g/mL$

S: ∴ the density of lead is 11.36 g/mL

Density Problems:

1) Explain what determines whether a solid will float or sink in a liquid. Use the concept of density to explain why wood will float, but steel will sink.

2) For each of the following explain whether the solid will sink or float:

b. A piece of gold in mercury.

c. A piece of lead in mercury.

3) Many ships are made of steel. Why do steel ships float?

4) Using your knowledge of density, explain why it is easier for a person to swim in salt water than it is for them to swim in fresh water.

5) Calculate the mass of a gold bar that is 18.00 cm long, 9.21 cm wide, and 4.45 cm high.

mass = ?

gold bar → density = 19.32 g/cm³ (from table 1 on pg. 193)

$\ell = 18.00\ cm$

$w = 9.21\ cm$

$h = 4.45\ cm$

volume = $\ell \times w \times h$

$= 18.00 \times 9.21 \times 4.45$

$= 737.72\ cm^3$

mass = density × volume

$= 19.32\ \frac{g}{cm^3} \times 737.72\ cm^3$

$= 14,252.75\ g$

∴ the mass is 14,252.75 g

Gas Test Problems:

1. During surgery, why do medical staff wear coverings over their shoes to eliminate sparks produced by static electricity?

2. In 1937, the Hindenburg blimp made its last trip. The Hindenburg was filled with hydrogen gas and caught fire. Based on what you observed in the flame test, what do you think happened to the Hindenburg blimp? Why?

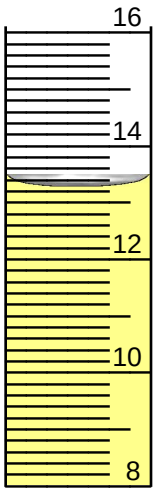
3. Why are birthday balloons filled with helium and not hydrogen?

4. What gas does a fire extinguisher produce and why is this useful?

Name : _____ Score : _____

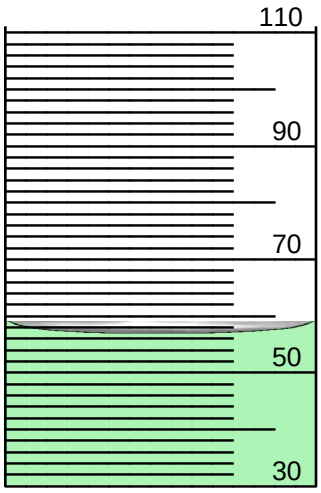
Teacher : _____ Date : _____

What is the reading in milliliters for each graduated cylinder?



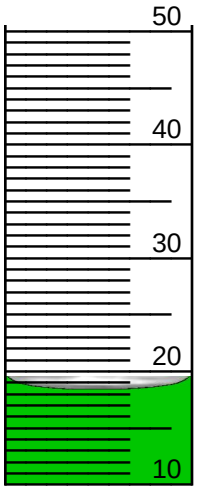
13.3 ml

3.75 ml

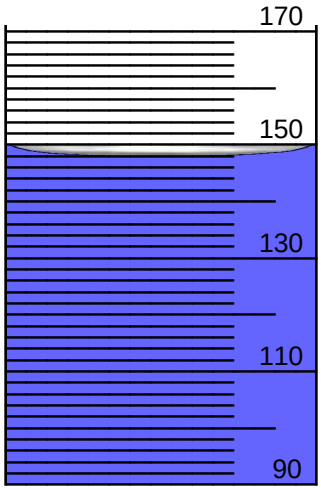


57 ml

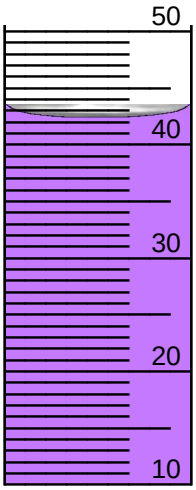
0.6 ml



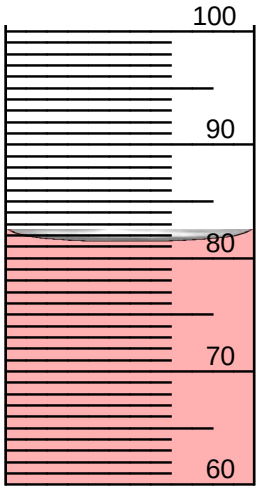
18.5 ml



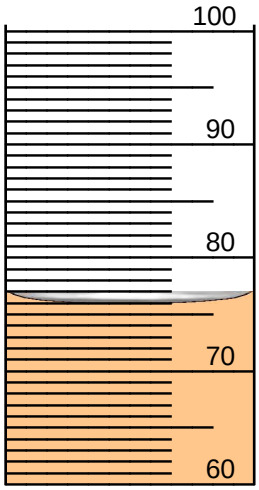
148 ml



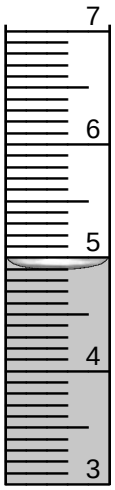
42.5 ml



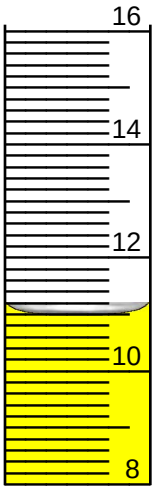
81.5 ml



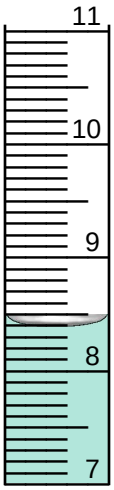
76 ml



4.9 ml



11 ml



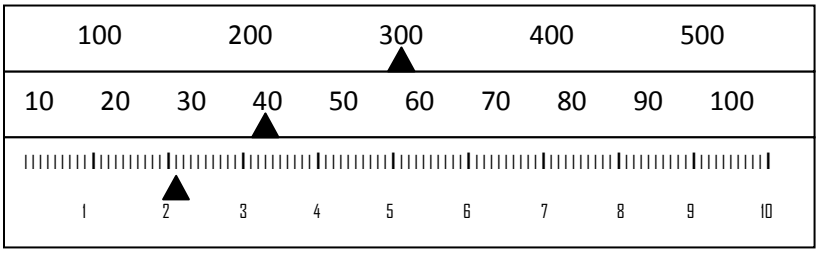
8.4 ml

NAME:_____ HR:_____

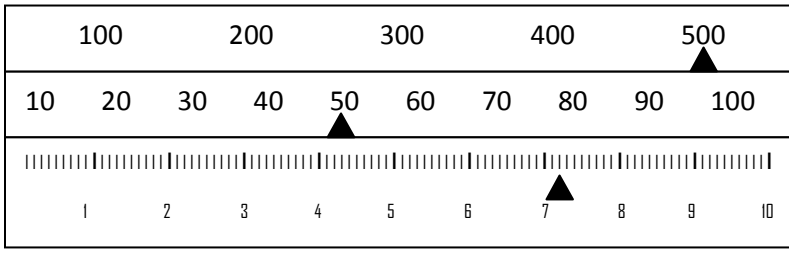
Measuring Mass Practice

Read the following triple beam scales and determine the masses. Triple Beam Balances measure in grams.

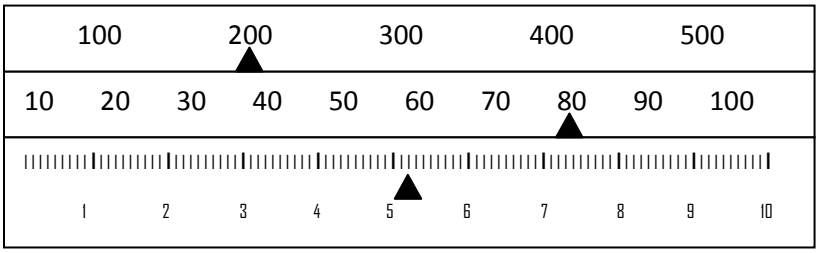
1. _____g



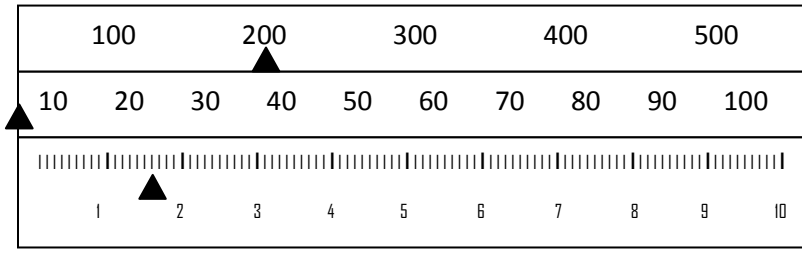
2. _____g



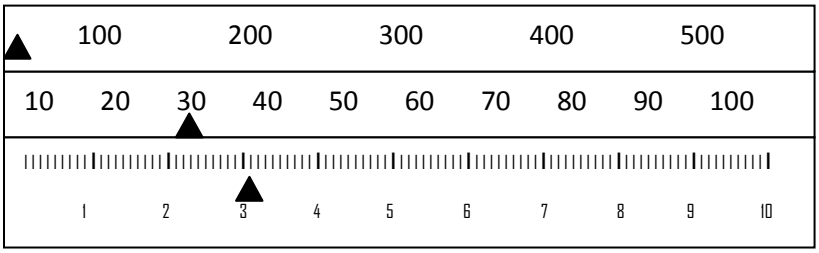
3. _____g



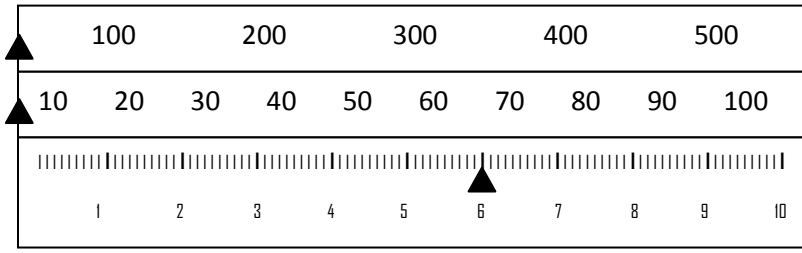
4. _____g



5. _____g



6. _____g



7. Read the triple beam balance below . What is the mass in grams? _____g
8. Read the triple beam balance below. What is the mass in mg? (THINK: how many mg in 1g?) _____mg