9A Temperature Scales

Read:

The Fahrenheit and Celsius temperature scales are commonly used scales for reporting temperature values. Scientists use the Celsius scale almost exclusively, as do many countries of the world. The United States relies on the Fahrenheit scale for reporting temperature information. You can convert information reported in degrees Celsius to degrees Fahrenheit or vice versa using conversion formulas.

Fahrenheit (°F) to Celsius (°C) conversion formula:

$$°C = \left(\frac{5}{9}\right)\left(°F - 32\right)$$

Celsius (°C) to Fahrenheit (°F) conversion formula:

$$°F = \left(\frac{9}{5} \times °C\right) + 32$$

Examples:

- What is the Celsius value for 65° Fahrenheit?

    Solution:

$$°C = \left(\frac{5}{9}\right)\left(65\,°F - 32\right)$$

$$°C = \left(\frac{5}{9}\right)(33) = (5 \times 33) \div 9$$

$$°C = 165 \div 9$$

$$°C = 18.3$$

- 200 °C is the same temperature as what value on the Fahrenheit scale?

    Solution:

$$°F = \left(\frac{9}{5}\right)(\,200\,°C) + 32$$

$$°F = [\left(9 \times 200\,°C\right) \div 5] + 32$$

$$°F = [1800 \div 5] + 32$$

$$°F = 360 + 32$$

$$°F = 392$$

Practice:

1. For each of the problems below, show your calculations. Follow the steps from the examples on the previous page.

    a. What is the Celsius value for 212 °F?

    b. What is the Celsius value for 98.6 °F?

    c. What is the Celsius value for 40 °F?

    d. What is the Celsius value for 10 °F?

    e. What is the Fahrenheit value for 0 °C?

    f. What is the Fahrenheit value for 25 °C?

    g. What is the Fahrenheit value for 75 °C?

2. The meteorologist reports that today will reach a high of 45 °F. Your friend from Sweden asks what the temperature will be in degrees Celsius. What value would you report to your friend?

3. Your parents order an oven from England. The temperature dial on the new oven is calibrated in degrees Celsius. If you need to bake a cake at 350 °F in the new oven, at what temperature should you set the dial?

4. A German automobile's engine temperature gauge reads in Celsius, not Fahrenheit. The engine temperature should not rise above about 225 °F. What is the corresponding Celsius temperature on this car's gauge?

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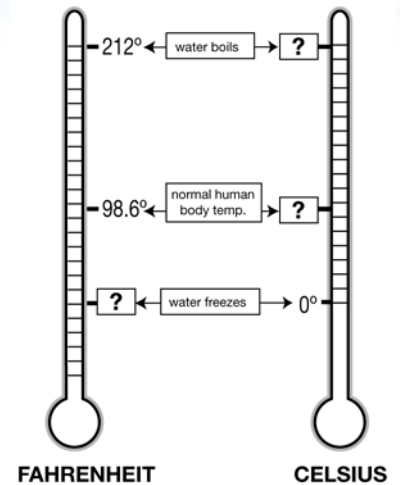
5. Your grandmother in Ireland sends you her favorite cookie recipe. Her instructions say to bake the cookies at 190 °C. To what Fahrenheit temperature would you set the oven to bake the cookies?

6. A scientist wishes to generate a chemical reaction in his laboratory. The temperature values in his laboratory manual are given in degrees Celsius. However, his lab thermometers are calibrated in degrees Fahrenheit. If he needs to heat his reactants to 232 °C, what temperature will he need to monitor on his lab thermometers?

7. You call a friend in Europe during the winter holidays and say that the temperature in Boston is 15 degrees. He replies that you must enjoy the warm weather. Explain his comment using your knowledge of the Fahrenheit and Celsius scales. To help you get started, fill in this table. What is 15 °F on the Celsius scale? What is 15°C on the Fahrenheit scale?

15 °F	=	
	=	15 °C

8. Challenge questions:

   a. A gas has a boiling point of –175 °C. At what Fahrenheit temperature would this gas boil?

   b. A chemist notices some silvery liquid on the floor in her lab. She wonders if someone accidentally broke a mercury thermometer, but did not thoroughly clean up the mess. She decides to find out if the silver stuff is really mercury. From her tests with the substance, she finds out that the melting point for the liquid is 35°F. A reference book says that the melting point for mercury is –38.87 °C. Is this substance mercury? Explain your answer and show all relevant calculations.

Extension: the Kelvin temperature scale

For some scientific applications, a third temperature scale is used: the Kelvin scale. The Kelvin scale is calibrated so that raising the temperature one degree Kelvin raises it by the same amount as one degree Celsius. The difference between the scales is that 0 °C is the freezing point of water, while 0 K is much, much colder. On the Kelvin scale, 0K (degree symbols are not used for Kelvin values) represents **absolute zero**. Absolute zero is the temperature when the average kinetic energy of a perfect gas is zero—the molecules display no energy of motion. Absolute zero is equal to –273 °C, or –459 °F. When scientists are conducting research, they often obtain or report their temperature values in Celsius, and other scientists must convert these values into Kelvin for their own use, or vice versa. To convert Celsius values to their Kelvin equivalents, use the formula:

$$K = °C + 273$$

Example:

Water boils at a temperature of 100 °C. What would be the corresponding temperature for the Kelvin scale?

$$K = °C + 273$$

$$K = 100°C + 273$$

$$K = 373$$

To convert Kelvin values to Celsius, you perform the opposite operation; subtract 273 from the Kelvin value to find the Celsius equivalent.

Example:

A substance has a melting point of 625 K. At what Celsius temperature would this substance melt?

$$°C = K – 273$$

$$°C = 625 K – 273$$

$$°C = 352$$

Although we rarely need to convert between Kelvin and Fahrenheit, use the following formulas to do so:

$$°F = \left(\frac{9}{5} \times K\right) – 460$$

$$K = \frac{5}{9}(°F + 460)$$

Practice:

1. Surface temperatures on the planet Mars range from –89 °C to –31 °C. Express this temperature range in Kelvin.

2. The average surface temperature on Jupiter is about 165K. Express this temperature in degrees Celsius.

3. The average surface temperature on Saturn is 134K. Express this temperature in degrees Celsius.

4. The average surface temperature on the dwarf planet Pluto is 50K. Express this temperature in degrees Celsius.

5. The Sun has several regions. The apparent surface that we can see from a distance is called the photosphere. Temperatures of the photosphere range from 5,000 °C to 8,000 °C. Express this temperature range in Kelvin.

6. The chromosphere is a hot layer of plasma just above the photosphere. Chromosphere temperatures can reach 10,000 °C. Express this temperature in Kelvin.

7. The outermost layer of the Sun's atmosphere is called the corona. Its temperatures can reach over 1,000,000 °C. Express this temperature in Kelvin.

8. Nuclear fusion takes place in the center, or core, of the Sun. Temperatures there can reach 15,000,000 °C. Express this temperature in Kelvin.

9. **Challenge!** Surface temperatures on Mercury can reach 660 °F. Express this temperature in Kelvin.

10. **Challenge!** Surface temperatures on Venus, the hottest planet in our solar system, can reach 755K. Express this temperature in degrees Fahrenheit.

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