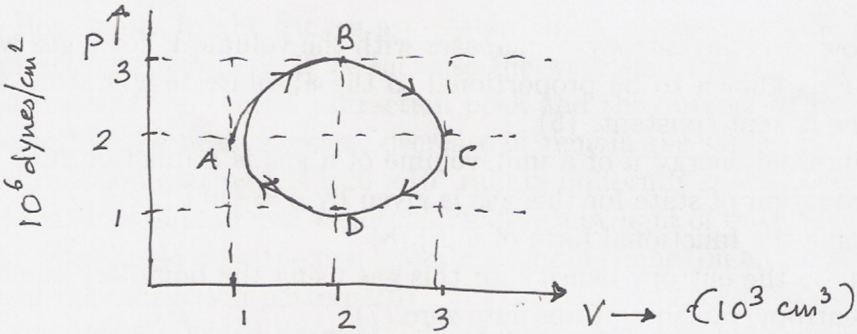
Physics II
ISI B.Math
Final Exam : May 5, 2009

Total Marks: 100

Answer any five questions



1. The molar specific heat at constant volume of a monatomic ideal gas is known to be $\frac{5}{2}R$. Suppose that one mole of such a gas is subjected to a cyclic quasistatic process which appears as a circle on the diagram of pressure P vs volume V shown in the figure. Find the following quantities

(a) The net work in Joules done by the gas in one cycle. (5)

(b) The internal energy difference (in Joules) of the gas between state C and state A. (5)

(c) The heat absorbed (in joules) by the gas in going from A to C via the path ABC of the cycle.(5)

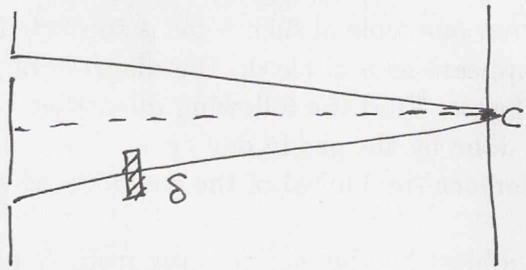
(d) The net change in entropy of the gas in one cycle starting from A , and completed via the path ABCDA.(5)

2. A cylindrical container 80 cm long is separated into two compartments by a thin piston, originally clamped in position 30 cm from the left end. The left compartment is filled with one mole of helium gas at a pressure of 5 atmospheres; the right compartment is filled with argon gas at 1 atmosphere of pressure. These gases may be considered ideal. The cylinder is submerged in 1 litre of water, and the entire system is initially at the uniform temperature of 25 C. The heat capacities of the cylinder and the piston may be neglected. When the piston is unclamped, a new equilibrium situation is ultimately reached with the piston in a new position.

a) What is the increase in the temperature of the water?(6)

b) What is the final position of the piston ? (7)
c)What is the increase of total entropy of the system? (7)

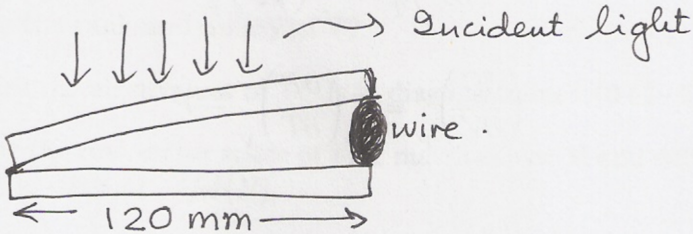
3. (a) Show that the entropy S increases with the volume V for a gas whose pressure P is known to be proportional to the absolute temperature when the volume is kept constant. (5)
(b) The internal energy u of a unit volume of a gas is a function of T only and the equation of state for this gas is given by $p = \frac{1}{3}u(T)$.
(i)Determine the functional form of $u(T)$.(8)
(ii) Calculate the entropy density for this gas using the boundary condition that the entropy vanishes at absolute zero.(7)



4. The diagram shows a double slit experiment in which monochromatic light of wavelength λ from a distant source is incident upon two slits, each of width w ($w \ll \lambda$) and an interference pattern is seen on a distant screen. A thin piece of glass of thickness δ and index of refraction n is placed between one of the slits and the screen, and the intensity of the central point C is measured as a function of the thickness δ. If the intensity for $\delta = 0$ is given by I_0
(a) What is the intensity at C as a function of δ ? (5)
(b) for what values of δ is the intensity at C minimum ?(4)
(c) Suppose that the width of one of the slits is now increased to $2w$, the other width remaining unchanged. What is the intensity at point C as a function of δ? Assume that the glass does not absorb any light.(6)
(d) Each of four pairs of light waves arrives at a certain point on the screen. The waves have the same wavelength. At the arrival point their amplitudes and phase differences are
(i)$2E_0, 6E_0$ and π radians (ii)$3E_0, 5E_0$ and π radians (iii) $9E_0, 7E_0$ and 3π radians (iv)$2E_0, 2E_0$ and 0 radians. Rank the four pairs according to the

intensity of light at those points, greatest first.(5)

5. (a) In a double slit experiment, the wavelength λ of a light source is 405 nm, the slit separation d is 19.44 μm and the slit width a is 4.050 μm. Consider both the interference and diffraction through the slits. How many bright interference fringes are within the central peak of the difraction maxima? How many bright fringes are within either of the first side peaks of the diffraction envelope ? If we increase the wavelength of light to 550 nm, do the width of the central diffraction peak and the number of interference fringes within the peak increase, decrease or remain the same? (14)
(b) A diffraction grating has 1.26×10^4 rulings uniformly spaced over a width of 25.4 nm. It is illuminated at normal incidence by light of wavelength 589.00 nm. At what angle does the first order maximum occur (on either side of the centre of the diffraction pattern?(6)
6. In the figure, a broad beam of light of wavelength 683 nm is sent directly



downward through the top plate of a pair of glass plates. The plates are 120mm long, touch at the left end and are separated by a wire of diamenter 0.048 nm at the right end. The air between the plates acts as a thin film.
(a) How many bright fringes will be seen by an observer looking down through the top plate? (10)
(b)Now, white light is sent directly downward through the plates. Is a dark or bright fringe located at the left end ?(5)
(c) To the right of that end, fully destructive interference occurs at different locations for different wavelengths of the the light. Does it occur first for the red end or blue end of the spectrum?(5)

Information you may (or may not) need

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

$$\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$$

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$$

$$\left(\frac{\partial U}{\partial V}\right)_P = T\left(\frac{\partial P}{\partial T}\right)_V - P$$