

**Reading:** Chapter 6 of ISSP

- (25) 1. ISSP, Ch. 5, Problem 4: **Heat capacity of layer lattice.** (Part a is similar to one of the problems in the midterm exam.)
- (25) 2. ISSP, Ch. 5, Problem 5: **Grüneisen constant.** [Hint: A way to approach this problem is to evaluate the partition function  $Z$  and use the relation that the free energy  $F$  is given by  $F = k_B T \log Z$ .]
- (25) 3. a) Using the fact that photons are bosons with dispersion relation  $\omega = ck$ , show that photon energy density in a cavity is

$$\frac{U}{V} = \frac{\pi^2}{15\hbar^3 c^3} (k_B T)^4$$

and hence a photon specific heat of

$$\frac{C_v}{V} = \left( \frac{4\pi^2 k_B^4}{15\hbar^3 c^3} \right) T^3$$

- b) Consider a dielectric solid with a Debye temperature equal to  $100K$  and with  $10^{22}$  atoms/cm<sup>3</sup>. Estimate the temperature at which the photon contribution to the heat capacity would be equal to the phonon contribution evaluated at  $1^\circ K$ .
- (25) 4. ISSP, Ch. 6, Problem 1: **Kinetic energy of electron gas.**