PHYS1B28: Thermal Physics
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Problem Sheet 4 (2005)

Answers to questions 1 – 4 should be handed in by Wednesday, December 14, 2005. Question 5 is for tutorial discussion.

1. A bubble of 5 mol of CO_2 gas is submerged at a certain depth in liquid water when the water (and thus the CO_2 gas) undergoes a temperature increase ΔT of 20.0 ^oC at constant pressure. As a result, the bubble expands.

(a) How much heat Q is added the CO_2 gas during the expansion and temperature increase?

(b) What is the change ΔE_{int} in the internal energy of the gas during the temperature increase?

(c) How much work is done by the gas as it expands against the pressure of the surrounding water during the temperature increase?

[5]

2. (a) 1 mole of an ideal gas at a pressure of 2×10^5 Pa and a temperature of 273 K expands adiabatically to a final pressure of 1×10^5 Pa. Calculate: the initial and final volume; final temperature; work; heat and change in internal energy for this process if the gas is (i) helium, and (ii) nitrogen.

(b) As a sample of gas is allowed to expand quasi-statically and adiabatically, its pressure drops from 120 kPa to 100 kPa, and its temperature drops from 300 K to 280 K. Explain whether the gas is monatomic or diatomic.

[10]

3. (a) A system proceeds from an equilibrium state i to an equilibrium state f by a path A and then returns to the equilibrium state i by a different path B. Along path A the system extracts heat of amount 40 J from the surroundings and does 20 J of work on the surroundings. Along path B the system has 10 J of work performed on it by the surroundings. Calculate the amount of heat absorbed by the system along path B and explain whether heat is extracted from the surroundings or rejected to the surroundings.

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(b) A gas at equilibrium occupies a volume of 0.68 m^3 and is at a pressure of 3.0×10^5 Pa. The gas then undergoes a quasi-static isothermal expansion until its volume is 1.26 m^3. Calculate the new equilibrium gas pressure and the work done by the gas in the process.

[10]

4. How much water at 100 ^oC could be evaporated per hour by the heat transmitted through a 1 cm × 1 cm steel plate 0.2 cm thick, if the temperature difference between the plate faces is 100 ^oC. For steel, the coefficient of thermal conductivity $K = 0.11$ cal$\cdot$s$^{-1}\cdot$cm$^{-1}\cdot$ K^{-1}. Heat of vaporization of water is 540 kcal/kg.

[5]

5. Explain why a small cube of ice will always melt when placed in a large glass of lukewarm water.