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Thermo no. 10

ME 200
Summer 2012
Exam 1
Friday 29 June

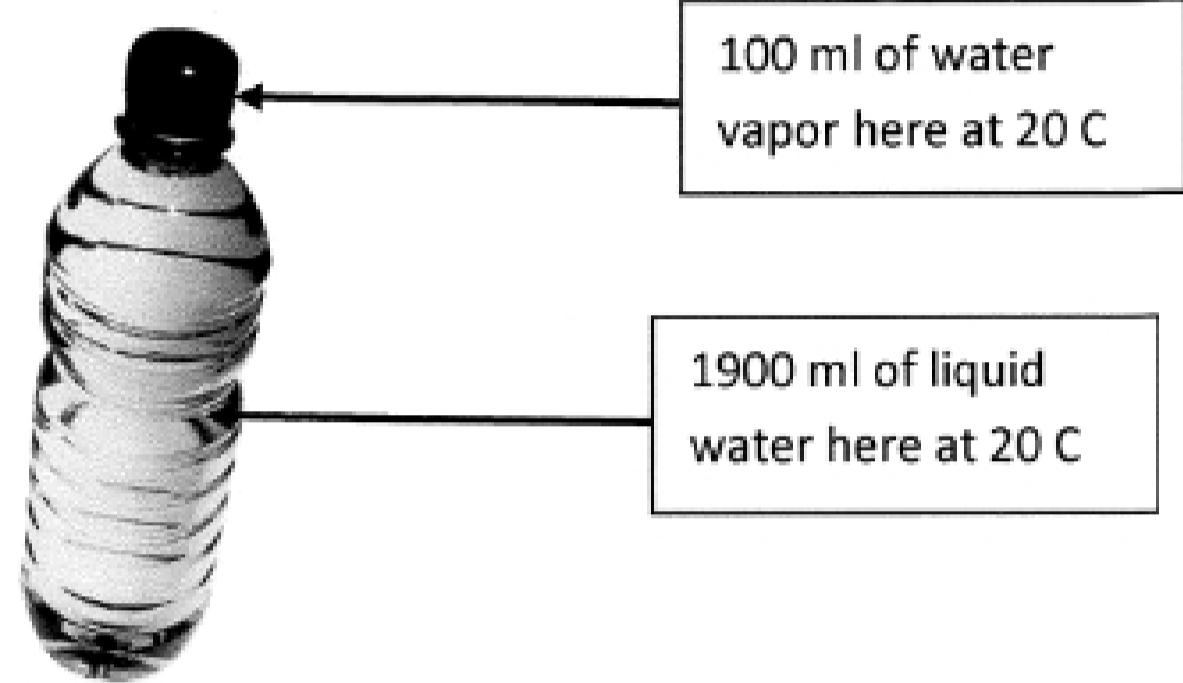
READ THESE INSTRUCTIONS

1. This is a closed book examination. All needed property tables, equation sheets and units conversions are provided as attachments to this exam.
2. Do not hesitate to ask questions if you do not understand a problem statement.
3. Start each problem on the same page as the problem statement. Write on only one side (the front) of each page. Material on the back side of any page **will not** be graded. Additional paper will be provided upon request.
4. Put only one problem on each page. A second problem on the same page **will not** be graded.
5. Follow the Problem Solution Format given in class in order to be eligible for full credit.
6. If you provide multiple solutions, you will receive only partial credit even if one of the solutions is correct. Delete the solution(s) you do not want.
7. For your own benefit, please write clearly and legibly.
8. After you have completed the exam, **at your seat**, put your papers in order. This may mean that you have to remove the staple and then re-staple at the front of the room. Regardless, **do not turn in loose pages**.
9. Once time is called you must stop writing **immediately**. Points will be subtracted from those writing after this time (**not kidding** on this one—it's a pet peeve of mine).

Problem	Possible score	Your score
1		
2		
3		
Total	100	

Problem 1. [points] Bottled beverages can reach high temperatures during transport, especially if left in closed compartments that are subject to direct sunlight. As an example, cases have been reported where closed car interior temperatures have exceeded 140 F (60 C). Under such conditions the contents (essentially all water) could reach a pressure such that the bottle would rupture sending plastic fragments in all directions. There is a news case of such an event having occurred in NZ.

To analyze that situation consider the following. Assume that a 2-liter bottle originally



contains strictly water substance at 20 C.

- If the bottle initially contains 1900 ml of liquid water and 100 ml of water vapor what is the original quality? Report your answer in %.
- What is the original water pressure? Report your answer in bar.
- What is the quality when the water temperature inside the bottle is 60 C? Again, report your answer in %.
- What is the pressure when the temperature inside the bottle is 60 C? Again, report your answer in bar.
- What temperature would be necessary to have the pressure inside the bottle exceed 10 bar? Report your answer in C.

SYSTEM = WATER; CLOSED

QUASI EQUILIBRIUM PROCESS

$$X_1 = \frac{m_{g1}}{m_{f1} + m_{g1}}$$

$$m_{g1} = \frac{V_{g1}}{v_{g1}} = \frac{100 \times 10^{-6} \text{ m}^3}{1.00 \times 10^{-3} \frac{\text{m}^3}{\text{kg}}} = 1.73 \times 10^{-6} \text{ kg}$$

$$m_{f1} = \frac{V_{f1}}{v_{f1}} = \frac{100 \times 10^{-6} \text{ m}^3}{57.8 \frac{\text{m}^3}{\text{kg}}} = 1.9 \text{ kg}$$

$$X_1 = 9.11 \times 10^{-7}$$

$$P_{\text{sat}} @ 20\text{C} = 0.0234 \text{ bar}$$

$v_2 = v_1$, since constant volume process (ridged bottle) and fixed mass (closed system)

$$m = (1.9 + 1.73 \times 10^{-6}) \text{ kg}$$

$$v_1 = \frac{2 \times 10^{-3} \text{ m}^3}{(1.9 + 1.73 \times 10^{-6}) \text{ kg}} = 1.005 = v_2$$

$$x_2 = \frac{v_2 - v_{sL}(60C)}{v_{sv}(60C) - v_{sL}(60C)} = \frac{1.005 \times 10^{-3} - 1.017 \times 10^{-3}}{7.67 - 1.017 \times 10^{-3}}$$

$$x_2 = 4.65 \times 10^{-6}$$

$$p_{SAT}(60C) = 0.199 \text{ bar}$$

$$T \approx 180 \text{ C}$$