

Concentration and Units of Measure

Chemical concentration is a critical aspect of modern chemistry. Typically we define concentration as the amount of solute (the compound of interest) dissolved in a solvent. Most often the solvent is water. Units of measure that describing how much of a solute is present in a specified quantity of solvent are numerous and diverse. The most common units involve ratios of solute to solvent.

Percent by Volume: % (v/v) = volume of solute divided by the volume of the solution multiplied by 100.

This ratio is useful when the solute is a liquid such as ethylene glycol is mixed with water. For example, if 100mL of ethylene glycol is mixed with enough water to make a total of 400mL of solution, then the concentration of ethylene glycol is 100mL

$$\% (v/v) = \frac{100\text{mL}}{400\text{mL}} \times 100 = 25.0\% (v/v)$$

Percent by Mass/Volume: % (m/v) = mass(g) of solute divided by the volume (mL) solution multiplied by 100.

This unit is probably the most common of all the concentration units. The formal definition of DUI for the state of Utah is 0.05% (m/v) or 0.05 grams of ethanol per 100mL of blood. A 15% salt solution is prepared by weighing 15g of NaCl into a 100mL volumetric flask, adding water, mixing until dissolved, then topping off with additional water (if needed) to the mark. http://le.utah.gov/code/TITLE41/htm/41_06a050200.htm

Percent by mass: % (m/m) or % (w/w) = mass of solute divided by the mass of solution multiplied by 100. In any mass/mass ratio such as this, the mass of the solution includes both the mass of solute plus the mass of solute. For example, if 10g of salt is dissolved in 100g of water,

$$\% (m/m) = \frac{10.0g}{10.0g + 100.0g} \times 100 = 9.09\% (m/m)$$

Another way of viewing percent by mass is “parts per hundred.”

Parts per Thousand: ppt = mass of solute divided by the mass of solution multiplied by 1000. For the same solution:

$$\text{ppt} = \frac{10.0g}{10.0g + 100.0g} \times 1000 = 909 \text{ ppt}$$

Parts per Million: ppm = mass of solute divided by the mass of solution multiplied by 1,000,000 (10^6)

Parts per Billion: ppb = mass of solute divided by the mass of solution multiplied by 1,000,000,000 (10^9)

Note that these ratio concentrations above are not dependent on the nature of the solute. A compound with a large molecular weight and another compound with a small molecular weight could have the same concentration but have different number of molecules in each solution. This is because these concentrations do not take into account the density or molecular weights of solutes. Also, % (m/m) is not usually equal to % (m/v) nor are either of these equal to % (v/v) . The density of the solutes and solvents and their respective solutions can change the values of these three concentration measures for a single solution.

Utah Laws for DUI

Prior to 2018:

41-6a-502. Driving under the influence of alcohol, drugs, or a combination of both or with specified or unsafe blood alcohol concentration -- Reporting of convictions.

- (1) A person may not operate or be in actual physical control of a vehicle within this state if the person:
- (a) has sufficient alcohol in the person's body that a subsequent chemical test shows that the person has a blood or breath alcohol concentration of .08 grams or greater at the time of the test;

53-3-418. Prohibited alcohol level for drivers -- Procedures, including hearing.

- (1) A person who holds or is required to hold a CDL may not drive a commercial motor vehicle in this state if the person:
- (a) has sufficient alcohol in the person's body that a subsequent chemical test shows that the person has a blood or breath alcohol concentration of .04 grams or greater at the time of the test after the alleged driving of the commercial motor vehicle;

72-10-501. Flying under the influence of alcohol, drugs, or with specified or unsafe blood alcohol concentration -- Calculations of blood or breath alcohol -- Criminal punishment -- Arrest without warrant.

- (1) (a) A person may not operate or be in actual physical control of an aircraft within this state if the person:
- (i) has sufficient alcohol in his body that a subsequent chemical test shows that the person has a blood or breath alcohol concentration of .04 grams or greater at the time of the test;

Effective 12/30/2018

41-6a-502. Driving under the influence of alcohol, drugs, or a combination of both or with specified or unsafe blood alcohol concentration -- Reporting of convictions.

- (1) A person may not operate or be in actual physical control of a vehicle within this state if the person:
- (a) has sufficient alcohol in the person's body that a subsequent chemical test shows that the person has a blood or breath alcohol concentration of .05 grams or greater at the time of the test;
 - (b) is under the influence of alcohol, any drug, or the combined influence of alcohol and any drug to a degree that renders the person incapable of safely operating a vehicle; or
 - (c) has a blood or breath alcohol concentration of .05 grams or greater at the time of operation or actual physical control.
- (2) Alcohol concentration in the blood shall be based upon grams of alcohol per 100 milliliters of blood, and alcohol concentration in the breath shall be based upon grams of alcohol per 210 liters of breath.

<http://le.utah.gov/xcode/Title41/Chapter6a/41-6a-S502.html>

What does “0.05 grams or greater” mean in regards to alcohol concentration?

What if an analytical chemist prepares a calibration standard for this type of analysis by preparing an 0.05%(v/v) solution of ethanol in water? How would this affect the reported blood alcohol levels using this standard?