PHYSICS EXAMINATION PROBLEMS
SOLUTIONS AND HINTS FOR STUDENT SELF-STUDY

Module Code	**PHY2201**
Name of module	**Statistical Physics**
Date of examination	**Jan 2006**

1. i) See course notes.

   ii) See course notes.

   iii) 99.3 MW

   iv) Use $\mathrm{d}S = \dfrac{C_V \mathrm{d}T}{T}$ and $\Delta S_1 + \Delta S_2 = 0 \quad \Rightarrow \quad \ln\left(\dfrac{T_f}{T_2}\right) = -\ln\left(\dfrac{T_f}{T_1}\right) \quad \Rightarrow \quad T_f = \sqrt{T_1 T_2}$.

2. i) See course notes.

   ii) Equilibrium; $\langle v_x \rangle = \langle v_y \rangle = \langle v_z \rangle = 0$.

   iii) See course notes.

   $$\langle \varepsilon \rangle = \int_0^\infty \varepsilon\, p(\varepsilon)\, \mathrm{d}\varepsilon = \frac{3}{2\beta} = \frac{3k_B T}{2} .$$

   Conduction electrons – ‘quantum gas’, rules governing occupancy dominate behaviour.

3. i) See course notes.

   2.4×10^4 K.

   In equilibrium maximum occupancy is when $T \to \infty \quad \Rightarrow \quad \dfrac{n_1}{n_0} = \dfrac{g_1}{g_0} = 3$. Energy supply (e.g. laser) can maintain a non-equilibrium distribution (population inversion) hence exceed this.

   ii) Use $Z = \sum_{i=0}^{\infty} \exp\left(-\dfrac{\varepsilon_i}{k_B T}\right)$ and the geometrical series summation rule

4. i) See course notes.

   ii) See course notes

   iii) 2640 J; isobaric, isothermal process hence dH=TdS.

   dG=0.

5. (i) $S = k_B \ln\Omega$; see course notes.

   $\Delta S = k_B \ln \Omega_{N/2} \approx N k_B \ln 2 \approx 1\,\mathrm{JK}^{-1}$.

   (ii) See course notes.

   Classical limit: $\exp\left(\dfrac{E_i - E_F}{k_B T}\right) >> 1$.