Name: ______________________________________

Date: ______________________________________

Block/Period: ________________________________

Thermal Physics **(DUE: May 16, 2024)**

Show your work and include the appropriate unit

1. A Brass strip is 3cm long at 0ºC. How long will it be in meters at 100ºC if the coefficient of linear expansion for Brass is 1.8×10^{-5} ºC^{-1} ?

Expansion

$\Delta L = \alpha L_0 \Delta T$

$\Delta L = 1.8 \times 10^{-5}\ ºC^{-1} \times 0.03m \times (100°C - 0\ °C)$

$\Delta L = 5.4 \times 10^{-5}$ m

2. The coefficient of volumetric expansion of mercury is 1.8×10^{-4} ºC^{-1} . If the temperature of 10 L of mercury increases by 30 ºC, how much volume will the mercury increase by?

$\Delta V_{mercury} = V_0 \beta \Delta T$

$\Delta V_{mercury} = 10L \times 1.8 \times 10^{-4}\ ºC^{-1} \times 30ºC$

$\Delta V_{mercury} = 0.054L$

3. Suppose that the gas tank in your car is completely filled when the temperature is 17ºC. How many gallons will spill out of the 20 gallon steel tank when the temperature rises to 35ºC? ($\beta_{gas} = 9.5 \times 10^{-4}$ ºC^{-1}) & ($\beta_{steel} = 0.36 \times 10^{-4}$ ºC^{-1})

$\Delta V_{spill} = \Delta V_{gas} - \Delta V_{steel}$

$\Delta V_{spill} = [\ 20 \text{ gallon} \times 9.5 \times 10^{-4}\ ºC^{-1} \times (\ 35ºC - 17ºC\ )] - [\ 20 \text{ gallon} \times 0.36 \times 10^{-4}\ ºC^{-1} \times (\ 35ºC - 17ºC\ )]$

$\Delta V_{spill} = 0.342 - 0.01296$

$\Delta V_{spill} = 0.329$ gallon

4. The hot water heating system of a building contains 60.0 ft^3 of water in steel pipes. How much water will overflow into the expansion tank if the system is filled at 40ºC and then is heated to 80ºC? ($\beta_{steel} = 0.36 \times 10^{-4}$ ºC^{-1}) & ($\beta_{water} = 2.10 \times 10^{-4}$ ºC^{-1})

$\Delta V_{overflow} = \Delta V_{water} - \Delta V_{steel}$

$\Delta V_{overflow} = [\ 60.0 \text{ ft}^3 \times 2.10 \times 10^{-4}\ ºC^{-1} \times (\ 80ºC - 40ºC\ )] - [\ 60.0 \text{ ft}^3 \times 0.36 \times 10^{-4}\ ºC^{-1} \times (\ 80ºC - 40ºC\ )]$

$\Delta V_{overflow} = 0.504 - 0.0864$

$\Delta V_{overflow} = 0.4176$ ft^3

5. 50g of copper is heated by placing it in boiling water (100°C). It is then placed in a beaker containing 250 g of an unknown liquid at 20°C. The final temperature of the copper and the liquid is found to be 25°C. What is the specific heat of the liquid? (Assume no heat is lost to the surroundings. Specific heat capacity of copper = 390J/kg°C.)

$-\Delta Q_{cu} = \Delta Q_{glass}$
$M_{cu}\ c_{cu}\ \Delta T_{cu} = m_{liquid}\ c_{liquid}\ \Delta T_{liquid}$
$-[\ 0.05\text{kg} \times 390\text{J/kg°C} \times (25°\text{C} - 100°\text{C})\ ] = 0.25\text{kg} \times c_{liquid} \times (25\ °\text{C} - 20\ °\text{C})$
$1462.5 = 1.25\ c_{liquid}$
$c_{liquid} = 1170\text{J/kg°C}$

6. A room is designed to maintain a temperature of 25°C. Outside the room on a cold night the temperature is measured as 10°C. The room is separated from the outside by a glass slab of area 0.25m^2 and thickness of 8mm (0.008m)
a) Find the rate of heat loss by conduction of the room.
b) Suppose the owners of the room wish to replace the glass slab with another transparent material that will allow for a rate of heat transfer of 150W. Determine the thermal conductivity of this material.

(a) $R = \frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{L} = 0.84 \times 0.25 \times \frac{(25-10)}{0.008} = 393.75\text{J/s}$

(b)) $R = KA\frac{\Delta T}{L}$
$KA\Delta T = RL$
$K = \frac{RL}{A \times \Delta T} = \frac{150 \times 0.008}{0.25 \times 15} = 0.32\text{J/s.m.°C}$

7. 0.25kg of honey at 63°C is added to an aluminum container of mass 300g initially at 15°C. Assuming no energy is lost to the surroundings, calculate the specific heat capacity of honey if the specific heat capacity of aluminum is 900J/kg°C and the final temperature of the mixture is 48°C?

$-\Delta Q_{honey} = \Delta Q_{Al}$
$[\ M_h\ c_h\ \Delta T_h\ ] = m_{Al}\ c_{Al}\ \Delta T_{Al}$
$-[\ 0.25\text{kg} \times c_h \times (48°\text{C} - 63°\text{C})\ ] = 0.3\text{kg} \times 900\text{J/kg°C} \times (48\ °\text{C} - 15°\text{C})$
$3.75\ c_h = 8910$
$c_h = 2376\ \text{J/kg°C}$

8. One end of a copper rod of length 30cm and thickness of 0.25cm is placed in such a way that one end is exposed to a temperature of 120°C while the other end is at 25°C. Calculate the rate of heat transfer by conduction along the rod.

$R = \frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{L} = 380 \times 4.91 \times 10^{-6} \times \frac{(120-25)}{0.3} = 0.59\ \text{J/s}$

$A = \pi r^2$
$A = \pi \times (\frac{2.5 \times 10^{-3}}{2})^2$
$A = 4.91 \times 10^{-6}\text{m}^2$

9. (a) The surface of the Sun has a temperature of about 5800K. The radius of the Sun is 6.96×10^8 m. Calculate the total energy radiated by the Sun each second. (Assume that ε = 0.965).

$$R = \frac{\Delta Q}{\Delta t} = \varepsilon\sigma A\,(T_1^4 - T_2^4) = 0.965 \times 5.67 \times 10^{-8} \times 6.087 \times 10^{18} \times (5800^4 - 0^4)$$

$R = 3.769 \times 10^{26}$ J/s

$A = 4\pi\, r^2$ $A = 4\pi \times (6.96 \times 10^8)^2$ $A = 6.087 \times 10^{18}\,m^2$

(b). A strip of lead metal initially with a length of 35cm is heated so that its temperature changes by 80°C. Find the change in length of the lead and its new length at the new temperature. ($\propto_{lead} = 29 \times 10^{-6}\ {}^{o}C^{-1}$)

$\Delta L = \alpha L_0 \Delta T$

$\Delta L = 29 \times 10^{-6}\ {}^{o}C^{-1} \times 0.35m \times (80\ °C)$

$\Delta L = 8.12 \times 10^{-4}$ m

$L_{new} = L_o + \Delta L = 0.35m + 8.12 \times 10^{-4}\ m = 0.351m$

10. (a) Express the following energy values in calories and BTU.

Energy (Joules)	**Energy (Calories)**	**Energy (BTU)**
a) 500J	119.5 cal	0.474 BTU
b) 2500J	597.5 cal	2.370 BTU
c) 198000J	47323.1 cal	187.678 BTU
d) 800kJ	191204.6 cal	758.294 BTU
e.) 1.2MJ	286806.9 cal	1137.441 BTU

(b) A major source of heat loss from a house in cold weather is through the windows. Calculate the rate of heat flow through a glass window 2.0 m × 1.5 m in area and 3.2 mm thick, if the temperatures at the inner and outer surfaces are 15.0°C and 14.0°C, respectively (k = 0.84J/s.m.°C)

$$R = \frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{L} = 0.84 \times 3 \times \frac{(15-14)}{0.0032} = 787.5\ J/s$$