Skill Sheet 25-A   Temperature Scales

Temperature, a measure of the average kinetic energy of the molecules of a substance, has an important role in our daily lives. Whether we are cooking dinner, dressing for school, or suffering from a cold, we often wish to know something about the temperature of our environment or some body of matter. To report values for temperature, the Fahrenheit and Celsius scales are commonly used by scientists and society. In this exercise, you will examine these scales and practice converting temperature values from one scale to the other.

1. Fahrenheit and Celsius

The Fahrenheit and Celsius temperature scales are the most commonly used scales for reporting temperature values. Scientists use the Celsius scale almost exclusively, as do many countries of the world. Some countries, such as the United States, still rely heavily on the Fahrenheit scale for reporting temperature information. When the meteorologist on television tells you the forecast for the week, the scale he is using for temperature is Fahrenheit. Your oven is calibrated in Fahrenheit values, as is the thermometer your doctor uses to assess your health. In the United States, we are comfortable with the Fahrenheit scale and design our appliances and tools using this system of measurement.

However, if you were in Europe, you would see temperatures given in degrees Celsius. Scientists use the Celsius scale for their experiments and report their results in degrees Celsius. Therefore, it may be necessary at some point in time to convert information reported in degrees Celsius to degrees Fahrenheit or vice versa. To accomplish this, we use conversion formulas.

2. Converting Fahrenheit values into Celsius

If you have been given temperature information in degrees Fahrenheit (°F) and need the values to be reported in degrees Celsius (°C), you would use the following formula:

$$°C = \frac{5}{9}(°F - 32)$$

Example:

What is the Celsius value for 65° Fahrenheit?

$$°C = \frac{5}{9}(65°F - 32)$$

$$°C = 18.3$$

3. Practice converting Fahrenheit to Celsius values

1. The weatherman tells you 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?

2. Your father orders a fancy oven from England. When it arrives, you notice that the temperature dial is calibrated in degrees Celsius. You wish to bake a cake at 350°F. At what temperature will you have to set the dial on this new oven?

3. Your new German automobile's engine temperature gauge reads in Celsius, not Fahrenheit. You know that the engine temperature should not rise above about 225°F. What is the corresponding Celsius temperature on your new car's gauge?

4. Converting Celsius to Fahrenheit values

To convert Celsius temperature values to degrees Fahrenheit, you must again use a conversion formula:

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

Example:

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

$$°F = \frac{9}{5}(200°C) + 32$$

$$°F = 392$$

5. Practice converting Celsius to Fahrenheit values

1. Your grandmother in Ireland sends you her favorite cookie recipe. Her instructions say to bake the cookies at 190.5°C. To what Fahrenheit temperature would you set the oven to bake the cookies?

2. 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?

3. You phone a friend who lives in Denmark and tell him that the temperature today only rose as high as 15°F. He replies that you must have enjoyed the warm weather. Explain his answer using your knowledge of the Fahrenheit and Celsius scales and conversion formulas.

6. 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 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, 0 K (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, you would 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 would 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:

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

$$K = \frac{5}{9}(°F + 460)$$

Solving problems

1. A gas has a boiling point of -175°C. At what Kelvin temperature would this gas boil?

2. 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 of the silver stuff is really mercury. From her tests with the substance, she finds out that the melting point for the liquid is 275 K. 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.

3. You are at a Science Camp in Florida. It's August 1st. Today's activity is an outdoor science quiz. The first question on the quiz involves a thermometer that reports the current temperature as 90°. You need to state the temperature scale in which this thermometer is calibrated: Kelvin, Fahrenheit, or Celsius. Which scale is correct? Defend your answer with your knowledge of the temperature scales.