Phys 212 College Physics II
Problem Session 1

1. A temperature of absolute zero occurs at -273.15 °C. What is this temperature on the Fahrenheit scale?

$$F = 1.8C + 32 = 1.8*(-273.15) + 32 = -459.67°F$$

2. A rock of mass 0.20 kg enters a pail containing 0.35 kg of water at a velocity of 17.5 m/s. The rock and the water have the same initial temperature. The specific heat capacity of the rock is 1840 J/(kg*°C).

   Ignore the heat absorbed by the pail itself, and determine the rise in the temperature of the rock and water.

Q = Kinetic Energy of the Rock $= \frac{1}{2}mv^2 =$

$$Q = \frac{1}{2} * 0.2 * (17.5)^2 = 30.6 \text{ Joules}$$

This energy, Q, will cause the water and rock Temperature to rise

heat to raise water Temp $= Q_1$

$$Q_1 = cm\Delta T = 4186 * 0.35 * \Delta T = 1465.1\,\Delta T$$

Heat to raise rock Temp

$$Q_2 = C_{rock} m_{rock} \Delta T = 1840 * 0.2\,\Delta T = 368\,\Delta T$$

Added energy $= \frac{1}{2}mv^2 = Q_1 + Q_2$

$$\frac{1}{2}mv^2 = 30.6 = 1465.1\,\Delta T + 368\,\Delta T = 1833\,\Delta T$$

$$\Delta T = \frac{30.6}{1833} = 0.0167\ °C$$

Both the rock and water have the SAME TEMP

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3. Find the mass of water that vaporizes when 3.10 kg of mercury at 215 °C is added to 0.210 kg of water at 75.0 °C.

Heat Loss by mercury warms and vaporizes water

Final Temp is 100°C since water boils

Q_1 = heat Loss by mercury

$Q_1 = cm\Delta T$ $\Delta T = 215 - 100 = 115°C$

C = Specific heat of Mercury = 139

$Q_1 = 139 * 3.10 * 115 = 49,554\ J$

Q_2 = heat need To warm water

$Q_2 = C_{H_2O}\, m_{H_2O}\, \Delta T = 4186 * 0.21 * (100 - 75)$ (25)

$Q_2 = 21976.5$

Q_3 = heat used to Vaporize water

$= mL_f$ where m is the mass of water Vaporized

$Q_1 = Q_2 + Q_3$

$Q_3 = Q_1 - Q_2 = mL_f$

$m = \frac{Q_1 - Q_2}{L_f} = \frac{49,554 - 21,976.5}{33.5 \times 10^4} = 0.82\ kg$

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4. What is the normal body temperature of 98.6°F on the Celsius temperature scale?

$F = 1.8C + 32$

$1.8C = F - 32$

$C = \frac{F-32}{1.8} = \frac{98.6-32}{1.8} = 37\,°C$

5. Thermal resistance is defined as the temperature across an object divided by the joules of heat that passes through the object per second.

   What is the thermal resistance of a .250 m length of wood with a 2.00 m^2 cross-sectional area.

$\frac{Q}{t} = \frac{KA}{L}\Delta T$

$R = \frac{\Delta T}{Q/t} = \frac{L}{KA} = \frac{0.25}{K_{wood}\, 2}$

$K_{wood} = 0.15$

$R = \frac{0.25}{0.15 \times 2} = 0.83\ °C/\text{watt}$

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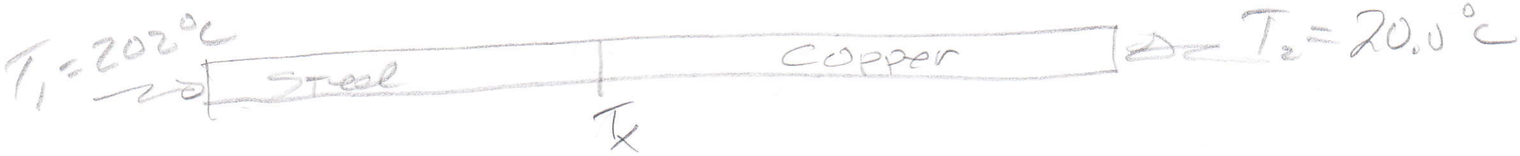
6. Two rods, one of steel and the other of copper, are joined end to end. The cross-sectional area of each is 5.0×10^{-4} m^2, and the length of each is 0.040 m. The free end of the steel rod is kept at 202 °C, while the free end of the copper rod is kept at 20.0 °C. The loss of heat through the sides of the rods may be ignored.

   a. What is the temperature at the steel-copper interface?
   b. How much heat is conducted through the unit in 3 s?
   c. What is the temperature in the copper rod at a distance of 0.025 m from the rod end?

$$K_{steel} = 14\ J/(s \cdot m \cdot C^\circ)$$

$$K_{Cu} = 390\ J/(s \cdot m \cdot C^\circ)$$



$$\frac{Q}{t} = \frac{K_{steel} A}{L}(T_1 - T_x) = \frac{K_{Cu} A}{L}(T_x - T_2)$$

$$K_{steel}(T_1 - T_x) = K_{Cu}(T_x - T_2)$$

$$K_{steel} T_1 - K_{steel} T_x = K_{Cu} T_x - K_{Cu} T_2$$

$$K_{steel} T_1 + K_{Cu} T_2 = K_{Cu} T_x + K_{steel} T_x = T_x (K_{Cu} + K_{steel})$$

$$T_x = \frac{K_{steel} T_1 + K_{Cu} T_2}{K_{Cu} + K_{steel}}$$

a) $$T_x = \frac{14 * 202 + 390 * 20}{14 + 390} = \frac{10628}{404} = 26.3\,^\circ C$$

How much heat is conducted through the unit in 3s.

$$Q = \frac{Q}{t} 3 = \frac{K_{steel} A}{L} (T_1 - T_x) * 3$$

$$T_1 - T_x = 202 - 26.3 = 175.69$$

$K_s = 14$

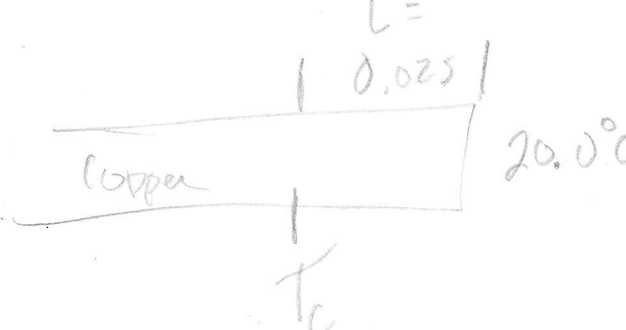
$$Q = 14 * \frac{5 \times 10^{-4}}{0.04} * 175.69 * 3$$

b) $Q = 0.307 \times 3 = \underline{\underline{0.922 \text{ Joules}}}$

$$\frac{Q}{t} = 0.307 \text{ watts}$$

c) If $L = .025m$ what is ΔT

$$\frac{Q}{t} = 0.307 = \frac{K_{cu} A}{L} \Delta T = \frac{390 * 5 \times 10^{-4}}{.025} \Delta T$$



$$\Delta T = \frac{0.307 * 0.025}{390 * 5 \times 10^{-4}} = 0.0394 \,°C$$

$$\Delta T = T_c - 20.0$$

$$T_c = \Delta T + 20 = \underline{20.0394 \,°C}$$

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7. A car parked in the sun absorbes energy at a rate of 460 watts per square meter of surface area. The car reaches a temperature at which it radiates energy at this same rate.

   Treating the car as a perfect radiator ($e = 1$), find the temperature.

$$\frac{Q}{t} = e\sigma T^4 A$$

$$\frac{Q/t}{A} = e\sigma T^4 = \sigma T^4 \qquad e = 1$$

$$\sigma = 5.67 \times 10^{-8}$$

Given

$$\frac{Q/t}{A} = 460 \text{ Watts}/m^2 = \sigma T^4$$

$$T^4 = \frac{460}{5.67 \times 10^{-8}}$$

$$T = \left(\frac{460}{5.67 \times 10^{-8}}\right)^{1/4}$$

$$\boxed{T = 300 \text{ K}}$$