UNIVERSITY OF OTTAWA
Principles of Physics I
PHY1321/31 Fall2015
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STUDENT #: ______________	
NAME: ____________________	
GROUP:___________________	

Assignment 2: Heat, Calorimetry and Heat Transfer

Assigned: Sept 25 *Due: Oct 2*

1 A diving bell in the shape of a cylinder with a height of2.50 m is closed at the upper end and open at the lower end. The bell is lowered from air into sea water of density = 1.025 g/cm3. The air in the bell is initially at 20.0°C. The bell is lowered to a depth (measured to the bottom of the bell) of 82.3 m. At this depth the water temperature is 4.0°C, and the bell is in thermal equilibrium with the water. (a) How high does sea water rise in the bell? (b) To what minimum pressure must the air in the bell be raised to expel the water that entered?

Lets hi be initial height of the air column in the bell, hf the final height of the air column in the bell when it is submerged. $V_i = Ah_i; \quad V_f = Ah_f$ (NOTE : A has not been given (cross-section area of the bell but it might be not needed to solve this problem

Using the ideal gas equation $pV = nRT$ we can write the following:
$p_i A h_i = nRT_i; \quad p_f A h_f = nRT_f$; since n stays constant as the bell is sealed by water, we have :

$$\frac{p_i A h_i}{RT_i} = n = \frac{p_f A h_f}{RT_f} \quad \Rightarrow \quad \frac{p_i h_i}{T_i} = \frac{p_f h_f}{T_f} \quad \Rightarrow$$

$$h_f = \frac{T_f}{T_i}\frac{p_i}{p_f}h_i = \frac{277}{293}\frac{101000}{101000+(1025)(9.8)(82.3)}2.5m = 0.257m$$; so Water level in the bell will reach 2.24m, (b) 929712.5Pa

2 A 2.5 kg aluminum is heated to 92°C and then dropped into 8 kg of water at 5°C. Assuming that water metal system is thermally isolated what is the system equilibrium temperature?
Final state is in thermal equilibrium – both substances will have the same final temp.
System is isolated-> heat emitted by aluminum and heat absorbed by water are the same.

$$m_{H_2O}c_{H_2O}(T_f - T_{H_2O}) + m_{Al}c_{Al}(T_f - T_{Al}) = 0$$

$$(m_{H_2O}c_{H_2O} + m_{Al}c_{Al})T_f = T_{Al}m_{Al}c_{Al} + T_{H_2O}m_{H_2O}c_{H_2O}$$

$$T_f = \frac{T_{Al}m_{Al}c_{Al} + T_{H_2O}m_{H_2O}c_{H_2O}}{(m_{H_2O}c_{H_2O} + m_{Al}c_{Al})} = \frac{(92)(2.5)(910)+(5)(8)(4186)}{(8)(4186)+(2.5)(910)}{}^oC = \frac{1380}{131}{}^oC = 10.53^oC$$

3 A water heater is operated by solar power. If solar collector has an area of 6.00m^2, and the intensity delivered by sunlight is 550W/m^2, how long does it take to increase the temperature of 1m^3 of water from 20°Cto 60°C?

The rate of collection of energy is $P = 550\ \text{W/m}^2\left(6.00\ \text{m}^2\right) = 3\,300\ \text{W}$. The amount of energy required to raise the temperature of 1 000 kg of water by 40.0°C is:

$$Q = mc\Delta T = 1\,000\ \text{kg}\left(4\,186\ \text{J/kg}\cdot°\text{C}\right)\left(40.0°\text{C}\right) = 1.67\times10^8\ \text{J}$$

Thus, $$P\Delta t = 1.67\times10^8\ \text{J} \ \text{or}\ \Delta t = \frac{1.67\times10^8\ \text{J}}{3\,300\ \text{W}} = \boxed{50.7\ \text{ks}} = 14.1\ \text{h}.$$

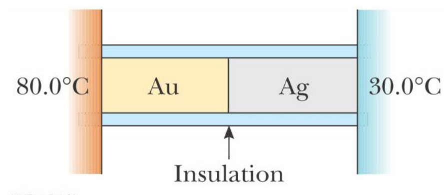
4. The *Nova* laser at Lawrence Livermore National Laboratory in California is used in studies of initiating controlled nuclear fusion . It can deliver a power of 1.60×10^{13} W over a time interval of 2.50 ns. Compare its energy output in one such time interval to the energy required to make a pot of tea by warming 0.800 kg of water from 20.0°C to 100°C.

The laser energy output: $P\Delta t = \left(1.60 \times 10^{13}\ \text{J/s}\right)2.50 \times 10^{-9}\ \text{s} = 4.00 \times 10^{4}\ \text{J}$.

The teakettle input: $Q = mc\Delta T = 0.800\ \text{kg}\left(4\,186\ \text{J/kg} \cdot ℃\right)80°\text{C} = 2.68 \times 10^{5}\ \text{J}$.

This is larger by 6.70 times.

5 A bar of gold is in thermal contact with a bar of silver of the same length and area (Fig.). One end of the compound bar is maintained at 80.0°C while the opposite end is at 30.0°C. When the energy transfer reaches steady state, what is the temperature at the junction?



In the steady state condition, $P_{Au} = P_{Ag}$

so that

$$k_{Au}A_{Au}\left(\frac{\Delta T}{\Delta x}\right)_{Au} = k_{Ag}A_{Ag}\left(\frac{\Delta T}{\Delta x}\right)_{Ag}$$

In this case $A_{Au} = A_{Ag}$

$\Delta x_{Au} = \Delta x_{Ag}$

$\Delta T_{Au} = (80.0 - T)$

and $\Delta T_{Ag} = (T - 30.0)$

where T is the temperature of the junction.

Therefore, $k_{Au}(80.0 - T) = k_{Ag}(T - 30.0)$

And $\boxed{T = 51.2℃}$

6 A glass window pane has an area of 3.00 m² and a thickness of 0.600 cm. If the temperature difference between its faces is 25.0°C, what is the rate of energy transfer by conduction through the window.

$$P = \frac{kA\Delta T}{L} = \frac{\left(0.800\ \text{W/m} \cdot ℃\right)\left(3.00\ \text{m}^2\right)(25.0°\text{C})}{6.00 \times 10^{-3}\ \text{m}} = 1.00 \times 10^{4}\ \text{W} = \boxed{10.0\ \text{kW}}$$

7 A 1kg of ice at -30° C is added to 10 kg of steam at 500°C. answer the following questions:

a) What is the phase of the system of ice + steam if no heat escaped from it.

b) What is the final temperature when the equilibrium is established

(use the opposite side of this page to provide the solution)

CHECK THE CLASS NOTES FOR THE SOLUTION TO THIS PROBLEM