

2016/2017 ACADEMIC YEAR SECOND SEMESTER EXAMINATION

FIRST YEAR EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS

SPH 602: STATISTICAL MECHANICS

DATE: APRIL 7, 2017

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants:

QUESTION ONE (30 MARKS)

- a) Differentiate between micro canonical ensemble, canonical ensemble and grand canonical ensemble.
 (3 marks)
- b) Describe the properties a system of gases must have to be treated as ideal classical gases.
 (2 marks)
- c) What are the challenges observed with systems considered as ideal gases in nature?
 - (3 marks)

TIME: 2:00-5:00PM

d) Explain the difference between bosons and fermions.

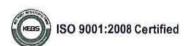
- (4 marks)
- e) Find the fluctuations of the given thermodynamic quantities given that they are independent of V and T. (4 marks)
- f) Describe the contributions of Johnson-Nyquist noise. (3 marks)
- g) Describe the short noise experimental procedure.
- (3 marks)

h) Describe two examples of single Hilbert space.

(4 marks)

i) Describe the origin of black body spectra.

(4 marks)



QUESTION TWO (20 MARKS)

a) Discus the non-interacting Bose and Fermi gas second quantization.

(20 marks)

QUESTION THREE (20 MARKS)

a) Show that Einstein relation for viscous friction of a Brownian particle related to the diffusion constant of the particle is given by:

$$\mu = \frac{1}{mr} = \frac{D}{KT} = 1/KT \int_0^\infty \langle u(t_0) | u(t_0 + t) \rangle dt$$

(10 marks)

b) Show that for bound electrons to a magnetic field the magnetic paramagnetic susceptibility X is given by:

$$X = \left(\frac{3}{2}\right) \frac{n\hat{\mu}\mu^2 B}{KBTF}$$

(10 marks)

QUESTION FOUR (20 MARKS)

- a) Discuss the difference between superfluid helium and ideal Bose condensate. (10 marks)
- b) Construct a grand canonical ensemble where all possible states of the system are represented, all possible values of N and all possible energy states Es (N) for a given N are shown. Obtain Gibbs free energy for each particle. (10 marks)

QUESTION FIVE (20 MARKS)

a) Discuss the symmetry properties of Bosons and Fermions. (12 marks)

b) Explain the relationship between emitted radiation and radiation inside the cavity.

(5 marks)

c) Show that the partition functions of a gas with N non-interacting identical particles is given by:

$$\overline{m}_i = \frac{\Sigma n_1 n_2 \dots n_i e^{-B(n_1 E_1 + n_2 E_2 + \dots)}}{\Sigma n_1 n_2 \dots e^{-B(n_1 E_1 + n_2 E_2 + \dots)}}$$
 (3 marks)

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