Chapter 14

Be able to define temperature as a measure of the average kinetic energy of a gas molecule.

Be able to define the Fahrenheit temperature scale in terms of the temperature values of the freezing of water at 32°F and the boiling of water at 212°F at a standard pressure of one atmosphere.

Be able to define the Celsius temperature scale in terms of the temperature values of the freezing of water at 0°C and the boiling of water at 100°C at a standard pressure of one atmosphere.

Be able to determine the temperature in Celsius given its value in Fahrenheit from
\[ T_C = \frac{5}{9}(T_F - 32) \]

Be able to determine the temperature in Fahrenheit given its value in Celsius from
\[ T_F = \frac{9}{5}T_C + 32 \]

Be able to define the absolute temperature of an ideal gas as proportional to the average kinetic energy of a gas molecule.
\[ \frac{1}{2}m_{\text{molecule}} \left( \frac{v}{v_{\text{ave}}} \right)^2 = \frac{3}{2}kT \quad \text{where} \quad k = 1.38 \times 10^{-23}\ \text{J/K} \]

Be able to calculate the mass of a molecule as about equal to the total number of protons and neutrons in the nuclei of the molecule times the mass of the proton, \( m_p = 1.67 \times 10^{-27}\ \text{kg} \)

Be able to calculate the average kinetic energy of a molecule given the absolute temperature of the gas.
\[ \text{KE}_{\text{ave}} = 1.5kT \]

Be able to calculate the root mean square speed of a molecule given the absolute temperature of the gas.
\[ v_{\text{rms}} = \sqrt{\frac{3kT}{m_{\text{molecule}}}} \]

Be able to explain why atoms of hydrogen and helium in a gas move much more rapidly than atoms of nitrogen or oxygen.

Be able to convert between absolute temperature and temperature in Celsius. \( T = T_C + 273 \)

Be able to define the internal energy of an object as the total random kinetic and potential energy observed when the object is at rest.

Be able to explain that the internal energy of an object depends on the amount of its mass and its temperature as well as on the kind of elements that it contains.

Be able to define the notion of heat as a process of energy exchange, heat changes internal energy.

Be able to define the idea of specific heat capacity, \( c \) by \( Q = cM \Delta T \) where \( Q \) is the amount of energy transferred, \( c \) is the specific heat capacity, \( M \) is the mass of the object and \( \Delta T \) is the change in the temperature of the object.

Be able to explain why objects with large total heat capacity \( cM \) don’t change their temperatures quickly.

Be able to explain the effect on weather of large bodies of water.

Be able to explain that when two objects are in thermal contact there is heat exchanged if they are at different temperatures.

Be able to state energy conservation in heat exchange, the internal energy of the hot object lost by heat exchange equals the internal energy of the cool object gained by the exchange.

Be able to solve simple problems dealing with heat exchange. \( Q = c_hM_h(T_h - T) = c_M(T - T_c) \)

Be able to calculate the change in length \( \Delta L \) of an object given the temperature change \( \Delta T \), the length of the object \( L \) and the coefficient of linear thermal expansion for the material \( \alpha \).
\[ \Delta L = \alpha L \Delta T \]

Be able to calculate the change in area \( \Delta A \) of an object given the temperature change \( \Delta T \), the area of the object \( A \) and the coefficient of linear thermal expansion for the material \( \alpha \).
\[ \Delta A = 2\alpha A \Delta T \]

Be able to calculate the change in volume \( \Delta V \) of an object given the temperature change \( \Delta T \), the volume of the object \( V \) and the coefficient of linear thermal expansion for the material \( \alpha \).
\[ \Delta V = 3\alpha V \Delta T \]

Be able to describe and explain density changes as water is cooled to room temperature and then frozen.