공학물리기초 - 2019. Final Exam.

I. Write the scientific key words defined
10pts (or described) by the following sentences
in English.

a) A logarithmic measure of the degree of randomness of the system.

b) A macroscopic system which is sufficiently large so that its temperature remains unchanged in any thermal interaction with other systems.

c) An ensemble representing an isolated system in equilibrium with a constant energy.

d) Any microstate in which a system can be found without contradicting the macroscopic information available about the system

e) The exponential factor e^{-E_r/k_BT}.

II. Consider a system A consisting of a spin $1/2$

15pts having magnetic moment μ_0 and another system A'

consisting of 4 spins $1/2$ each having moment μ_0.

Both systems are located in the same magnetic field

$\vec{B}$. They are free to exchange energy with one

another. When moment of A points up

(i.e., A is in its + state), two of the moments

of A' point up and other two of them point 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. Assume "A+A'" is

isolated.

a) Calculate the ratio P_-/P_+ where $P_{(-)}$ is the

5pts probability that the moment of A points up (down).

b) Discuss if the result in a) is consistent

10pts. or inconsistent with the postulate of equal

a priori probabilities. Explain logically

why you reached that conclusion.

English is preferred, but Korean or French

is allowed on this part.

III. Fill in boxes with scientific words in English or with formula(s).

15 pts total

(1 pt each unless specified otherwise),

Transport equations usually take a form of the flux-gradient relation also known as the [a) words]. For instance, transport of energy is described by the relation $\vec{Q} = -K \vec{\nabla} T$ where K is [b) words]. Transport of the electrical charge, on the other hand, is described by the Ohm's law, $\vec{j} = \sigma \vec{E}$ where σ is [c) words]. The Ohm's law is an [d) word] law not a [e) words] such as Newton's law.

From Newton's law, the charge carriers' [f) words], $\bar{v}$ can be expressed as $\bar{v} = \frac{1}{2} \frac{qE}{m} \cdot \tau$. 2 pts

If we express the characteristic time τ as $l/\bar{v}$, where l is the mean free path, we find $\bar{v} \propto E^{1/2}$, and cannot ~~des~~ recover the Ohm's law.

III. cont'd.

However, we should consider the $\boxed{\text{g) word}}$ property of the material and the mean free time (mean collision time) should be expressed in terms of l and $\boxed{\text{h) words}}$ as $\tau \simeq l / \boxed{\text{i) notation for h)}}$.

---

j) For a time-independent $\vec{E}$, express the Ohm's law in the flux-gradient relation form by introducing a useful quantity which you have learned earlier in this course.

5 pts

IV Consider a one-dimensional harmonic oscillator of mass "m" and spring constant "a". The energy "E" of the oscillator is given by

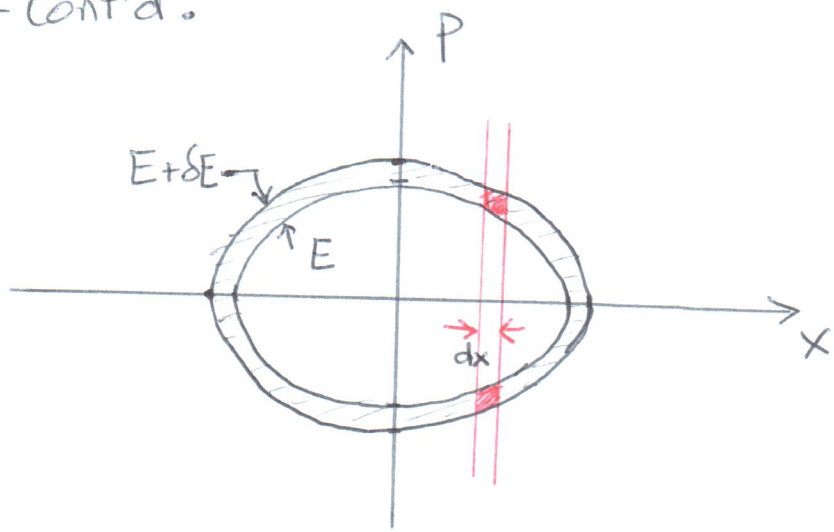
$$E = \frac{1}{2m} p^2 + \frac{1}{2} a x^2.$$

Suppose one knows that the energy of the oscillator lies in the small range between E and $E + \delta E$.

Then, in the 2 dimensional phase space (x, p), this system's state must lie between two ellipses determined by E and $E + \delta E$.

15 pts,

IV – cont'd.



Suppose that the only information available about the oscillator is its energy in the specified range.

a) Find the probability $P(x)\,dx$ that x lies between x and $x+dx$. Express $P(x)$ in terms of x and given parameters of the problem.

10 pts

b) For a specific oscillator, find the time-average value of the potential energy as $t \to \infty$.

5 pt.

V. Consider a one-dimensional oscillator

20pts. which is described by a position x and momentum p and energy

$$\epsilon = \frac{p^2}{2m} + \frac{1}{2} a x^2 + b x ,$$

where the 1st term on RHS is its kinetic energy and the 2nd and 3rd terms are potential energy. a is a positive constant and b is another " . Suppose this oscillator is in thermal equilibrium with a heat reservoir at a temperature "T".

a) What is the mean (expected) value of x,

5pts i.e., $\langle x \rangle$?

b) What is the mean (expected) value of x^2,

5pts i.e., $\langle x^2 \rangle$?

c) What is the mean total energy ?

5pts.

d) Explain if the result for b) is consistent

5pts. with the equipartition theorem in detail.

Korean or French is allowed for this part.

VI. Consider another one-dimensional oscillator

5 pts. in thermal equilibrium with a reservoir at temperature "T." Now, its potential energy is given by

$$V(x) = d\,|x| .$$

($|x|$ is an absolute value of x, d is a positive constant).

- What is its mean potential energy ? Show your derivation clearly.

You don't need to consider quantum mechanical effects explicitly in all problems.