

# The Alcohol Pharmacology Education Partnership

## 1A - Is he Drunk? Calculate the BAC

The blood alcohol concentration (BAC) is a measure of how much alcohol is in a certain amount of blood. The term BAC is often used interchangeably with blood alcohol level (BAL). Factors influencing the BAC include, body weight, gender, and ethnicity, as well as composition of recent meals, and interactions with other drugs, whether present or not! The BAC is used to reflect the level of intoxication for legal purposes; it does not necessarily indicate if the person is actually intoxicated.

The BAC is usually expressed as a percent based on weight/volume. [Note: sometimes concentration can be expressed on a volume/volume basis.] This means that the BAC is the grams (g) of alcohol present per 100 mL of blood. For example, a BAC of 0.12% is equivalent to 0.12 g alcohol per 100 mL of blood. At 0.12%, most people are intoxicated!

Typically 100 mL is referred to as 1 deciliter or 1 dL. So, 0.12% is also equivalent to 0.12 g/dL.

The BAC can be calculated based on how much alcohol one drinks and the volume of water in the body. Remember, alcohol distributes into water spaces. Since the alcohol is in equilibrium between the water spaces and the bloodstream, we can simply calculate the alcohol in the blood.

It takes a few mathematical steps to do this calculation.

**Try this: Calculate the BAC of a 160 lb man drank 4 beers and indicate whether you think he is drunk.**

Note: a typical can of beer contains 12 ounces (of fluid, not alcohol!).

To calculate the BAC, you must know:

- the amount of alcohol ingested
- an estimate of the individual's water volume

Here is the equation:

$$\text{BAC} = \frac{\text{mass ethanol ingested (g)}}{\text{volume of water in the person's body (L)}}$$

### Step 1: Calculate the amount of alcohol ingested

To determine the amount of alcohol ingested we need to determine how much alcohol is contained in the beer.

$$12 \text{ ounces of fluid} \times 4 \text{ beers} = 48 \text{ ounces of } \textit{beer} \text{ consumed}$$

But the amount of beer is not the same as the amount of **alcohol**. Sometimes the percentage of alcohol is written on the label or it can be obtained from an online source. Many regular beers contain approximately 5% alcohol.

So, calculate how many ounces of alcohol were consumed:

$$0.05 \times 48 \text{ ounces} = 2.4 \text{ ounces of } \textit{alcohol} \text{ consumed.}$$

### Convert the ounces to milliliters and then to grams of alcohol ingested

It is much easier to work in the metric system, so now we convert ounces to milliliters (mL). 1 ounce is equal to 29.6 mL.

So,

$$2.4 \text{ ounces} \times 29.6 \text{ mL} / 1 \text{ ounce} = 71.0 \text{ mL}$$

Now we are ready to convert our 71 mL of alcohol to grams. In the case of water, 1 mL weighs 1 g. But 1 mL of alcohol weighs less than 1 mL of water—in fact it weighs only 79% of 1 mL of water. This means that alcohol has a "specific gravity" of 0.79 compared to water, which is always 1.0 at a given temperature.

Taking into account the specific gravity of ethanol is 0.79, the mass of alcohol consumed (in grams) in 4 beers is

$$71\text{mL} \times 0.79 = \mathbf{56.1 \text{ g alcohol consumed}}$$

Thus, in the 4 beers that the man drank, he swallowed 56.1 g of alcohol.

## Step 2: Calculate the volume of water in the man's body

To get the denominator, or the volume into which the alcohol distributes, we need to know how much water is in the body. Although a blood test for alcohol only indicates the concentration of alcohol in the blood, the blood alcohol is in equilibrium with all water spaces so we can make the calculation based on total body water.

First, let's convert the man's weight (mass) into a volume. Again, let's go metric and convert lbs to kilograms (kg, or 1000 g). One lb is equivalent to 0.45 kg.

$$\text{The man weighs (kg): } 160 \text{ lbs} \times 0.45 \text{ kg/lb} = 72.6 \text{ kg}$$

Just as 1 g = 1 mL, 1 kg = 1 liter or 1000 mL. So,

$$\text{The man's "volume" (mL) is: } 72.6 \text{ kg} \times 1000 \text{ mL} / 1 \text{ kg} = 72,600 \text{ mL}$$

This volume of 72,600 mL (or 72.6 L) is the volume of the man's body, not his water volume, so we must make another adjustment to reflect that the alcohol will distribute into the body water.

The percent of the body mass that is water can be calculated from equations that take into account a person's weight, height, age, and sex. This is the most accurate calculation without actually measuring it in a person (not easy!). But, there are a variety of estimates that can be used just based on gender. On average, males have about 68% of their body mass as water, and females have about 55% water. Since we don't know anything more than the man's weight, we must use this estimate. (Note, the estimates can vary widely!)

$$\text{BAC} = \frac{\text{weight of alcohol ingested (g)}}{\text{Body volume (mL)} \times 68\%}$$

or

$$\text{BAC} = \frac{56.2 \text{ g alcohol}}{72,600 \text{ mL body volume} \times 0.68} = 0.0011 \text{ g alcohol/mL}$$

But the conventional BAC is expressed per 100 mL of blood, so multiply the numerator and the denominator by 100 to get:

$$\text{BAC in g/dL: } 0.11 \text{ g} / 100 \text{ mL or } 0.11\text{g/dL and BAC as \%: } 0.11\%$$

In most states, the legal definition for intoxication is 0.08%. A BAC of 0.04 is sufficient to exhibit some behavioral effects of alcohol. At 0.11% , the man is most certainly showing signs of intoxication. However, the only way to know for sure is to observe his behavior.