Physics 10154 - Exam #5B

Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A 25-kg block of wood floats on water. At equilibrium, the block is 73% submerged.

a) What is the density of the wood?
b) How much additional mass can be placed on top of the wood before the wood block is completely immersed and begins to sink?

a) $\Sigma F_y = F_B - F_g = 0$

$$\rho_f V_f g - \rho_o V_o g = 0$$

$$\rho_f V_f = \rho_o V_o$$

$$\frac{V_f}{V_o} = \frac{\rho_o}{\rho_f}$$

$$\frac{0.73 V_o}{V_o} = \frac{\rho_o}{1000} \Rightarrow \boxed{\rho_o = 730\ kg/m^3}$$

b) Need $F_B - F_g - m_{additional} g = 0$

$$V_o = \frac{m_o}{\rho_o} = .03425\ m^3$$

immersed $\longrightarrow$ $\rho_f V_o g - \rho_o V_o g - m_{add} g = 0$

so $V_f = V_o$

$$(1000)(.03425) - (730)(.03425) = m_{add} = 9.2\ kg$$

$$\boxed{(m_{add})g = 91\ N}$$

2. (30 pts) A 21-gram cube of ice at an initial temperature of -35°C is placed inside a 550 gram aluminum container with an initial temperature of 24°C.

What is the final temperature of this system when it reaches thermal equilibrium? If the final temperature is 0, determine how much of the ice melts.

The specific heat of aluminum is 900 J/kg °C. Other constants needed are on your formula sheet.

To melt ice:

$$\Delta Q = (.021)(2090)(35) + (.021)(333{,}000) = 8529\ J$$

To cool Al to 0°C:

$$\Delta Q = (.550)(900)(-24) = -11880$$

$\Rightarrow$ all ice melts, $T_F > 0$

$$\Delta Q_{ice} + \Delta Q_{Al} = 0$$

$$8529 + (.021)(4186)(T_F - 0) + (.550)(900)(T_F - 24) = 0$$

$$8529 + 87.91 T_F + 495 T_F - 11880 = 0$$

$$582.91 T_F = 3351$$

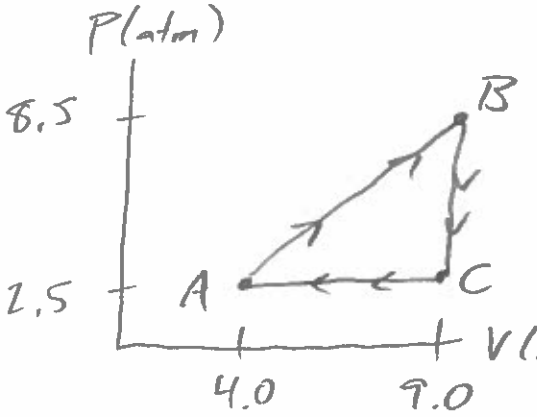
$$\boxed{T_F = 5.7\ °C}$$

3. (20 pts) A gas has three states on a P-V diagram:

State A is a pressure of 2.5 atm, volume of 4.0 L.
State B is a pressure of 8.5 atm, volume of 9.0 L.
State C is a pressure of 2.5 atm, volume of 4.0 L.

The gas cycles through the states in the order ABCA.

Assume the heat added to the system during the AB step is 2200 Joules. How much heat is added to the system during the steps BC and CA combined?



$W_{by\ gas}(AB) = (5.5\ atm)(5.0\ L)$

$= (557150\ Pa)(5.0\times10^{-3}\ m^3)$

$= 2786\ J$

$W_{by\ gas}(BC) = 0$

$W_{by\ gas}(CA) = (2.5\ atm)(-5.0\ L)$

$= (253250)(-5.0\times10^{-3})$

$= -1266\ J$

$W_{cycle} = 1520\ J$

$Q_{cycle} = 1520\ J$ since $\Delta V = 0$

$Q_{AB} + Q_{BCA} = 1520$

$2200 + Q_{BCA} = 1520$

$\boxed{Q_{BCA} = -680\ J}$

4. (20 pts) Two speakers equally far away have a loudness of 45 dB and 53 dB, respectively, when one is turned on while the other is off. What is the loudness perceived when both speakers are emitting sound at the same time?

$$45 = 10 \log\left(\frac{I_{45}}{10^{-12}}\right)$$

$$4.5 = \log\left(I_{45}/10^{-12}\right)$$

$$10^{4.5} = \frac{I_{45}}{10^{-12}} \Rightarrow I_{45} = 10^{-7.5} = 3.16 \times 10^{-8}$$

$$53 = 10 \log\left(\frac{I_{53}}{10^{-12}}\right)$$

$$10^{5.3} = \frac{I_{53}}{10^{-12}} \Rightarrow I_{53} = 10^{-6.7} = 2.00 \times 10^{-7}$$

$$I_{TOT} = 3.16 \times 10^{-8} + 2.00 \times 10^{-7}$$

$$= 2.3 \times 10^{-7}$$

$$\beta_{TOT} = 10 \log\left(\frac{2.3 \times 10^{-7}}{10^{-12}}\right)$$

$$= \boxed{53.6 \text{ dB}}$$