2.5: The Kelvin Temperature Scale

Thus far, we have assumed nothing about the value of the temperature corresponding to any particular volume of our standard fluid. We could define one unit of temperature to be any particular change in the volume of our standard fluid. Historically, **Fahrenheit** defined one unit (degree) of temperature to be one one-hundredth of the increase in volume of a fixed quantity of standard fluid as he warmed it from the lowest temperature he could achieve, which he elected to call 0 degrees, to the temperature of his body, which he elected to call 100 degrees. Fahrenheit's zero of temperature was achieved by mixing salt with ice and water. This is not a very reproducible condition, so the temperature of melting ice (with no salt present), soon became the calibration standard. Fahrenheit's experiments put the melting point of ice at 32 F. The normal temperature for a healthy person is now taken to be 98.6 F; possibly Fahrenheit had a slight fever when he was doing his calibration experiments. In any case, human temperatures vary enough so that Fahrenheit's 100-degree point was not very practical either. The boiling point of water, which Fahrenheit's experiments put at 212 F, became the calibration standard. Later, the centigrade scale was developed with fixed points at 0 degrees and 100 degrees at the melting point of ice and the boiling point of water, respectively. The centigrade scale is now called the **Celsius scale** after Anders Celsius, Anders, a Swedish astronomer. In 1742, Celsius proposed a scale on which the temperature interval between the boiling point and the freezing point of water was divided into 100 degrees; however, a more positive number corresponded to a colder condition.

Further reflection convinces us that the Charles' law equation can be simplified by defining a new temperature scale. When we extend the straight line in any of our volume-*versus*-temperature plots, it always intersects the zero-volume horizontal line at the same temperature. Since we cannot associate any meaning with a negative volume, we infer that the temperature at zero volume represents a natural minimum point for our temperature scale. Let the value of T^* at this intersection be T_0^*. Substituting into our volume-temperature relationship, we have

$$0=n\beta\left(P\right)T_0^*+n\gamma(P)$$

or

$$\gamma\left(P\right)=-\beta(P)T_0^*$$

So that

$$V = n\beta\left(P\right)T^*-n\beta(P)T_0^* \tag{2.5.1}$$

$$= n\beta\left(P\right)\left[T^*-T_0^*\right] \tag{2.5.2}$$

$$= n\beta\left(P\right)T \tag{2.5.3}$$

where we have created a new temperature scale. Temperature values on our new temperature scale, T, are related to temperature values on the old temperature scale, T^*, by the equation

$$T=T^*-T_0^*$$

When the size of one unit of temperature is defined using the Celsius scale (*i.e.*, T^* is the temperature in degrees Celsius), this is the origin of the ***Kelvin temperature scale*** [2]. Then, on the Kelvin temperature scale, T_0^* is -273.15 degrees. (That is, $T=0$ when T_0^* = 273.15; 0 K is -273.15 degrees Celsius.) The temperature at which the volume extrapolates to zero is called the ***absolute zero*** of temperature. When the size of one unit of temperature is defined using the Fahrenheit scale and the zero of temperature is set at absolute zero, the resulting temperature scale is called the ***Rankine scale***, after William Rankine, a Scottish engineer who proposed it in 1859.