1. Convert 45 m/s, a wind speed measured at Niwot Ridge last fall, to km/hr and miles/hr (3 points).

\[\frac{45 \text{ m}}{\text{s}} \left( \frac{\text{45 m}}{1000 \text{ m}} \right) \left( \frac{1 \text{ km}}{1 \text{ hr}} \right) \left( \frac{3600 \text{ s}}{1 \text{ hr}} \right) = 162 \frac{\text{km}}{\text{hr}}\]

\[\frac{45 \text{ m}}{\text{s}} \left( \frac{\text{45 m}}{1000 \text{ m}} \right) \left( \frac{1 \text{ km}}{10 \text{ km}} \right) \left( \frac{6.2 \text{ miles}}{1 \text{ mile}} \right) = 100 \frac{\text{miles}}{\text{hour}}\]

2. The melting point of ice decreases by \(7.4 \times 10^{-3}\) deg C when pressure increases by 1 atm. A 160-lb ice skater can exert a pressure equivalent to 600 atm on the ice directly under their ice skates. Consequently, the ice under the skates melts at a temperature lower than 0 deg C, so that the skate actually slides on a film of water. How much does a pressure of 600 atm lower the freezing point of ice, in deg C? (5 points).

The change in melting point per change in pressure is given as:

\[\frac{\Delta T_{\text{melt}}}{\Delta P} = -7.4 \times 10^{-3}\text{C} \quad \text{per atm}\]

How much does a pressure of 600 atm lower the freezing point of ice?

\[\Delta T_{\text{melt}} = 600\text{atm} \times \frac{\Delta T_{\text{melt}}}{\Delta P} = 600\text{atm} \times -7.4 \times 10^{-3}\text{C} \quad \text{per atm} = -4.4^\circ\text{C}\]

3. Starting with a mass of 100g of ice at -10degC, calculate the energy needed in Joules (J) to vaporize the ice at +100degC, as follows (6 points):

   a. how much energy is needed to raise the ice temperature from -10degC to 0degC?

The amount of energy needed to raise the temperature of ice is proportional to the specific heat of ice:
\[ E_{\text{heat ice}} = (\text{mass}) \times (\text{specific heat of ice}) \times (\text{temperature change}) \]

Substituting in the values given in the problem statement

\[ E_{\text{heat ice}} = (100 \, g) \times \left( 1.93 \times 10^3 \frac{J}{\text{kg} \cdot \degree C} \right) \times (10 \degree C) \times \left( \frac{1 \text{kg}}{1000 \text{g}} \right) = 1.9 \times 10^3 \text{ J} \]

**b. how much energy is needed to melt the ice at 0\degree C?**

The amount of energy needed to melt ice is proportional to the latent heat of fusion

\[ E_{\text{melt}} = (\text{mass}) \times (\text{latent heat of fusion}) \]

Substituting in the values given in the problem statement

\[ E_{\text{melt}} = (100 \, g) \left( 3.34 \times 10^4 \frac{J}{\text{kg}} \right) \times \left( \frac{1 \text{kg}}{1000 \text{g}} \right) = 3.3 \times 10^4 \text{ J} \]

**c. how much energy is needed to raise the liquid water temperature from 0\degree C to +100\degree C?**

The amount of energy needed to raise the temperature of liquid water is proportional to the specific heat of liquid water:

\[ E_{\text{heat water}} = (\text{mass}) \times (\text{specific heat of water}) \times (\text{temperature change}) \]

Substituting in the values given in the problem statement

\[ E_{\text{heat water}} = (100 \, g) \times \left( 4.2 \times 10^4 \frac{J}{\text{kg} \cdot \degree C} \right) \times (100 \degree C) \times \left( \frac{1 \text{kg}}{1000 \text{g}} \right) = 4.2 \times 10^4 \text{ J} \]

**d. how much energy is needed to vaporize the liquid at +100\degree C?**

The amount of energy needed to vaporize the liquid is proportional to the latent heat of vaporization

\[ E_{\text{vaporization}} = (\text{mass}) \times (\text{latent heat of vaporization}) \]

Substituting in the values given in the problem statement

\[ E_{\text{vaporization}} = (100 \, g) \left( 2.5 \times 10^6 \frac{J}{\text{kg}} \right) \times \left( \frac{1 \text{kg}}{1000 \text{g}} \right) = 2.5 \times 10^5 \text{ J} \]
e. *What is the total amount of energy needed?*

The total amount of energy is found by summing all the energy required for the temperature and phase changes:

\[
E_{\text{total}} = E_{\text{heat ice}} + E_{\text{melt}} + E_{\text{heat water}} + E_{\text{vaporization}}
\]

Substituting in the values calculated earlier in the problem:

\[
E_{\text{total}} = 1.9 \times 10^3 \, J + 3.3 \times 10^4 \, J + 4.2 \times 10^4 \, J + 2.5 \times 10^5 \, J = 3.3 \times 10^5 \, J
\]

f. *How much energy is needed to vaporize the ice at 0degC?*

The amount of energy needed to vaporize ice is proportional to the latent heat of sublimation:

\[
E_{\text{sublimation}} = (\text{mass}) \times (\text{latent heat of sublimation})
\]

Substituting in the values given in the problem statement

\[
E_{\text{sublimation}} = (100 \, \text{g}) \times \left( 2.834 \times 10^6 \, \frac{J}{\text{kg}} \left( \frac{1 \, \text{kg}}{1000 \, \text{g}} \right) \right) = 2.8 \times 10^5 \, J
\]