

Temperature

Making a relative scale is simple. Create a device which reacts to changes in temperature. Pick one temperature and assign it a number. Next, pick a second temperature and assign it a number. Divide the space between the numbers into regularly sized increments. Now you have a temperature scale.

Celsius is a relative scale. The temperature at which water freezes is defined as $0\text{ }^{\circ}\text{C}$. The temperature at which water boils is defined as $100\text{ }^{\circ}\text{C}$. Every temperature is expressed relative to this scale.

Ether boils at $34.6\text{ }^{\circ}\text{C}$. This value only has meaning because it is a comparison to the temperature at which water freezes and boils.

Fahrenheit is also a relative scale. The coldest temperature which was readily available in the laboratory (at the time) was assigned $0\text{ }^{\circ}\text{F}$. An upper limit was defined in a similar manner, and temperatures reported relative to this scale. On this scale water boils at $212\text{ }^{\circ}\text{F}$.

Kelvin is NOT a relative scale. The Kelvin scale is ABSOLUTE. While studying the relationships between the temperature, the pressure, and the volume of a gas Charles, Boyle and others noted that $-273.15\text{ }^{\circ}\text{C}$ must be the lowest temperature attainable. As the temperature of a gas is lowered at constant volume the pressure decreases. Experiments reveal that all gases have 0 pressure at $-273.15\text{ }^{\circ}\text{C}$. Since a gas can not exert a negative pressure—which is what would happen if the linear relationship between temperature and pressure continues—then $-273.15\text{ }^{\circ}\text{C}$ must be the absolute lowest temperature possible. So, the size of the degree is still arbitrary—it is the same size as a degree

C. However, 0 K is the lowest possible temperature; it was not arbitrarily assigned.

Absolute Scale vs Relative Scale

Time and Calendars

Time can be expressed in using relative or absolute scales. We use a relative scale because it is convenient.

Our calendar is based on the time it takes the Earth to revolve around the Sun. A Eurocentric/Christian bias has resulted in the year 0 being assigned to the year in which a religious icon was born. Negative years are written as years BC (some people use the term BCE for Before Common Era).

In a lunar calendar the length of the year is determined by the cycles of the moon. So, the unit with which a year is measured in the lunar calendar would be different than the length of a solar year. The year 0 would be arbitrarily assigned.

An absolute scale could also be used to measure time. Time can be measured in any unit so the length our year is commonly used, but the year 0 is not defined arbitrarily. In an absolute calendar the year 0 is the year the universe began.

Thus the date of an event can be determined using relative scales such as a Lunar calendar or a Solar calendar (with the year zero defined based on a historical event), or the date of an event can be determined using an absolute scale; a calendar based on the Solar year with the time 0 being the creation of the universe.

The first two calendars are like Fahrenheit and Celsius. The last calendar is like Kelvin.

Temperature Conversions

One conversion is easy. Celsius to Kelvin.

$$0\text{ }^{\circ}\text{C} = 273.15\text{ K}$$

So, just add 273.15 to a temperature given in $^{\circ}\text{C}$ to find the temperature in K.

$$25\text{ }^{\circ}\text{C} = 298.15\text{ K}$$

$$20\text{ }^{\circ}\text{C} = 273.15\text{ K}$$

Or subtract 273.15 from a temperature given in K to find the temperature in $^{\circ}\text{C}$.

$$196\text{ K} = -77\text{ }^{\circ}\text{C}$$

Fahrenheit to Celsius is more complicated. The size of the degree is different and the zero point is different. You can use a formula:

$$T_{\text{C}} = (T_{\text{F}} - 32) \times \frac{5\text{ }^{\circ}\text{C}}{9\text{ }^{\circ}\text{F}}$$

or

$$T_{\text{F}} = T_{\text{C}} \times \frac{9\text{ }^{\circ}\text{C}}{5\text{ }^{\circ}\text{F}} + 32\text{ }^{\circ}\text{F}$$

or

$$T_{\text{F}} = T_{\text{C}} \times 1.8\text{ }^{\circ}\text{C}/^{\circ}\text{F} + 32\text{ }^{\circ}\text{F}$$

Or you could analyze the temperature scales. To convert from one temperature scale to another you need to do two things.

1. Compare the size of the units by comparing two known temperatures, like the boiling and freezing points of water, or the freezing points of two different solids.
2. Compare how far away the point of interest is from a common temperature.

To convert between °C and °F we can use two well know temperatures, the boiling an freezing point of water.

On the celsius scale there are $(100 - 0) = 100$ degrees between freezing and boiling.

On the Fahrenheit scale there are $(212 - 32) = 180$ degrees between freezing and boiling.

So,

$$100 \text{ } ^\circ\text{C units} = 180 \text{ } ^\circ\text{F units or } 1 \text{ } ^\circ\text{C unit} = 1.8 \text{ } ^\circ\text{F unit}$$

But temperatures cannot be interconverted simply by using this conversion factor. The scales start at different numbers.

For example, benzene freezes at $5.0 \text{ } ^\circ\text{C}$. What is the freezing point of benzene in °F.

$5 \text{ } ^\circ\text{C}$ is 5 celcius degrees above the freezing point of water.

$$5 \text{ } ^\circ\text{C units} \times 1.8 \text{ } ^\circ\text{F}/1 \text{ } ^\circ\text{C} = 9 \text{ } ^\circ\text{F units}$$

On the Fahrenheit scale the freezing point of benzene is $9 \text{ } ^\circ\text{F}$ above the freezing point of water; since water freezes at $32 \text{ } ^\circ\text{F}$, the freezing point of benzene is $41 \text{ } ^\circ\text{F}$.

During the great oil crisis of the seventies we were all told that we should be cold all winter long; that is, we should keep our thermostats set to 68 °F. What is the temperature in °C?

68 °F is $(68 - 32) = 36$ °F units above the freezing point of water.

36 °F units $\times 1$ °C/1.8 °F = 20 °C units above the freezing point of water.

So, 68 °F is 20 °C.

Instead of using the freezing point, the boiling point could be used as a point of comparison.

For example, 68 °F is $(212 - 68) = 144$ °F units below the boiling point of water.

144 °F units $\times 1$ °C/1.8 °F = 80 °C units below the boiling point of water, or $(100 - 80) = 20$ °C.