

Chem 2990

**Density and Specific Gravity Calculations**

Dr. Walker

Consider the following data and perform the indicated calculations.

- The specific gravity of an aqueous salt solution is determined by filling a pycnometer with distilled water. The net mass of the distilled water is 145.34g. The pycnometer is emptied and dried. Then, it is refilled with an identical volume of salt water. The net mass of the salt water is 184.14g. Calculate the specific gravity of the salt water.
- Specific gravity of emerald [ $Be_3Al_2(SiO_3)_6$ ] is 2.67 - 2.78. It's color can range from its typical blue-green to a yellow-green. An owner of a cut green gem stone requests a test that can distinguish his emerald from tourmaline, another type of green gem stone. Chrome tourmaline has a rich green color due to the presence of chromium atoms in the crystal. [*Chromdravite form of tourmaline:  $NaMg_3Cr_6Si_6O_{18}(BO_3)_3(OH)_4$* ]. The specific gravity of tourmaline ranges from 2.82–3.3. The mass of the gem stone in air is 456.2 mg. The mass of the stone suspended in distilled water is 287.9 mg. What is the specific gravity for the stone? Is it a better match for an emerald or tourmaline?
- Knowing that one carat = .2 grams or 200 milligrams, calculate the mass of the unknown green stone (from Problem 2 above) in carats. Look up the current price for emeralds and tourmaline stones. What is the difference in price for the gem, if it were emerald or tourmaline?
- Metal alloys differ substantially in their densities, which are most often listed in units of  $kg/m^3$ . The ASTM B19 specification for brass states that the composition is 68.5% - 71.5% copper, up to .07% lead, up to .05% iron and the remainder is zinc. Neglecting the contribution of lead and iron to the density, describe how density could be used to measure the content of zinc in brass.

Alloy	Density ( $kg/m^3$ )
Zinc	7135
Copper	8930

Calculate the densities associated with the specified composition according to ASTM. If a sample of brass weighs 25.894g in air, what should its mass in water be at the two composition limits?

- A metal sinker with an exact volume of 10.00mL has a mass of 79.900g in air. The sinker is suspended in a liquid sports drink that contains approximately 50% by weight protein. The mass of the sinker suspended in the liquid is only 67.500g. What is the density of the liquid protein drink? If the manufacturing release specification for density is 1.22-1.25, can the manufacturer release the product? If the product is to be sold in 1-pint sized serving containers, what is the net weight of the liquid in each serving in both grams and pounds?

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## 6. Idaho Potatoes

Construct a chart of percent total solids (y-axis) as a function of specific gravity (x-axis). Add a trend line with its equation and  $r^2$ .

- In your opinion, can total solids in a potato be measured accurately by its specific gravity?

Three potatoes were selected from a freshly harvested crop of Idaho potatoes. A cubic portion was cut from the interior of each potato. Each of these samples were weighed in air and while suspended in pure distilled water.

- Calculate the specific gravity of each potato sample from the resulting data below.
- Calculate the average specific gravity of all three samples.
- Does the average specific gravity of these potatoes meet the commercial standard of at least  $\rho \geq 1.08$ ?
- Calculate the % Total Solids for each sample.
- Would McDonalds or Frito Lay buy these potatoes for their products?

**Specific Gravity of Potatoes**

Specific gravity	% Total Solids (primarily starch)
1.072	19.0
1.074	19.4
1.076	19.8
1.078	20.3
1.080	20.7
1.082	21.1
1.084	21.6
1.086	22.0
1.088	22.4
1.090	22.8
1.092	23.2
1.094	23.7

## Potato Test Results:

Sample	Mass of samples		Specific Gravity	% Total Solids	Average Spec Gravity	Average % Total Solids	Pass/Fail Standard?	Purchased by McDonalds?
	In Air (grams)	In water (grams)						
1	15.841	1.243						
2	18.002	1.352						
3	16.729	1.229						

7. Steel is one of the most widely used materials, particularly in construction and in the manufacture of cars. It is estimated that there are over 20 billion tons of steel in use, equivalent to well over 2 tons for every person on Earth. Annual worldwide production of steel is approximately 2 billion tons.

Steel is made by combining iron ore ( $\text{Fe}^{3+}$ ) with carbon and heating to  $1,500^\circ\text{C}$ . The carbon reduces the iron to its elemental state ( $\text{Fe}^0$ ). Excess carbon and other impurities in this "pig iron" are then removed by blowing oxygen through the mixture. The resulting oxides of C, Si, Mn and P are removed as "slag." Modern furnaces can convert *350 tons of reactants to steel in less than 40 minutes.*



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Other metals are then added to create different types of “alloy steel” with specific properties. These alloy steels contain some combination of one or more of the following elements: nickel, chromium, tungsten, molybdenum, vanadium, manganese, cobalt, copper, niobium, zirconium, selenium and lead.

**Stainless Steel** is designed to protect against oxidation (rust.) It features low carbon content and at least 10.5% chromium content. Stainless steel is used extensively in tanks and pipes where liquid products are produced.

**Carbon Steel (“Tool Steel”)** on the other hand, is characterized by a high carbon content, up to 2.1% of its weight. Even though carbon steel is more susceptible to oxidation, it is stronger and harder with better wear resistance, making it useful for tools, knives, swords, etc.

These two steel alloys differ in their specific gravities:

Questions:

- A. A sample coupon of steel is weighed both in air (43.557g) and while suspended in water (38.133g).

Calculate the specific gravity of this sample.

- B. What type of steel is this?

- C. A manufacturer orders 125 sheets of this steel each measuring 8 x 12 feet with a 12-gauge thickness. Calculate the weight of this order in pounds.

- D. How many cubic meters of steel does this order occupy?

- E. Will this volume of steel fit on a single semi-truck?

<i>Steel Type</i>	<i>Spec.Grav.</i>
Carbon Tool Steel	7.82
Stainless Steel	8.03

The federal government limits the gross vehicle weight of semi-trucks on interstate freeways. Assuming the weight of a semi-truck pulling an empty flatbed load is 35,000 pounds, can this order be shipped on a single flatbed semi-truck?