Phases of Matter

Solid

- Atoms in _____ contact so they can't move much
- Set _____ and _____
- Can't _____

Liquid

- Atoms _____ past each other
- Set _____
- Takes _____ of container
- Hard to _____

Gas

- Atoms _____ apart
- _____ set _____ or _____
- _____

Fluids

- _____
- Both _____ and _____

Density

$$\rho = \frac{m}{V}$$

Where ρ = density, m = mass, V = Volume

Table 11.1 Densities of Various Substances

Substance	$\rho(10^3 \text{ kg/m}^3 \text{ or g/mL})$	Substance	$\rho(10^3 \text{ kg/m}^3 \text{ or g/mL})$	Substance	$\rho(10^3 \text{ kg/m}^3 \text{ or g/mL})$
Solids		**Liquids**		**Gases**	
Aluminum	2.7	Water (4ºC)	1.000	Air	1.29×10^{-3}
Brass	8.44	Blood	1.05	Carbon dioxide	1.98×10^{-3}
Copper (average)	8.8	Sea water	1.025	Carbon monoxide	1.25×10^{-3}
Gold	19.32	Mercury	13.6	Hydrogen	0.090×10^{-3}
Iron or steel	7.8	Ethyl alcohol	0.79	Helium	0.18×10^{-3}
Lead	11.3	Petrol	0.68	Methane	0.72×10^{-3}
Polystyrene	0.10	Glycerin	1.26	Nitrogen	1.25×10^{-3}
Tungsten	19.30	Olive oil	0.92	Nitrous oxide	1.98×10^{-3}
Uranium	18.70			Oxygen	1.43×10^{-3}
Concrete	2.30–3.0			Steam (100° C)	0.60×10^{-3}
Cork	0.24				
Glass, common (average)	2.6				
Granite	2.7				
Earth's crust	3.3				
Wood	0.3–0.9				
Ice (0°C)	0.917				
Bone	1.7–2.0				

Things with _____ density _____ on things with _____ density

- Solids _____ dense
- Gases _____ dense

You can use density to determine unknown material.

An ornate silver crown is thought to be fake. How could we determine if is silver without damaging the crown?

1. Find its mass using a balance. (It is 1.25 kg)
2. Find its volume by submerging in water and finding volume of displaces water. (It is 1.60×10^{-4} m³)
3. Find the density

Silver's density is 10.5×10^3 kg/m³

Homework

1. What physical characteristic distinguishes a fluid from a solid?

2. Which of the following substances are fluids at room temperature: air, mercury, water, glass?

3. How do gases differ from liquids?

4. A pile of empty aluminum cans has a volume of 1.0 m³. The density of aluminum is 2700 kg/m³. Explain why the mass of the pile is not $\rho_{Al}V = \left(2700 \frac{kg}{m^3}\right)(1.0 \; m^3) = 2700 \; kg$.

5. Gold is sold by the troy ounce (31.103 g). What is the volume of 1 troy ounce of pure gold? (OpenStax 11.1) **1.610 cm³**

6. Mercury is commonly supplied in flasks containing 34.5 kg (about 76 lb). What is the volume in liters of this much mercury? (OpenStax 11.2) **2.54 L**

7. (a) What is the mass of a deep breath of air having a volume of 2.00 L? (b) Discuss the effect taking such a breath has on your body's volume and density. (OpenStax 11.3) **2.58 g**

8. A straightforward method of finding the density of an object is to measure its mass and then measure its volume by submerging it in a graduated cylinder. What is the density of a 240-g rock that displaces 89.0 cm³ of water? (Note that the accuracy and practical applications of this technique are more limited than a variety of others that are based on Archimedes' principle.) (OpenStax 11.4) **2.70 g/cm³**

9. Suppose you have a coffee mug with a circular cross section and vertical sides (uniform radius). What is its inside radius if it holds 375 g of coffee when filled to a depth of 7.50 cm? Assume coffee has the same density as water. (OpenStax 11.5) **3.99 cm**

10. (a) A rectangular gasoline tank can hold 50.0 kg of gasoline when full. What is the depth of the tank if it is 0.500-m wide by 0.900-m long? (b) Discuss whether this gas tank has a reasonable volume for a passenger car. (OpenStax 11.6) **0.163 m**

11. A trash compactor can reduce the volume of its contents to 0.350 their original value. Neglecting the mass of air expelled, by what factor is the density of the rubbish increased? (OpenStax 11.7) **2.86 times denser**

12. A pirate in a movie is carrying a chest (0.30 m × 0.30 m × 0.20 m) that is supposed to be filled with gold. To see how ridiculous this is, determine the weight (in newtons) of the gold. To judge how large this weight is, remember that 1 N = 0.225 lb. (Cutnell 11.3) **3400 N**

13. A water bed has dimensions of 1.83 M × 2.13 m × 0.229 m. The floor of the bedroom will tolerate an additional weight of no more than 6660 N. Find the weight of the water in the bed and determine whether it should be purchased. (Cutnell 11.4) **8750 N**