

# Thermal Physics II – Problem Sheet 3

## Part I: Questions

1. How are the statistical description of the particles and thermodynamics connected in the micro-canonical ensemble?
2. What defines the equipartition theorem?
3. How many microstates has an ensemble of 1221 independent particles that can occupy 15 states? Why must this be a integer number?
4. How is the temperature in the micro-canonical ensemble defined?
5. Revise the recipe for the generation of the thermodynamics in the micro-canonical ensemble.

## Part II: Problems

### 1. Limits of Derived Results

In the lecture, the heat capacity of an Einstein solid was derived to be

$$c_N = \frac{3N\hbar^2\omega^2}{k_B T^2} \frac{\exp(-\beta\hbar\omega)}{[1 - \exp(-\beta\hbar\omega)]^2},$$

where  $\beta = 1/(k_B T)$  as usual. Find the limit for the heat capacity for very low and very high temperature, respectively.

### 2. Counting Microstates

Quarks that build baryonic matter can come in three “colours”: red, blue and yellow. Of course, the colours anti-red, anti-blue and anti-yellow (whatever this means) can also occur. Find the number of combinations of the six colours in an baryon, that contains three quarks, and in an Meson, that contains two quarks. Consider all possible combinations of colours for the first part.

In the real world, the colour of the observable particle (baryon or Meson) must be white which is achieved by adding red, blue and yellow (or the similar combination of anti-colours) or by adding red and anti-red, blue and anti-blue or yellow and anti-yellow. Again, find the number of possibilities to make a baryon and a meson under this restriction.