Student ID Number: _________

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part D, 16 August 2002, 14:00 - 17:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.
2. All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.
3. For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.
4. Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.
5. All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.
6. Each problem is worth 10 points.
7. Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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D1. In solid materials, a vacancy is a term used to described an unoccupied lattice site. Consider n vacancies in a solid with each vacancy raising the energy by an amount ϵ. The solid is composed of N atoms on $N + n$ lattice sites. State any approximations that you use to answer the following points.

(a) (2 points) What is the number of ways of arranging the vacancies on the lattice sites?

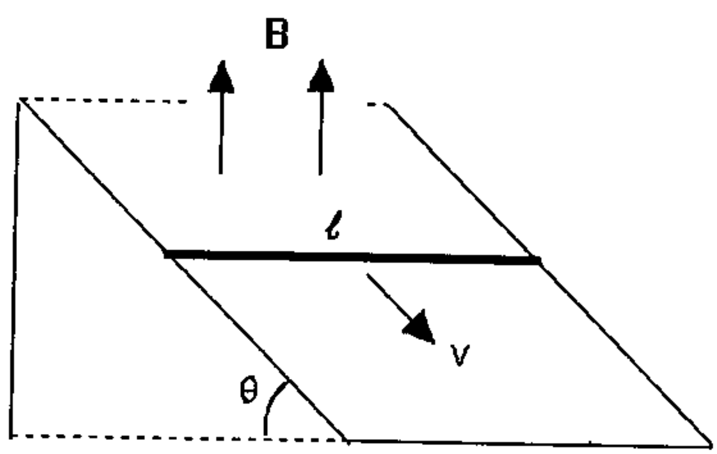
(b) (2 points) What is the entropy S?

(c) (3 points) What is the Helmholtz free energy F?

(d) (3 points) Minimize F to obtain the equilibrium number of vacancies n, and show that the results is

$$n = \frac{N}{e^{\epsilon/k_B T} - 1} \quad .$$

D2. (10 points) A metal conducting bar of length ℓ, mass m, and resistance R slides down a set of resistanceless, frictionless rails as shown in the sketch. The rails are connected to by a resistanceless conductor at the lower end and are inclined at an angle θ with respect to the horizontal. The entire assembly is immersed in a uniform magnetic field B that is directed vertically upward. Derive an expression for the terminal speed V_T of the rod. Neglect air resistance.



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D3. Crystalline LiF has a simple cubic array structure with a spacing between lattice planes of $d = 0.20$ nm. Consider such a crystal with its front face cut parallel to the lattice planes. An x-ray beam is shined on the front face at an angle of θ with respect to the face, as shown in the illustration. The x-rays are generated when electrons, which are accelerated across a 25 kV potential in a cathode-ray tube, strike a metal target. You may find the following relation useful: $hc = 1240$ eV nm.

(a) (3 points) Derive an expression relating the angle of reflection to the wavelength of the incident x-rays and the lattice spacing d.

(b) (2 points) Determine the minimum angle at which x-rays will be detected for the orientation shown.

(c) (2 points) In addition to bremsstrahlung x-rays, the anode target also emits characteristic x-rays at discrete energies. The K_α emission from a copper target ($Z = 29$) is at an energy of 8.0 keV. At how many discrete angles will there be reflection of these x-rays from the LiF crystal for the orientation shown.

(d) (3 points) If an unknown material emits K_α x-rays at an energy of 24.5 keV, determine the atomic number of the material (and thus the element).