General Physics II Honors (PHYS 102H)

Problem set # 1 *(due January 31)*

All problems are mandatory, unless marked otherwise. Each problem is 10 points.

Q1 A small square hole is cut in a large sheet of copper. Does the area of this hole increase or decrease if the whole sheet is uniformly heated? Give a qualitative reasoning for your choice in a few sentences.

Q2 A small bubble escapes from a treasure chest and rushes to the surface. The chest is $h = 30$ m below the surface, where the water temperature was $T_d = 5^o$C, and the original bubble volume was $V_0 = 0.5\text{cm}^3$. If it is nice and sunny outside, and the surface water temperature is $T_s = 20^o$C, what is the volume of the bubble right before it breaks the surface?

Q3 Imagine a thermally isolated container split by a thermally conducting divider that is free to slide back and forth. At some moment the divider is exactly in the middle, dividing the container into two equal halves. Each half is filled with the identical gases, but the second half contains half as much molecules at twice the temperature. Since the pressure is the same in both halves, the piston should not instantly move. If the container is left like that for a long time, will the divider move eventually? If yes, by how much? Assume that the container is rectangular with length L and the cross-section areas for both the container and the divider are A.

Q4 An empty barrel has diameter $d = 0.7$m and is $H = 2$m deep. At a nice spring day ($T = 20^o$C, $P = 1$atm) someone put a $M = 12$kg piston that can slide without friction inside the barrel, compressing the air inside it. In equilibrium the piston is h_i above the bottom of the barrel. Now a $m = 15$kg dog jumps on top of the piston and decides to stay there.
(a) By how much more Δh does the piston slides down? *Hint*: you may be surprised to find that the change in position is quite small, and the Taylor expansion $\frac{1}{1+x} \approx 1 - x$ for $x \ll 1$ may be handy for simplifying the final answer.
(b) To what temperature should the gas be warmed to raise the piston (with the dog) back up to h_i?