

PHYS20352: Thermal and Statistical Physics
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Example Sheet 7

1. (a) For a liquid-vapor transition, assuming that vapor is an ideal gas, derive the following Clapeyron equation

$$\ln \frac{P_2}{P_1} = \frac{L_m}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right),$$

where P 's and T 's are coexistence pressures and temperatures of the two phases respectively, R is the gas constant, and L_m is the vaporization molar latent heat and can be assumed a constant over the temperature range.

- (b) One way to save energy in our kitchen is to use pressure cookers (and perhaps for better quality of foods also). Use the above equation to estimate the required pressure increase inside a pressure cooker if the water boiling temperature is to increase by 20 °C. The water vaporization molar latent heat is 40625 J mol⁻¹.
2. (Challenge Question) Use the maximum entropy theorem to prove that the temperatures, pressures and chemical potentials of two phases of a substance at equilibrium are equal respectively, namely $T_1 = T_2$, $P_1 = P_2$, and $\mu_1 = \mu_2$.
3. The following questions are intended to strengthen your understanding of some elementary notions of probability and microstates.
- (a) Four dice are rolled. What are the probabilities of obtaining: (i) four sixes; (ii) a six, a five, a four, and a three; and (iii) two sixes and two fives?
- (b) A monkey types eight letters at random on a keyboard comprising the 26 letters of the standard English alphabet. What are the probabilities that: (i) all are "a"s; (ii) each of the first eight letters of alphabet are present; (iii) there are five "a"s and three "b"s; and (iv) there are three "a"s, three "b"s, and two "c"s?
- (c) A child distributes eight identical marbles between three different boxes. How many distinguishably different arrangements are there? [Hint: Consider all the possible arrangements of eight marbles and two partitions in a line, but remember that the partitions are identical, as are the marbles.]