SNOW HYDROLOGY (GEOG 5311)
HOMEWORK ASSIGNMENT 0
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Due: 8/5/02

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

$$45\frac{m}{s}=\left(\frac{45m}{s}\right)\left(\frac{1km}{1000m}\right)\left(\frac{3600s}{1hr}\right)=\mathbf{162\frac{km}{hr}}$$

$$45\frac{m}{s}=\left(\frac{45m}{s}\right)\left(\frac{1km}{1000m}\right)\left(\frac{3600s}{1hr}\right)\left(\frac{6.2miles}{10km}\right)=\mathbf{100\frac{miles}{hour}}$$

2. ***The melting point of ice decreases by 7.4 x 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:

$$\frac{\Delta T_{melt}}{\Delta P}=\frac{-7.4x10^{-3}{}^{\circ}C}{1atm}$$

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

$$\Delta T_{melt}=600atm\times\frac{\Delta T_{melt}}{\Delta P}=600atm\times\frac{-7.4x10^{-3}{}^{\circ}C}{1atm}=\mathbf{-4.4^{\circ}C}$$

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

$$E_{\text{heat ice}} = (100g) \times \left(1.93x10^{3} \frac{J}{kg°C}\right) \times (10°C) x \left(\frac{1kg}{1000g}\right) = \mathbf{1.9x10^{3}\ J}$$

b. how much energy is needed to melt the ice at 0degC?

The amount of energy needed 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

$$E_{\text{melt}} = (100g)\left(3.34 \times 10^{5} \frac{J}{kg}\right)\left(\frac{1kg}{1000g}\right) = \mathbf{3.3 \times 10^{4}\ J}$$

c. how much energy is needed to raise the liquid water temperature from 0degC to +100degC?

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

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

Substituting in the values given in the problem statement

$$E_{heat\ \text{water}} = (100g) \times \left(4.2x10^{3} \frac{J}{kg°C}\right) \times (100°C) x \left(\frac{1kg}{1000g}\right) = \mathbf{4.2x10^{4}\ J}$$

d. how much energy is needed to vaporize the liquid at +100degC?

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

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

Substituting in the values given in the problem statement

$$E_{vaporization} = (100g)\left(2.5 \times 10^{6} \frac{J}{kg}\right)\left(\frac{1kg}{1000g}\right) = \mathbf{2.5 \times 10^{5}\ J}$$

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:

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

Substituting in the values calculated earlier in the problem:

$$E_{total} = 1.9\times10^{3}\,J + 3.3\times10^{4}\,J + 4.2x10^{4}\,J + 2.5\times10^{5}\,J = \mathbf{3.3\times10^{5}\ J}$$

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

The amount of energy needed 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

$$E_{\text{sublimation}} = (100\text{g})\times\left(2.834\times10^{6}\,\frac{J}{kg}\right)\left(\frac{1kg}{1000g}\right) = \mathbf{2.8\times10^{5}\ J}$$