Chemistry: Matter Worksheet  Answer Key
Use your scientific model of matter and investigation results to answer the following questions.

Sodium Bicarbonate & Acetic Acid Experiment
1. Explain how your sodium bicarbonate and acetic acid experiment tested the Law of Conservation of Matter. Use your experimental data to support your answer.

   Specific answers will vary, but will generally include
   The law of conservation of mass was tested by changing the composition of the acetic acid and sodium bicarbonate in a closed system and comparing the mass before and after the composition change. The mass of the system before and after the change remained the same, which supports the law of conservation of mass.

2. Does gas have mass? Use your experimental data to support your answer.

   Yes. The mass of the system before the gas was allowed to escape was greater than the mass of the system after the gas was allowed to escape, which demonstrates that the gas has mass.

Wood Experiment
3. According to the particle model how can two objects have different densities? [Hint: there are three ways]

   An object’s or substance’s density is determined by the mass of the particles and how close the particles are to each other. Two objects can have different densities by having 1) particles of similar mass and different spacing; 2) particles with different mass and similar spacing between the particles; or 2) particles with different mass and different spacing.

4. Wood is made mostly of a substance called cellulose. Why did the three species of wood have different densities?

   The particles that made up the wood are spaced differently in all three species. The particles are closest to each other in the oak, and farthest from each other in the pine.
5. Use the information below and your experimental densities to identify species A, B and C. The published densities for the 3 species of wood we used in the investigation are:

- Oak \(-0.74 \text{ g/cm}^3\)
- Yellow Pine \(-0.42 \text{ g/cm}^3\)
- Poplar - 0.3 g/cm\(^3\) to 0.5 g/cm\(^3\)

Species A – yellow pine
Species B – oak
Species C – poplar

6. Which species do you think is the “strongest”? Explain your reasoning.

Answers will vary. Oak is the strongest, because it is the densest.

Model Application Questions
Apply your scientific model of matter to different situations. Show your work for all math problems including units and the correct number of sig figs.

7. What is the mass of a 3.81 cm thick, 8.89 cm wide, and 243.84 cm long piece of wood for ...

a. Species A

\[ m = V \cdot D = (3.81 \text{ cm})(8.89 \text{ cm})(243.84 \text{ cm})(0.74 \text{ g/cm}^3) = 3468.8137 \text{ g} \]

2 s.f. \[ \underline{3500 \text{ g}} \]

b. Species B

\[ m = V \cdot D = (3.81 \text{ cm})(8.89 \text{ cm})(243.84 \text{ cm})(0.42 \text{ g/cm}^3) = 6111.7193 \text{ g} \]

2 s.f. \[ \underline{6100 \text{ g}} \]

c. Species C

\[ m = V \cdot D = (3.81 \text{ cm})(8.89 \text{ cm})(243.84 \text{ cm})(0.50 \text{ g/cm}^3) = 4129.5401 \text{ g} \]

2 s.f. \[ \underline{4100 \text{ g}} \]
8. Determine the density in grams per milliliter for each of the following:

a. A 20.0 mL sample of salt solution has a mass of 24.0 g.

\[ D = \frac{m}{V} = \frac{24.0 \text{ g}}{20.0 \text{ mL}} = 1.20 \text{ g/mL} \quad 3 \text{ s.f.} \]

b. A cube of butter weighs 0.250 lb and has a volume of 130.3 mL.

\[ D = \frac{m}{V} = \frac{0.250 \text{ lb}}{130.3 \text{ mL}} \times \frac{454 \text{ g}}{1 \text{ lb}} = 0.871 \text{ g/mL} \quad 3 \text{ s.f.} \]

c. A gem has a mass of 4.50 g. When the gem is placed in a graduated cylinder containing 2.00 mL of water, the water level rises to 3.45 mL.

\[ V_{\text{gem}} = 3.45 \text{ mL} - 2.00 \text{ mL} = 1.45 \text{ mL} \]

\[ D = \frac{m}{V} = \frac{4.50 \text{ g}}{1.45 \text{ mL}} = 3.09 \text{ g/mL} \Rightarrow \frac{3.10}{\text{g/mL}} \quad 3 \text{ s.f.} \]

d. A lightweight head on the driver of a golf club is made of titanium. If the volume of a sample of titanium is 114 cm³ and the mass is 485.6 g, what is the density of titanium?

\[ D = \frac{m}{V} = \frac{485.6 \text{ g}}{114 \text{ cm}^3} = 4.28 \text{ g/cm}^3 \Rightarrow 4.26\text{ g/cm}^3 \quad 3 \text{ s.f.} \]

9. Look at the picture below and explain what determines if an object will float or sink in water.

Objects float in water if their density is less than the density of water.

Objects sink in water if their density is greater than the density of water.

- Cork (D = 0.26 g/mL)
- Ice (D = 0.92 g/mL)
- H₂O (D = 1.0 g/mL)
- Aluminum (D = 2.70 g/mL)
- Lead (D = 11.3 g/mL)
10. Use the density values in the table below to solve the following problems.

<table>
<thead>
<tr>
<th>Solids (at 25°C)</th>
<th>Density (g/cm³ or g/mL)</th>
<th>Liquids (at 25°C)</th>
<th>Density (g/mL)</th>
<th>Gases (at 0°C)</th>
<th>Density (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cork</td>
<td>0.26</td>
<td>gasoline</td>
<td>0.66</td>
<td>hydrogen</td>
<td>0.090</td>
</tr>
<tr>
<td>ice</td>
<td>0.92</td>
<td>ethyl alcohol</td>
<td>0.785</td>
<td>helium</td>
<td>0.179</td>
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<td>sugar</td>
<td>1.59</td>
<td>olive oil</td>
<td>0.92</td>
<td>methane</td>
<td>0.714</td>
</tr>
<tr>
<td>salt (NaCl)</td>
<td>2.16</td>
<td>water (at 4°C)</td>
<td>1.000</td>
<td>neon</td>
<td>0.90</td>
</tr>
<tr>
<td>aluminum</td>
<td>2.70</td>
<td>milk</td>
<td>1.04</td>
<td>nitrogen</td>
<td>1.25</td>
</tr>
<tr>
<td>diamond</td>
<td>3.52</td>
<td>mercury</td>
<td>13.6</td>
<td>air (dry)</td>
<td>1.29</td>
</tr>
<tr>
<td>copper</td>
<td>8.92</td>
<td></td>
<td></td>
<td>oxygen</td>
<td>1.43</td>
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<tr>
<td>silver</td>
<td>10.5</td>
<td></td>
<td></td>
<td>carbon dioxide</td>
<td>1.96</td>
</tr>
<tr>
<td>lead</td>
<td>11.3</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gold</td>
<td>19.3</td>
<td></td>
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</tr>
</tbody>
</table>

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a. How many liters of ethyl alcohol have a mass of 1.50 kg?

\[
V = \frac{m}{D} = \frac{1.50 \text{ kg}}{0.785 \text{ g/mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 1.91082 \text{ L} \approx 1.91 \text{ L (3 sf.)}
\]

b. How many grams of mercury are present in a barometer that holds 6.5 mL of mercury?

\[
m = VD = (6.5 \text{ mL})(0.92 \text{ g/mL}) = 5.96 \text{ g} \Rightarrow 5.96 \text{ g (2 sf.)}
\]

c. What is the mass, in grams, of a cube of copper that has a volume of 74.1 cm³?

\[
m = VD = (74.1 \text{ cm}³)(8.92 \text{ g/cm}³) = 664.972 \text{ g} \Rightarrow 665 \text{ g (2 sf.)}
\]

d. How many kilograms of gasoline fill a 12.0 gallon gas tank? (1 gallon = 4 quarts; 1 quart = 0.9464 L)

\[
m = VD = 12.0 \text{ gal} \times 0.6047 \text{ lb gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{0.9464 \text{ L}}{1 \text{ qt}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ kg}}{1000 \text{ g}}
\]

\[
m = 29.981952 \text{ kg} \Rightarrow 30.0 \text{ kg (2 sf.)}
\]

11. Use the density table from the table in the previous problem to answer the following questions:

a. A graduated cylinder contains 28.0 mL of water. What is the new water level after 35.6 g of silver metal is submerged in the water?

\[
V = \frac{m}{D} = \frac{35.6 \text{ g}}{10.5 \text{ g/mL}} = 3.39047 \text{ mL} \Rightarrow 3.39 \text{ mL (3 sf.)}
\]

new water level = 28.0 mL + 3.39 mL = 31.39 mL \Rightarrow 31.4 \text{ mL (5 sf. to tenths)}
b. A thermometer containing 8.3 g of mercury has broken. What is the volume of mercury spilled?

\[ V = \frac{m}{D} = \frac{8.3 \text{ g}}{13.6 \text{ g/mL}} \times \frac{1 \text{ mL}}{13.6 \text{ g}} = 0.610 \text{ mL} \Rightarrow 0.61 \text{ mL 2 s.f.} \]

c. A fish tank holds 35 gallons of water. How many pounds (lb) of water are in the fish tank?

\[ m = VD = \frac{35 \text{ gal}}{1 \text{ gal}} \times \frac{4 \text{ lb}}{1 \text{ gal}} = \frac{0.944 \text{ gal}}{1 \text{ gal}} \times \frac{1000 \text{ lb}}{1 \text{ gal}} \times \frac{1 \text{ gal}}{1 \text{ gal}} \times \frac{4 \text{ lb}}{1 \text{ gal}} = 291.841 \text{ lbs} \Rightarrow 290 \text{ lbs 2 s.f.} \]

d. The mass of an empty container is 88.25 g. The mass of the container and a liquid with a density of 0.758 g/mL is 150.50 g. What is the volume (mL) of the liquid in the container?

\[ \text{mass of liquid} = 150.50 \text{ g} - 88.25 \text{ g} = 62.25 \text{ g} \]
\[ V = \frac{m}{D} = \frac{62.25 \text{ g}}{0.758 \text{ g/mL}} \times \frac{1 \text{ mL}}{0.758 \text{ g}} = 82.124 \text{ mL} \Rightarrow 82.1 \text{ mL 3 s.f.} \]

12. A graduated cylinder contains three liquids A, B and C, which have different densities and do not mix. Liquid A is on top of the other two liquids; liquid B is below liquid A and above liquid C; liquid C is below the other two liquids. The liquids are mercury (D = 13.6 g/mL), vegetable oil (D=0.92 g/mL), and water (D=1.00 g/mL).

Identify liquids A, B and C in the graduated cylinder.

- Liquid A is vegetable oil, D = 0.92 g/mL
- Liquid B is water, D = 1.00 g/mL
- Liquid C is mercury, D = 13.6 g/mL

Liquids will arrange themselves with the least dense liquid on top and the most dense liquid on bottom.

13. A package of aluminum foil is 66 2/3 yard long, 12 inches wide, and 0.000 30 inches thick. If aluminum has a density of 2.70 g/cm³, what is the mass, in grams of the foil?

\[ \text{Volume} = (66 \frac{2}{3} \text{ yd}) \times (12 \text{ in}) \times (3.0 \times 10^{-4} \text{ in}) = \frac{36 \text{ in}}{1 \text{ yd}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ in}}{1 \text{ cm}} = 141.5913 \text{ cm}^3 \]
\[ m = VD = (140 \text{ cm}^3) (2.70 \text{ g/cm}^3) = 370 \text{ g} \Rightarrow 140 \text{ cm}^3 2 \text{s.f.} \]

14. A circular pool with a diameter of 27 feet is filled to a depth of 5.0 x 10⁻¹ inches. Assume the pool is a cylinder (V_{cylinder} = \pi r^2 h).

a. What is the volume of water in the pool in cubic meters?

\[ V = \pi (13.5 \text{ ft})^2 (5.0 \times 10^{-1} \text{ in}) \times \frac{12^2 \text{ in}^2}{12 \text{ ft}^2} \times \frac{2.54 \text{ cm}^3}{1 \text{ in}^3} \times \frac{1 \text{ cm}^3}{100^3 \text{ cm}^3} = 67.568 \text{ m}^3 \Rightarrow 68 \text{ m}^3 2 \text{s.f.} \]

b. The density of water is 1.00 g/cm³. What is the mass, in kilograms, of the water in the pool?

\[ m = VD = (68 \text{ m}^3) \times 1.00 \text{ g/cm}^3 \times \frac{1000 \text{ cm}^3}{1 \text{ m}^3} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 68,000 \text{ Kg} \Rightarrow 68 \times 10^3 \text{ kg} 2 \text{s.f.} \]