# PHYSICS EXAMINATION PROBLEMS
# SOLUTIONS AND HINTS FOR STUDENT SELF-STUDY

| Module Code | PHY2201 |
|---|---|
| Name of module | Statistical Physics |
| Date of examination | Jan 2005 |

1. i) see course notes.

   ii) Because $S$ is a function of state (see course notes).

   iii) see course notes, +ve as process is irreversible.

2 Probability that a particle has $x$-comp of velocity in range $v_x$ to $v_x+\mathrm{d}v_x$

Isotropy and independence of $v_x$ $v_y$ and $v_z$ imply $p(v_x)\,p(v_y)\,p(v_z) = f(v_x^2+v_y^2+v_z^2)$

Use variable substitution $\varepsilon = mv^2/2$ and $p(\varepsilon)\mathrm{d}\varepsilon = p(v)\mathrm{d}v$

$\varepsilon^{1/2}$ is density-of-states factor, $\exp(-\beta\,\varepsilon)$ is Boltzmann factor.

3 see course notes.

See course notes.

Centrifugal force at distance $r$ from axis is $m_\mathrm{A}\omega^2 r$. This results in an apparent gradient of potential energy in the radial direction. Since potential is highest at smaller $r$'s we have $\varepsilon(r) = -m_\mathrm{A}\omega^2 r^2/2$. Substitute into Boltzmann distribution.

4. i) see course notes

   ii) see course notes

   iii) For a gas, work done increasing volume by $\mathrm{d}V$ is $-p\mathrm{d}V$ (−ve because we must do work to compress the gas). For the rubber, the work done increasing the length by $\mathrm{d}l$ is $+f\mathrm{d}l$ where $f$ is the tensile force produced by the rubber. Substitute this into fundamental thermodynamic relationship in place of $-p\mathrm{d}V$. Then use $\mathrm{d}F = \mathrm{d}U - \mathrm{d}(\mathrm{T}S)$.

   $\Delta S = -3.3\times10^{-5}\ \mathrm{J\ K^{-1}}$.

5. (i) $S = k_\mathrm{B}\ln\Omega$

   (ii) see course notes

   Zero-point energy of quantum harmonic oscillator

   Use $c_\mathrm{v} = (\partial U/\partial T)_\mathrm{v}$

   See notes

   $c_\mathrm{v}$ (actual) = 0.26 $c_\mathrm{v}$ (classical)