

**Matter and Fields (Thermodynamics)**  
Problem Sheet 3  
**Return by Monday, December 13 (assessed)**

1. The partition function of “Van der Waals” gas is given by  $Z = \frac{1}{N!} \left(\frac{\tau}{\tau_0}\right)^{\frac{3}{2}N} \left(\frac{V}{V_0} - 1\right)^N \exp\left(\frac{\alpha N^2}{V\tau}\right)$ , where  $V$  is the volume,  $\tau$  is the temperature and  $N$  is the number of particles. Note that  $\alpha$  is a positive constant.

20% a. Find an expression for the average energy.

20% b. Prove that  $(P + \frac{\alpha N^2}{V^2})(V - V_0) = N\tau$ .

2. Units of temperature, pressure and volume

10% a. Convert 20C to Kelvin.

10% b. Convert 5350 cm<sup>3</sup> to litres.

10% c. Convert 5Pa (Pascal) to atmospheres.

3. Consider an ideal gas in 2d, namely assume that the gas is confined in a 2d plane, whose area is  $A$ .

10% a. Write down the partition function of the 2d gas.

10% b. Show that  $U = Nk_B T$

10% c. Show that  $PA = Nk_B T$  ( $A$  is the area of the plane).