WHAT ARE THE FOUR BASIC TEMPERATURE SCALES?

One of the more important scientific measurements is the temperature of an object. Temperature can be thought of as the degree of agitation of the atoms in a body with all motion stopping at a point designated as absolute zero. Although people have employed multiple temperature scales throughout history, today there remain only four basic scales. These are the **Celsius, Fahrenheit, Kelvin , and Rankine** scales.

The earliest of these is the Fahrenheit Scale invented by the German-Dutch scientist Gabriel Fahrenheit (1686-1736). He was the first individual to construct a glass enclosed mercury thermometer. His scale was set as 0 deg for the freezing point of a water-salt solution and 212 ºF for the boiling point of water. On his scale the freezing point of pure water under standard conditions is 32 ºF. He tried to place the human body temperature at 100 ºF(it is actually 98.6 ºF). The Fahrenheit scale is today used only in the United States while the rest of the world uses the Celsius Scale.

The Celsius Scale was invented by the Swedish scientist Anders Celsius (1701-1744). His scale is much more sensible. It sets the freezing point of water at 0 ºC and the boiling boiling point at 100 º C. Originally Celsius used an inverse scale but this was corrected by Linnaeus. Until about thirty years ago the Celsius temperature was expressed in terms of centigrade. In addition, the two newer calibration points for the Celsius Scale are -273.15 ºC for absolute zero and the triple point of water very near 0 º C. The distance between freezing and boiling is thus 180 º F in the Fahrenheit scale and 100 º C in the Celsius scale. This allows one to write down the conversion formula-

$$^0F = (\frac{9}{5})\,^0C + 32$$

If you want to evaluate this formula in your head, just double the Celsius number and subtract 10% from the result before adding 32. Thus for a body temperature of 37ºC we have 74-7.4+32=98.6 ºF. Notice that the Fahrenheit and Celsius Scales are equal to each other only at -32(5/4)= -40 degree. The human body has a relatively narrow comfort zone of about-

$$59 < {}^\circ F < 86 \qquad \text{or} \qquad 15 < {}^\circ C < 30$$

Any temperature below this requires wearing heavier clothes and some form of heating while temperatures above this range will require air conditioning. These narrow ranges make sense if one considers that the human body can be thought of as a thermodynamic engine which must dissipate the excess heat generated by food combustion but not at an excessive rate because it needs to maintain a 37 ºC body temperature.

With advancing knowledge of the origin of heat and the determination of the mechanical equivalent of heat, it became clear that heat is the manifestation of molecular and atomic motion. The more vigorous the motion the higher the temperature. The reverse is also

true and a point of zero motion will be reached at low enough temperature. In the nineteenth century the Scottish engineer, physicist and mathematician William Thompson (1824-1907), later known as Lord Kelvin, determined that when a gas is cooled to -273.15 ºC its molecules cease to move and the point of absolute zero has been reached. This observation lead to the Kelvin Scale of temperature measurement where absolute zero is designated as 0 K and the freezing point of water is given as 273.15 K. The triple point of water is one-hundredth of a degree different at 273.16 K. Water boils under STP conditions at 373.15 K. Note that by the latest SI convention the degree sign in front of K is dropped. The conversion between Celsius and Kelvin is simply-

$$K = 273.15 +^{o} C$$

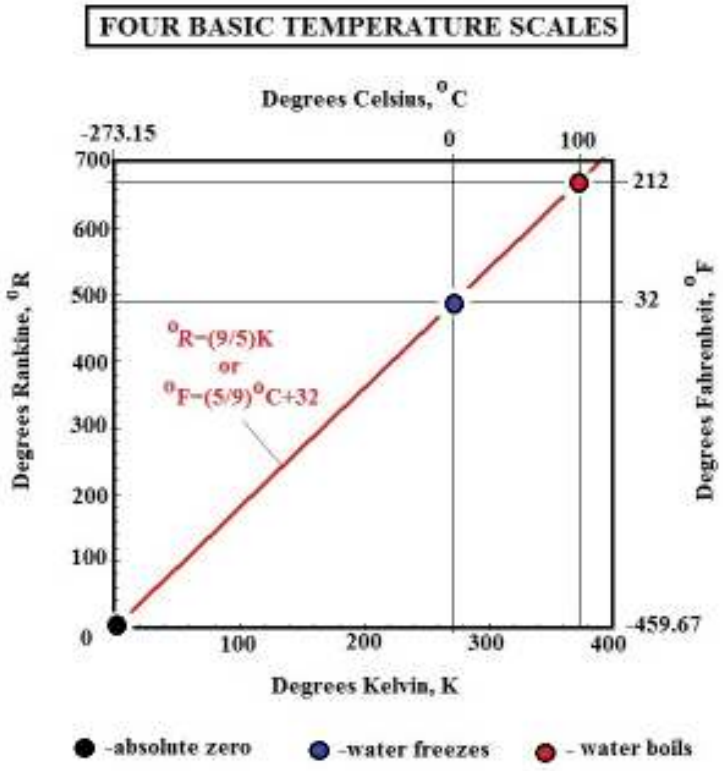
The winter here in Gainesville has been rather mild. Yesterday we had a pleasant and sunny 295 K afternoon.

The final temperature scale is that of William Rankine (1820-1872), another Scottish engineer and physicist. His scale is essentially the Fahrenheit Scale shifted to absolute zero at -459.67 ºF. That is, we have-

$$^{o}R =^{o} F + 459.67$$

You will also notice that ºR is exactly (9/5)K. I remember some 50 years ago while working at the United Technology Research laboratories, engineers from the Pratt and Whitney jet engine plant next door would come over to talk to us about their engine combustion problems using Rankine for temperature measurements. It would drive those of us brought up with SI units and mainly versed in degrees centigrade crazy.

Finally let me show you two figures which summarize the relations between the four temperature scales. The first shows K, ºR, ºF, and ºC over a range from absolute zero to above the boiling point of water-



The second figure is a table over the narrower range of -40ºC to 120ºC.

	C	F	K	R
	120.00	248.00	393.15	707.67
	110.00	230.00	383.15	689.67
boiling water ⇨	100.00	212.00	373.15	671.67
	90.00	194.00	363.15	653.67
	80.00	176.00	353.15	635.67
	70.00	158.00	343.15	617.67
	60.00	140.00	333.15	599.67
	50.00	122.00	323.15	581.67
	40.00	104.00	313.15	563.67
	30.00	86.00	303.15	545.67
	20.00	68.00	293.15	527.67
	10.00	50.00	283.15	509.67
freezing water ⇨	0.00	32.00	273.15	491.67
	-10.00	14.00	263.15	473.67
	-20.00	-4.00	253.15	455.67
	-30.00	-22.00	243.15	437.67
C=F=-40 ⇨	-40.00	-40.00	233.15	419.67

TEMPERATURE SCALES

conversion formulas

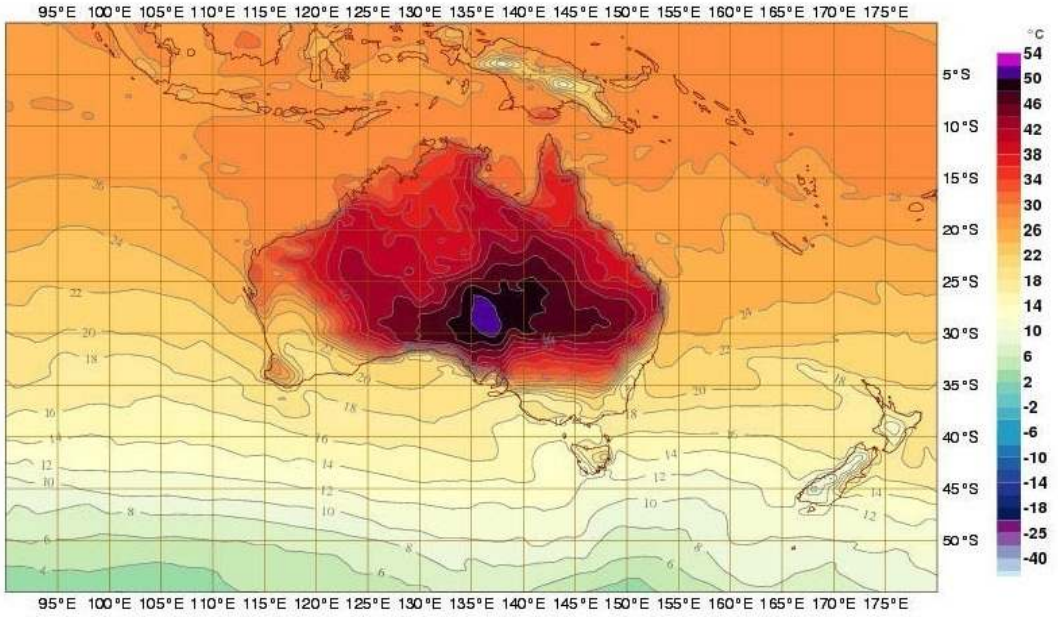
F=(9/5)C+32=R-459.67

K=C+273.15

R=(9/5)K

Looking at the weather in today's Wall Street Journal, we find the highest reported temperature as 102 ºF in Perth, Australia and the lowest temperature as -3 ºF in Bismark, North Dakota, USA. The temperature in Australia this winter is so hot that their weather bureau has been forced to add additional colors to their temperature map. Here is the forecast for January 14, 2013-

Latest Australian Weather Forecast for Jan.14, 2013 showing an unbelievable Hot Spot of 52 C=126 F in South Central Australia.



The hot spot is located near Coober Pedy where some of the world's best opals are mined and were miners live below ground to escape the heat.