PHYSICS-2

Elementary Physics of Energy

May 7, 2012 Mid term examination

100 Total Points

Your name in capitals:

1. (a) *A coal burning power plant burns coal at 1000^0C and exhausts heat into a river with average temperature 7^0C. Assuming that it is an ideal engine, calculate the power output (i.e. capacity) of the plant if you are given that rate of energy pollution into the river is is 160 MW. [20]*

   (b) *If the plant is not ideal but has a second law efficiency of 50%, calculate the power output.* [5]

   a) Solution: From Carnot theory $\eta = (1000 - 7)/(1273) = .78$. We are given $p_{out} = 160MW$.

   Now $\eta = 1 - p_{out}/p_{in}$ and hence $p_{in} = p_{out}/(1 - \eta) = p_{out}/.22 = 727$ MW. Hence power capacity $p_W = p_{in} - p_{out} = 567$ MW.

   b) We multiply the output of the ideal plant by 50% to get the required answer 283.5 MW.

2. *A jeweller uses 250 kJ heat to melt a block of silver at 10^0C, in order to pour into her molds. What is the weight of the block?* [25]

   We again use:

   $$Q = L_{melting}\ m + C\ m\ (T_B - T_{room}).$$

   with unknown mass m.

   Plugging in the various values, we find in units of kilo Joules $250kJ = m\ kg \times 88.3\ kJ/kg + .235\ kJ/(kG^0C) \times m\ kg \times 950.8^0C$. Hence the mass $m = .8$ KG.

3. *An ideal refrigerator maintains a chamber at $5^0\,C$ and the outside temperature is $20^0\,C$ and it consumes power at the rate of $100\,W$. Find the time taken in minutes to remove 1000 Btu of heat from the chamber.*

   Answer The efficiency of the machine is $\eta = P_c/P_W = 278/15 = 18$. The power absorbed is given from $P_c = P_W \times \eta$ hence $P_c = 18 \times 100 =$

1800W. This is an impressively large number compared to what we are paying for.

We next calculate the time required to remove 1000 Btu of heat i.e. 1.055×10^6 J from the chamber. Clearly $t \times 1800 = 1.055 \times 10^6$ or $t = 586$ sec $= 9.77$ minutes.

DATA

- Heat capacity of water $=4.2 kJ/(kg^0 C)$. Density of water $=1 gm/cc$.
- Heat capacity of silver $=.235 kJ/(kg^0 C)$.
- Melting temp of silver $=960.8^0 C$.
- Latent heat of fusion for silver $= 88.3 kJ/kg$.
- 1 Btu = 1055 J.
- 1 calorie = 4.2 J.