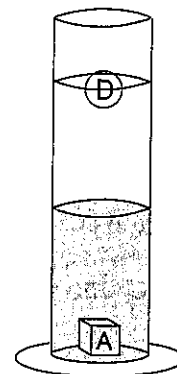# Density

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Overview:

Density is an identifying property of matter. Calculating the density of an object, especially minerals, greatly assists in the identification of the object. Density is the mass per unit volume.

The Equation:

The density equation involves three variables: v, m, and d. When given any two variables, the third variable can be found. This can be shown by the accompanying "Density Triangle".

From this triangle if one needs the equation for density, cover d and the answer is shown, m/v. The same procedure is used for mass, $m = (d)(v)$ and volume, $v = m/d$. The most common unit for density is g/cm³, which is the same as g/cc and g/mL.
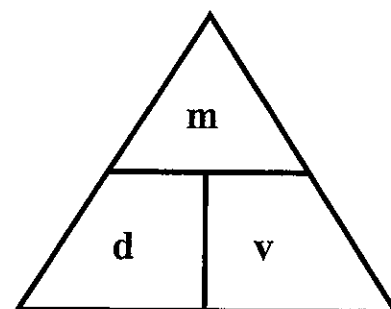
If the density question involves a density graph, select any value along the mass axis and from this value move directly to the graph line. At this intersection point, read over to the volume axis to get its value. Substitute these values (m and v) into the density equation to obtain the answer.

At times the density value will change for a substance, especially for gases. When the volume of a gas changes due to temperature or pressure changes, its density is affected. For example, when the volume of a gas increases due to an increase in temperature or a decrease in pressure, the density will decrease. This is an inverse relationship: $\downarrow d = \frac{m}{\uparrow v}$ (Remember, during these volume and density changes, the mass of the substance will remain the same.) This is why a hot air balloon rises; the hot air expands the balloon causing its density to decrease. This action occurs constantly in the atmosphere due to the heating of the air by the Sun. This produces rising and sinking air currents, which may produce changes in the local weather.

Additional Information:

- Normally, solids are denser than liquids, and gases are the least dense.
- The exception to the above rule is water. The solid phase, ice, is less dense than that of the liquid phase.
- When water changes to ice, the volume increases causing the density to decrease.
- Any object with a density value less than 1 g/cm³ will float when placed in water. An object with a density value higher than 1 g/cm³ will sink when placed in water.
- The same substance will have the same density value regardless of its size.

Density

1. A rock sample has a mass of 16 grams and a volume of 8 cubic centimeters. When the rock is cut in half, what is the volume and density of each piece?

   (1) 8 cm³ and 0.5 g/cm³
   (2) 8 cm³ and 1.0 g/cm³
   (3) 4 cm³ and 2.0 g/cm³
   (4) 4 cm³ and 4.0 g/cm³   1_____

2. The graph below shows the relationship between mass and volume for three samples, A, B, and C, of a given material. What is the density of this material?
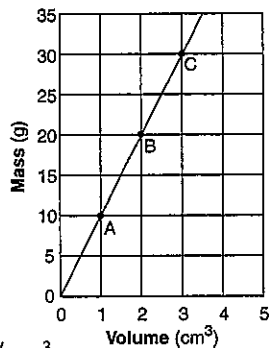
   (1) 1.0 g/cm³
   (2) 5.0 g/cm³
   (3) 10.0 g/cm³
   (4) 20.0 g/cm³   2_____

Note: Question 3 has only three choices.

3. As air on the surface of Earth warms, the density of the air

   (1) decreases
   (2) increases
   (3) remains the same   3_____

4. If the mass of a spinel crystal is 9.5 grams, what is the volume of this spinel crystal?

   Table 1

Gemstone Mineral	Composition	Hardness	Average Density (g/cm³)
emerald	Be₃Al₂(Sl₆O₁₈)	7.5–8	2.7
sapphire	Al₂O₃	9	4.0
spinel	MgAl₂O₄	8	3.8
zircon	ZrSiO₄	7.5	4.7

   (1) 0.4 cm³
   (2) 2.5 cm³
   (3) 5.7 cm³
   (4) 36.1 cm³   4_____

5. Liquid W was added to the graduated cylinder containing liquid C. Objects A and D were then dropped into the cylinder. Which statement is correct?
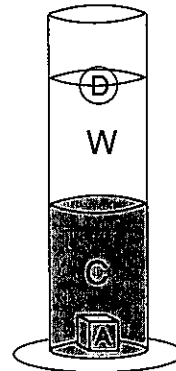

   (1) Liquid W is denser than liquid C and object D.
   (2) Liquid C is denser than liquid W and object A.
   (3) Liquid C is less dense than object A, but more dense than liquid W and object D.
   (4) Object A is denser than liquid C, but not as dense as liquid W and object D.   5_____

6. The diagram below represents a solid object with a density of 3 grams per cubic centimeter. What is the mass of this object?

(1) 0.5 g
(2) 2 g
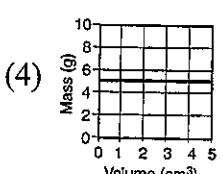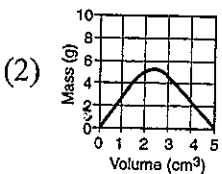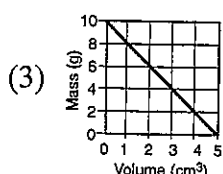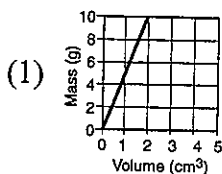(3) 18 g
(4) 36 g
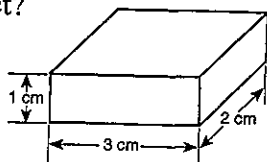
1 cm
2 cm
3 cm
(Not drawn to scale)

6 _____

7. Which graph best represents the relationship between mass and volume of a material that has a density of 5 grams per cubic centimeter?
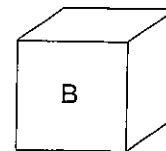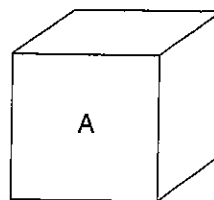
(1)

Mass (g)
Volume (cm³)

(3)

Mass (g)
Volume (cm³)

(2)

Mass (g)
Volume (cm³)

(4)

Mass (g)
Volume (cm³)

7 _____

Note: Question 8 has only three choices.

8. When a substance is compressed the density would

(1) increase
(2) decrease
(3) remains the same

8 _____

Base your answers to question 9 on the diagrams below. The diagrams represent two different solid, uniform materials cut into cubes A and B.

A

B

Mass of A = 320 g
Volume of A = 64 cm³

Density of B = 3 g/cm³
Volume of B = 27 cm³

(Not drawn to scale)

9. a) What is the density of cube A?

(1) 0.2 g/cm³
(2) 5.0 g/cm³
(3) 12.8 g/cm³
(4) 64.0 g/cm³

a _____

b) What is the mass of cube B?

(1) 3 g   (3) 27 g
(2) 9 g   (4) 81 g

b _____

Note: Question c has only three choices.

c) Assume cube B was broken into many irregularly shaped pieces. Compared to the density of the entire cube, the density of one of the pieces would be

(1) less
(2) greater
(3) the same

c _____

10. Explain how heat would change the density of a parcel of air.

_____

_____