과제 #3

마감일: 10월 19일 9시 30분

제출방법:

- **강의실 교탁**

주의사항:

- **숙제를 베껴 내면 관련된 모든 학생에게 불이익이 있습니다.**
- **마감일시를 반드시 준수.**

Problem 1 Consider a system A consisting of a spin 1/2 having magnetic moment μ_0, and another system A′ consisting of 3 spins 1/2, each having magnetic moment μ_0. Both systems are located in the same magnetic field B. The systems are placed in contact with each other so that they are free to exchange energy. Suppose that when the moment of A points up (i.e., when A is in its + state), two of the moments of A′ point up and one of them points down. Count the total number of states accessible to the combined system A+A′ when the moment of A points up, and when it points down. Hence, calculate the ratio P-/P+, where P- is the probability that the moment A points down and P+ is the probability that it points up. Assume that the total system A+A′ is isolated.

Problem 2 In research in nuclear physics and elementary particles, it is of great interest to do scattering experiments on targets consisting of protons whose spins are preferentially polarized in a given direction. Each proton has a spin 1/2 and a magnetic moment $\mu_0=1.4\times10^{-23}$ erg/gauss. Suppose that one tries to achieve atomic spin polarization by taking a sample of paraffin, applying a magnetic field of 50,000 gauss, and cooling the sample to some very low absolute temperature T. How low would this temperature have to be so that, after equilibrium has been reached, the number of proton moments pointing parallel to the field is at least 3 times as large as the number of proton moments pointing in the opposite directions? Express your answer in terms of the ratio T/T_R where T_R is room temperature.

Problem 3 A vertical cylinder contains v moles of a monatomic ideal gas and is closed off

by a piston of mass M and area A. The whole system is thermally insulated. The downward acceleration due to gravity is g. Initially, the piston is clamped in position so that the gas has a volume V_0 and an absolute temperature T_0. The piston is now released and, after some oscillations, comes to rest in a final equilibrium position corresponding to some smaller volume V of the gas where it has a temperature T. Neglect any frictional forces which might prevent the piston from sliding freely within the cylinder. Neglect also the heat capacities of the piston and of the cylinder.

(a) What must be the final mean pressure of the gas?

(b) By considering the work done on the gas and using your knowledge of the properties of an ideal monatomic gas, calculate the final temperature T and volume V of the gas in terms of T_0, V_0, the gas constant R, and the quantities v, M, A, g.