Chemistry 201

Absolute temperature
Temperature conversion
Ideal gas law

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Absolute Temperature

We will use the absolute temperature scale (Kelvin) for all chemical calculations. Why? One important reason is that the absolute temperature is proportional to the kinetic energy of a substance.

$$K = \frac{3}{2} nRT$$

K stands for kinetic energy, R is the gas constant and n is the number of moles.

$$\frac{1}{2} Nmv^2 = \frac{3}{2} nRT$$

N is the number of molecules.

Temperature scales

The absolute scale in Kelvins is offset from the Celsius scale by 273.16 degrees, meaning that 0 $^{o}C \sim 273$ K to three significant figures. This value is accurate enough for our purposes. Therefore, we can use the formula

$$K = {}^{o}C + 273$$

The Celsius scale is used by every country in the world as the temperature scale (except the United States). We use the Fahrenheit scale.

Conversion from Fahrenheit to Celsius

The zero of the Celsius scale occurs at 32 ^{o}F and the The boiling point of water (100 ^{o}C) occurs as 212 ^{o}F. This means that one degree Celsius is exacly 9/5 times one degree Fahrenheit.

$$^{o}C = \frac{5}{9}(\,^{o}F - 32)$$

For common values it is useful to have recall that 50 ^{o}F = 10 ^{o}C, 68 ^{o}F = 20 ^{o}C and 86 ^{o}F = 30 ^{o}C. Body temperature is exactly 98.6 ^{o}F = 37.00 ^{o}C.

Ideal gas law

The number of moles, n, appears in the ideal gas law:

$$PV = nRT$$

This is an equation of state, which means it relates the variables of state, pressure, volume, and temperature. R is a constant known as the universal gas constant.

R = 8.31 J/mol-K or R = 0.08206 L-atm/mol-K

Note that the units of the ideal gas law are units of energy.

The ideal gas law as an energy equation

At first PV may not look like an energy. However, when a fuel is combusted (for example in the cylinder of a car engine), it builds up a pressure, which causes an expansion, an increase in volume. Pressure-volume work is the how engines propel cars. Temperature also represents an energy. The temperature of a gas is proportional to the kinetic energy of the gas molecules. nRT is actually an energy term as can be seen from the units of R.

Solving for the number of moles

We can use the ideal gas law to obtain the number of moles of a gas, provided we are given P, V and T. The formula is:

$$n = \frac{PV}{RT}$$

For example, how moles are present in 22.4 liters of gas at 273 K and at sea level.

Solution: At sea level, P = 1 atm so

$$n = \frac{PV}{RT} = \frac{(1\ atm)(22.4\ L)}{\left(0.08206\ \frac{Latm}{molK}\right)(298\ K)}$$

Molar gas volume

The solution to the problem is n = 1.0.

We conclude that one mole has a volume of 22.4 liters at 273 K. We call this the molar gas volume.

Note that the molar gas volume changes with temperature.

Problem: Calculate the molar gas volume at 373 K.