

## Solutions to Homework Problem Set 7

Stowe 8.24

(a) Using the first law, the change in internal energy is given by  $\Delta E = Q - W + \mu\Delta N = Q - P\Delta V + \mu\Delta N = 2.2 \times 10^{-2} - 10^5 \times 10^{-7} - 0.3 \times 1.6 \times 10^{-19} \times 10^{17} \text{ J} = 7.2 \times 10^{-3} \text{ J}$ .

(b) According to the second law,  $dS = \frac{dQ}{T}$ , so  $\Delta S = \int \frac{dQ}{T}$ . At the constant temperature,  $T$  can be taken out of the integral, so  $\Delta S = \frac{1}{T} \int dQ = \frac{Q}{T} = \frac{2.2 \times 10^{-2}}{295} \text{ J/K} = 7.5 \times 10^{-5} \text{ J/K}$ . Since the system absorbs heat, so entropy increases. Note that the entropy change is derived from the heat transfer over temperature, regardless of what processes (e.g., amount of work or particle transfer or change in internal energy) it goes through.

Stowe 8.27

(a) Using the second law,  $dS = dQ/T$ . Suppose that the small amount of heat does not change the temperature of the ocean, there is  $\Delta S = Q/T = 0.1/280 \text{ J/K} = 3.6 \times 10^{-4} \text{ J/K}$ .

(b) Since the change of entropy only depends on heat transfer at a given temperature, the entropy change in this case is the same as in (a).

(c) In above cases, the number of states change by the factor  $\Omega_f/\Omega_i = e^{\Delta S/k} = e^{1.6 \times 10^{19}} = 10^{1.1 \times 10^{19}}$ .

Stowe 8.29

(a) Using the combined first and second law,  $dS = \frac{dQ}{T} = \frac{1}{T}(dE + PdV)$ , in this case. So the change of the entropy is derived by  $\Delta S = \int \frac{1}{T}(dE + PdV)$ . In this problem,  $dE = 0$ ,  $P$  is constant, so  $\Delta S = \int \frac{P}{T}dV = \frac{P}{T}\Delta V = \frac{1.001 \times 1.013 \times 10^5 \text{ Pa}}{300 \text{ K}} \times 10^{-9} \text{ m}^3 = 3.4 \times 10^{-7} \text{ J/K}$ .

(b) The number of states changes by the factor  $\Omega_f/\Omega_i = e^{\Delta S/k} = e^{2.5 \times 10^{16}} = 10^{1.1 \times 10^{16}}$ .