PHYS 1220 Quiz 1 (of 1)

Brief Solutions

1. Xylene boiling temperatures

a. Boiling temperature of *o*-xylene in kelvin

$144 + 273.15 = 417.15$ K

b. Difference between boiling temperatures of *o*-xylene and *p*-xylene

Difference are the same in kelvin and in Celsius, so 6 K.

2. Third Street viaduct

a. Shorter in the winter.

b. How much shorter?

$$\begin{aligned}
\Delta L/L_0 &= \alpha\Delta T \\
\Delta L &= L_0\alpha\Delta T \\
&= (170.0\text{ m})(11\times10^{-6}/^\circ\text{C})(45^\circ\text{C}) \\
&= 0.08415\text{ m} \\
&= 8.415\text{ cm}
\end{aligned}$$

3. Volume expansion of PEEK

The coefficient of volume expansion is three times the coefficient of length expansion, so $\beta = 165 \times 10^{-6}/^\circ$C.

4. Expansion of xylenes

The bottle expands, but the xylenes expand more. Initially, the bottle has extra room: 4.00 liters of xylenes in a 4.10 liter bottle, at 20°C.

The xylenes expand by a volume $\Delta V = V_0\beta\Delta T = (4.00\text{ L})(10\times10^{-4}/^\circ\text{C})(25^\circ\text{C}) = 0.10$ L. We now know the xylenes won't overflow, because its expanded volume is the initial volume of the bottle. The bottle will expand, leaving a little space. How much will the bottle expand?

For the bottle, $\Delta V = V_0\beta\Delta T = (4.10\text{ L})(27\times10^{-6}/^\circ\text{C})(25^\circ\text{C}) = 0.00277$ L. The difference between the bottle's capacity and the volume of the xylenes is 2.8 mL; a close call.

5. Heat rises

This is convection. Thermal expansion makes the hot plume buoyant.

6. Heat transfer in a vacuum

This is radiation. Conduction and convection require material contact.

7. Antarctic Ice Sheet

a. Warm to 0°C

Heating without a phase change: use the specific heat capacity of ice.

$$
\begin{aligned}
Q &= mc\Delta T \\
&= (2.6 \times 10^{19} \text{ kg}) \left(2100 \frac{\text{J}}{\text{kg°C}}\right) (15°\text{C}) \\
&= 8.19 \times 10^{23} \text{J}
\end{aligned}
$$

b. Melt at 0°C

Heat input all goes to melting ice: use the latent heat of melting of ice.

$Q = mL = (2.6 \times 10^{19} \text{ kg})(334,000 \text{ J/kg}) = 8.684 \times 10^{24} \text{ J}$

8. Heat current through a pot bottom

$$
H = kA\Delta T/\Delta x = \left(250 \frac{\text{W}}{\text{m} \cdot \text{K}}\right) (0.0154 \text{ m}^2)(3 \text{ K})/(0.005 \text{ m}) = 2,310 \text{ W}
$$

9. Air in a chip bag moved to Laramie

Pressure, temperature, and volume all change in this scenario. Volume changes in response to pressure and temperature. The number of moles n is constant, and the gas constant R, true to its name, is also constant.

$$
\begin{aligned}
\frac{p_1 V_1}{T_1} &= \frac{p_2 V_2}{T_2} \\
V_2 &= V_1 \frac{p_1 T_2}{p_2 T_1} \\
&= (1.50 \text{ L}) \left(\frac{1.01}{0.75}\right) \left(\frac{294.15}{300.15}\right) \\
&= 1.98 \text{ L}
\end{aligned}
$$

10. Air in a cooled gallon jug

Here, volume is constant while pressure changes in response to a temperature change.

$$\begin{aligned}
\frac{p_1}{T_1} &= \frac{p_2}{T_2} \\
p_2 &= p_1 \frac{T_2}{T_1} \\
&= (1.01 \times 10^5 \text{ Pa}) \frac{253.15}{293.15} \\
&= 8.72 \times 10^4 \text{ Pa}
\end{aligned}$$