D 122528 **(Pages : 2)** **Name.....**

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2025

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

8 *Short questions answerable within* 7.5 *minutes.*
Answer **all** *questions, each question carries weightage* 1.

1. Distinguish between Microstates and Macrostates ?
2. What do you mean by phase space ?
3. What is meant by Canonical Ensemble ?
4. What is meant by ideal gas ?
5. What do you mean by a density matrix ?
6. Define Fermi gas.
7. Outline the features of the Pauli theory of Paramagnetism.
8. What is the significance of chemical potential ?

(8 × 1 = 8 weightage)

Section B

4 *Essay questions, each answerable within* 30 *minutes*
Answer any **two** *questions, each question carries weightage* 5

9. Prove Liouvilles' theorem and explain its physical significance.
10. Explain, the density and energy fluctuations in the Grand Canonical ensemble ?

Turn over

11. Explain Landau's theory of diamagnetism.

12. Explain the thermodynamic behaviour of the ideal Bose system.

(2 × 5 = 10 weightage)

Section C

7 *Problem questions, each answerable within* 15 *minutes*
Answer any **four** *questions, each question carries weightage* 3.

13. Derive the EoS of ideal Fermi gas.

14. Get an expression for the energy fluctuation of the Canonical Ensemble.

15. Show that ideal fermi gas deviates from ideal perfect gas by some factor and also find that factor.

16. Draw the Phase space trajectory of the Harmonic Oscillator.

17. Calculate the Fermi energy in electron volts for Sodium assuming that it has one free electron per atom. Given the density of Sodium is 0.97 g/cm^3, Atomic Weight = 23.

18. Find the average number of photons in an enclosure of 22.4 litres at 273 K ?

19. Find the pressure of black body radiation at 300 K and 6000 K ?

(4 × 3 = 12 weightage)

D 102185 **(Pages : 2)** **Name.....**

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2024

(CBCSS)

Physics

PHY2C07—STATISTICAL MECHANICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Short questions answerable within 7½ *minutes.*

Answer **all** *questions, each carries weightage* 1.

1. What are the consequences of Liouville's theorem ?
2. Describe how energy fluctuates in the Canonical Ensemble ?
3. What do you mean by the terms Phase space and Ensemble.
4. Write down the partition functions of Canonical and Grand canonical ensembles.
5. What is Gibbs Paradox ?
6. Define Fermi gas.
7. Explain Virial Theorem.
8. Outline the features of Landau's diamagnetism.

(8 × 1 = 8 weighage)

Section B

4 Essay questions, each answerable within 30 *minutes.*

Answer any **two** *questions, each carries weightage 5.*

9. Differentiate between microstates and macrostates. Derive an expression for the entropy of classical ideal gas.
10. Explain quantum mechanical ensemble theory. Explain the density matrix.
11. Explain the thermodynamic behaviour of the ideal Bose gas. What is the condition for the onset of bose condensation ?
12. Define Fermi Temperature and Fermi Energy. Explain Pauli's story of paramagnetism.

(2 × 5 = 10 weightage)

Turn over

Section C

7 Problem questions, each answerable within 15 minutes.

Answer any **four** *questions, each carries,weightage 3.*

13. Show that for an ideal Bose gas PV = 2E/3.
14. A Bose gas comprises 5 particles and 4 available energy states. How many macrostates are possible.
15. The Fermi energy of Silver is 5.5 eV. Find the average energy of Silver at 0 K.
16. Find the pressure of black body radiation at 500 K and 8000 K.
17. Find the average number of photons in an enclosure of 22.4 litres at 273 K.
18. Find the partition function of an ideal gas in a Canonical ensemble.
19. A system of N noninteracting and distinguishable particles of spin 1 is in thermodynamic equilibrium. Find the entropy of the system.

(4 × 3 = 12 weightage)

C 42803 **(Pages : 2)** **Name.....**

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2023

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

8 Short questions answerable within 7.5 minutes.
Answer **all** *questions, each question carries 1 weightage.*

1. Distinguish between microstate and macrostate.
2. State Liouville's theorem. What are its consequences ?
3. Show that the partition function of a molecule is equal to the product of the partition functions due to its various degrees of freedom.
4. Differentiate between an 'ideal gas' and an 'ideal classical gas'.
5. Draw curves for the distribution of energy in the spectrum of a black body at two different temperatures. List the result obtained from these curves.
6. How Maxwell-Boltzmann distribution can be considered as a limiting case of Bose-Einstein distribution ?
7. What do you mean by fluctuations ? When are these fluctuations negligible ?
8. Define Fermi energy. What is its significance at (i) $T = 0$ K ; and (ii) $T > 0$ K ?

($8 \times 1 = 8$ weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries 5 weightage.*

9. Explain the Gibbs paradox and its resolution by deriving the Sackur -Tetrode formula.
10. State and Prove Equipartition theorem and Virial theorem using canonical ensemble formalism. Illustrate with example.
11. Explain the quantum mechanical ensemble theory. Explain density matrix.
12. Discuss Landau theory of diamagnetism for an ideal Fermi Gas.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries 3 weightage.*

13. Ten distinguishable particles are to be placed in four energy levels with energies $0, \in, 2\in$ and $3\in$. If the total energy of the system consisting of these particles is $3\in$, find :
    (i) The number of possible microstates of the system ;
    (ii) The number of microstates corresponding to each macrostate ; and
    (iii) The total thermodynamic probability of the system.
14. The thermodynamic probability of an ideal gas increases from e^{10} to e^{10^3}. Find the change in its terms of the Boltzmann's constant *k*.
15. Find the average energy of an ideal classical gas in a canonical ensemble in temperature T.
16. For a Bose gas at 2 K, find the condensation fraction n_0/N and the gaseous fraction n_{ex}/N, if $T_c = 3.2$ K.
17. State and explain equipartition theorem.
18. The density of electron in lithium is $4.7 \times 10^{28} m^{-3}$. Calculate the degeneracy pressure of the electron gas in the metal.
19. Find out the wavelength corresponding to maximum emission by a black body at 500° C. Would you be able to see this radiation ?

(4 × 3 = 12 weightage)

C 23369 **(Pages : 2)** **Name.....**

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions answerable within* 7.5 *minutes.*
Answer **all** *questions, each question carries weightage* 1.

1. Differentiate between μ-space and Γ-space.
2. Explain Gibb's paradox.
3. A system has three energy levels $\in$, $2\in$ and $3\in$. Determine the partition function
4. What do you mean by a grand canonical ensemble and write an expression for the density function?
5. State the postulates of equal a priori probability.
6. Why is the electronic contribution to the specific heat of a metal vary with temperature at low temperatures ?
7. How is Bose-Einstein condensation different from the ordinary condensation of a gas in physical space ?
8. What do you mean by an ideal Fermi Gas ?

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Derive Liouville's theorem and explain its consequences.
10. Explain microcanonical ensemble. Find the quantum states and the phase space of linear harmonic oscillator.
11. Derive Plank's formula for black body radiation using Bose-Einstein statistics. Using the result, deduce Stefan's-Boltzmann law.
12. Explain Pauli Para magnetism and obtain the expression for susceptibility.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. The energy of a mole of an ideal gas at constant volume is doubled. How would the total number of available microstates change ?
14. A composite system has two interacting systems 1 and 2 having thermodynamic probabilities $\Omega_1 = 8 \times 10^{20}$ and $\Omega_2 = 3 \times 10^{19}$,
    (i) Calculate the individual entropies S_1 and S_2 of the two systems.
    (ii) Also calculate the total entropy and the thermodynamic probability of the composite system.
15. A system in a canonical ensemble is at a temperature of 400 K. If the probability of the system being in a microstate 1 is 3 times the probability of it being in microstate 2, which of the two states has higher energy and by how much ?
16. Find the condensation temperature for the vapour of Rb^{87} atom at a number density of $n = 2.5 \times 10^{12}\ cm^{-3}$ treating it as a B.E gas.
17. Derive the density matrix for a system in a canonical ensemble.
18. TheFermi energy in silver is 5.49 eV. What is the average energy of a free electron in silver at 0K ? At what temperature would the molecules of an ideal classical gas have this much average energy ?
19. The cosmic microwave background radiation (CMBR) has a temperature of ≈ 2.7 K. Find out the wavelength λ_m corresponding to maximum spectral density of the cosmic background radiation. What photon energy corresponds to the maximum U_λ ?

(4 × 3 = 12 weightage)

C 4759 **(Pages : 2)** **Name**.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2021

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admissions)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 Short questions answerable within 7.5 minutes.
Answer **all** *questions, each question carries weightage* 1.

1. What are the expected values of S and Ω for a system at T = 0 K ?
2. Differentiate between distinguishable and indistinguishable particles.
3. Define partition function. What is the significance of partition function in statistical mechanics ?
4. What is an Ensemble ? Write down the probability distribution function of a micro canonical ensembles ?
5. Which are the different motions a diatomic molecule is capable of performing ?
6. What is Bose-Einstein condensation ? Which property of boson is responsible for this phenomenon ?
7. Define black body radiation. What are its characteristic properties ?
8. Show that the Fermi distribution curve is symmetrical about the Fermi energy E_F.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Derive expressions for energy fluctuations in the case of canonical ensemble.

10. Describe the thermodynamic behaviour of an ideal Bose gas.

11. Derive the equation for thermodynamic probability of an ideal gas from micro-canonical ensemble. Hence derive thermodynamics of the system.

12. Describe the thermodynamic behaviour of an ideal Fermi gas.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. How does the number of microstates of 1 g of H_2 gas change, if its volume gets doubled by a process of reversible adiabatic expansion?

14. The entropy of a microstate of a system is 1 JK^{-1} while that of another one is 1.001 JK^{-1}. How many times more likely is the second microstate as compared to the first one ?

15. A system in contact with a heath bath at temperature T has two accessible energy states with energies 0 and 0.1 eV. If the probability of the system being in the higher energy state is 0.1 eV, find the temperature of the heath bath.

16. Find the condensation temperature for liquid helium with a density of 145 kgm^{-3}.

17. What is Gibb's paradox ? How is it resolution ?

18. The peak wavelength of radiation coming out of a hole in an enclosure is 5 μm. Find the total energy density inside the cavity.

19. The density of electrons in copper is $8.51 \times 10^{28} m^{-3}$. Find (i) the fermi energy of copper ; (ii) The average zero point energy of a free electron in copper ; and (iii) The degeneracy pressure of the electron gas in copper.

(4 × 3 = 12 weightage)

C 83073 (Pages : 3) Name.....

Reg. No.....

SECOND SEMESTER M.A./M.Sc./M.Com. DEGREE EXAMINATION

JUNE 2020

(CBCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2019 Admissions)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*

Each question carries a weight of 1.

1. Explain what is meant by thermodynamic limit.
2. Write a brief note on the formula $S = k \ln \Omega$.
3. What do you mean by a grand canonical ensemble ?
4. Explain the importance of the symmetry property of density matrix given as $\hat{\rho}_{mn} = \hat{\rho}_{nm}$.
5. For a canonical ensemble, derive the formula for the density matrix given below

$$\hat{\rho} = \frac{e^{-\beta \hat{H}}}{Tr\left(e^{-\beta \hat{H}}\right)}.$$

6. Explain the terms : (a) Identical particles ; and (b) Indistinguishable particles.
7. What do you mean by an ideal Fermi gas ?
8. For a Fermi-Dirac distribution the mean occupation number for single particle state is given by,

$$\langle n_\epsilon \rangle = \frac{1}{e^{(\epsilon - \mu)/kT} + 1}.$$

Show graphically how this function varies with temperature.

(8 × 1 = 8 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries a weight of 5.

9. Explain the Gibbs paradox and its resolution by deriving the Sackur-Tetrode formula.

10. Derive expressions for energy fluctuations in the case of canonical ensemble.

11. Find the expressions for grand partition function in the cases of Bose-Einstein and Fermi-Dirac distribution assuming ideal gas conditions.

12. Derive the formula for specific heat of a solid in terms of Einstein function.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries a weight of 3.

13. Show that in the case of an ideal gas undergoing a reversible adiabatic process $PV^{5/3}$ is a constant.

14. Show that the entropy of a system in a grand canonical ensemble can be written as,

$$S = -k \sum_{r,s} P_{r,s} \ln P_{r,s},$$

where

$$P_{r,s} = \frac{\exp(-\alpha N_r - \beta E_s)}{\sum_{r,s} \exp(-\alpha N_r - \beta E_s)}.$$

15. Which of the following matrices qualify as a density matrix for a two level system? Qualify your answer in each case.

$$\rho_1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad \rho_2 = \frac{1}{2}\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}, \quad \rho_3 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}.$$

16. Show that for a free particle confined to a box of volume V the partition function is,

$$Q_1(\beta) = Tr\left(e^{-\beta \hat{H}}\right) = V \quad \text{left}\left(\frac{m}{2\pi\beta\hbar^2}\right)^{3/2}$$

where

$$\hat{H} = -\frac{\hbar^2}{2m}\nabla^2.$$

17. Give a qualitative argument for treating photons and phonons as bosons.

18. State and explain equipartition theorem.

19. Given the following data, make an estimate of the Fermi energy of free electron gas in metallic sodium and express it in the units of electron volts. Effective mass of electron = 8.9×10^{-31} kg, charge $e = 1.6 \times 10^{-19}$ C, no. of conduction electrons per atom = 1, atoms per unit cell = 1, lattice constant $a = 4.29 \times 10^{-10}$ m, Planck's constant $h = 6.6 \times 10^{-34}$ Js.

(4 × 3 = 12 weightage)

C 82894 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.A./M.Sc./M.Com. DEGREE EXAMINATION, JUNE 2020

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

12 short questions. Each answerable within 5 *minutes.*
Answer **all** *questions. Each question carries weightage* 1.

1. Compare classical statistics with quantum statistics.
2. Define the statistical quantity Ω. How is it related to entropy ?
3. Distinguish between micro canonical, canonical and grand canonical ensembles.
4. Find the relationship between the Boltzmann factor exp(-βEr) and Helmholtz free energy.
5. Define phase space. Distinguish between Γ space and μ space.
6. State and explain Liouville's theorem in quantum statistics.
7. Classify the following into fermions and Bosons with reason : a) ^4He ; b) ^3He ; c) photon ; and d) electron.
8. From the nature of wave functions show that Bosons do not obey Pauli exclusion principle while Fermions obey it.
9. Define the g_ν functions for Bose systems.
10. What is Bose -Einstein condensation ? Write down the criterion to occur it.
11. What is Fermi energy ? Write down an equation for it in terms of n.
12. Distinguish between strongly degenerate and completely degenerate Fermi systems.

(12 × 1 = 12 weightage)

Turn over

Section B

4 essay questions. Each answerable within 30 minutes.
Answer any **two** *questions. Each question carries weightage 6.*

13. Derive the statistical factor P_{rs} for a system in grand canonical ensemble and relate it to various thermodynamic functions.

14. Derive the most probable occupation numbers for the three cases of quantal gases in the formalism of micro-canonical ensemble.

15. Discuss the thermodynamics of phonons and hence derive Debye equation for specific heat capacity of solids.

16. Discuss Landau diamagnetism and explain how is it different from Langevin diamagnetism.

(2 × 6 = 12 weightage)

Section C

6 problem questions. Each answerable within 15 minutes.
Answer any **four** *questions. Each question carries weightage 3.*

17. Derive condition for equilibrium between two systems under energy and particle exchange in an adiabatic enclosure.

18. Draw the phase space of a linear classical harmonic oscillator. What happens for a quantum oscillator?

19. Consider an N particle system and a phase space consisting of 2 cells with energies 0 and E. Find the partition function and internal energy.

20. Derive the density matrix for a system in microcanonical ensemble.

21. Derive an expression for specific heat capacity at constant volume for an ideal Bose gas.

22. Calculate the pressure of electron gas discharge at 2500 K and concentration $10^{16}/cm^3$.

(4 × 3 = 12 weightage)

C 82890 (Pages : 2) Name.....

Reg. No.....Acc. No.....

SECOND SEMESTER M.A./M.Sc./M.Com. DEGREE EXAMINATION
JUNE 2020

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question has a weightage of 1.

1. Write Boltzmann formula for entropy and explain.
2. What is Gibbs paradox ?
3. State Virial theorem.
4. State Liouvillie's theorem.
5. What is density matrix ?
6. Find expressions for pressure and energy of an ideal Bose gas.
7. Write blackbody distribution law and explain the terms.
8. What is Stefan - Boltzmann law ?
9. Distinguish between para and diamagnetism.
10. Write the expression for specific heat for a metallic solid ?
11. Define Fermi energy.
12. What are photons and phonons ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries a weightage of 6.

13. Obtain the partition function for a collection of classical, one dimensional harmonic oscillators using canonical ensemble. Hence find pressure, internal energy and chemical potential.
14. Show that for large N, micro-canonical, canonical and grand canonical ensembles are equivalent.

Turn over

15. Obtain an expression for the specific heat of a non-metallic solid at high and low temperatures.

16. Using Landau's theory of diamagnetism obtain an expression for susceptibility.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries a weightage of 3.

17. Obtain the phase space trajectory of a freely falling particle.

18. 2 particles and 3 energy levels are given. Compute the number of possible states if the particles are bosons and fermions.

19. Starting from grand canonical ensemble, using occupation number concept, obtain expressions for partition function for bosons and fermions.

20. Find an expression for critical temperature of a Bose gas below which Bose Einstein condensation will occur.

21. Show that entropy of photon gas is proportional to T^3.

22. If number density of electrons in a white dwarf is $10^{36}/m^3$, what is the approximate Fermi temperature?

(4 × 3 = 12 weightage)

C 63089 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2019

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

(Total 12 questions each answerable within 5 minutes)

Answer **all** *questions.*

Each question carries a weightage of 1.

1. Distinguish between micro states and macro states.
2. Name thermodynamic potentials. What is their significance ?
3. What is the importance of Hamilton's equations in classical statistics ?
4. What is Partition function ? Derive its relationship with Helmholtz free energy.
5. Explain the equivalence of grand canonical ensemble with canonical ensemble.
6. Define density matrix. What is its importance ?
7. Compare the properties of fermions and bosons.
8. Define thermal wavelength.
9. Explain radiation pressure.
10. Define Fugacity. How does it vary with temperature for Bosons ?
11. Write down Fermi distribution. Explain how it varies with temperature.
12. Distinguish between degenerate and nondegenerate Fermi systems.

(12 × 1 = 12 weightage)

Section B

(4 Essay questions, each answerable within 30 minutes)

Answer any **two** *questions.*

Each question carries a weightage of 6.

13. Explain Gibb's paradox and its resolution.
14. What is grand canonical ensemble ? Discuss the derivation of thermodynamics of a system using grand canonical ensemble.

Turn over

15. Derive most probable occupation numbers for the three cases of quantal gases in the formalism of micro-canonical ensemble.

16. Explain Bose Einstein condensation. Derive the criterion for Bose Einstein condensation to occur.

(2 × 6 = 12 weightage)

Section C

(6 Problem questions, each answerable within 15 minutes)
Answer any **four** *questions.*
Each question carries a weightage of 3.

17. Derive the statistical condition for equilibrium between two systems in thermal contact Evaluate the partition function for a classical one dimensional harmonic oscillator.

18. Evaluate the partition function for a classical one dimensional harmonic oscillator and find its entropy.

19. Derive the density matrix for a free particle of mass m enclosed in a cubical enclosure of side L.

20. Assuming the sun to be black body at temperature at of 5800 K, calculate the power received at the earth's surface per unit area. The radius of sun = 7×10^8 m and the distance of the sun from earth =15×10^{10} m, $\sigma = 5.87 \times 10^{-8}$ W m^{-2}/s.

21. Derive an expression for specific heat capacity at constant volume for an ideal Femi gas at low but finite temperatures.

22. The molar mass of Li is .00694 and its density is 0.53×10^3 kg/m^3. Calculate the Fermi energy and Fermi temperature of electrons.

(4 × 3 = 12 weightage)

D 43529 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2018

(CUCSS–PG)

Physics

PHY 2C 07—STATISTICAL MECHANICS (4C)

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What is phase space ?
2. Differentiate micro canonical, canonical and grand canonical ensembles.
3. Derive the statistical interpretation of entropy with reference to micro canonical ensemble.
4. Studying the statistics of paramagnetism, derive Curie law of paramagnetism.
5. State and explain the Virial theorem.
6. Derive an expression for the density fluctuation in grand canonical ensemble.
7. What do you mean by Bose-Einstein condensation ?
8. Give a brief description of Landau diamagnetism.
9. State the conditions of applicability of Fermi-Dirac distribution.
10. Write a note on thermionic emission.
11. Bring out the statistics of occupation numbers.
12. What do you mean by statistical equilibrium ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. What is Gibbs paradox ? How is it resolved ?
14. What is a Fermi gas ? Deduce an expression for the energy of Fermi gas at absolute zero. Comment on its physical significance.
15. Derive Planck's formula for black body radiation using Bose-Einstein statistics. Using this result, deduce Stefan-Boltzmann law.

Turn over

16. Define canonical partition function. How can you obtain various thermodynamic quantities from it ? Also discuss the energy fluctuation in canonical ensemble.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

17. Show that the number of microstates accessible to a system in the energy interval between E and E + dE is :

$$\Omega(E) = \frac{2mV}{h^2}(2m)^{3/2}E^{1/2}dE$$

where m is the mass of the particle constituting the system and V is the volume of the system.

18. Calculate the probability that a harmonic oscillator with energy $\varepsilon_n = \left(n + \frac{1}{2}\right)\hbar\omega$ is in a state with n an odd number. Assume that the harmonic oscillator is in contact with a heat bath at a temperature T.

19. A system consists of three particles. Each particle has two energy states 0 and ε. Obtain the partition function and probability of finding the particle in each energy state when the system is in equilibrium with a heat bath at temperature 600 K assuming that the particles are (i) fermions and (ii) bosons.

20. Show that the entropy of a system in grand canonical ensemble can be written as

$$S = -k\sum_{r,s} P_{r,s} \ln P_{r,s}$$

where $P_{r,s}$ is the probability that the system is in a state characterized by the number N_r of particles and the amount E_s of energy.

21. Treating $_2He^4$ – I as an ideal Bose-Einstein gas, find the critical temperature T_C at which there is a transition of liquid He-I to liquid He-II. Given the molar volume of liquid He at T_C is 27.4×10^{-6} m^3 and mass of $_2He^4$ is 6.65×10^{-27} kg.

22. Find the probability that a system is in a state with energy 0.2 eV above the Fermi energy in a metal atom.

(4 × 3 = 12 weightage)

D 43533

(Pages : 2)

Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2018

(CUCSS–PG)

Physics

PHY 2C 07 – STATISTICAL MECHANICS

(2017 Admissions)

Time : Three Hours

Maximum : 36 Weightage

Section A

(12 *short questions. Each answerable within* 30 *minutes*)

Answer **all** *questions.*

Each question carries a weightage of 1.

1. Explain the role of statistics in the study of thermodynamic systems.
2. State and explain postulate of equal a priory probabilities.
3. What is an ensemble? What is its relevance in the statistical approach?
4. State Liouville's theorem. What are its consequences?
5. Write down the different forms of partition function.
6. Explain the quantum statistical analogue of principle of equal- a-priori probabilities
7. Write down the equation for mean occupation number $<n_\epsilon>$ of a single particle state with energy ϵ and give a graphical representation of its variation with ϵ.
8. Write down the anti symmetric wave function using Slater determinant. Show that it obeys Pauli exclusion principle.
9. Compare Debye theory of specific capacity of solids with that of Einstein.
10. Show that Bose Einstein condensation is a first order phase transition.
11. Fermi systems are quite lively at absolute zero. Explain this statement.
12. Explain Landau diamagnetism.

(12 × 1 = 12 weightage)

Section B

(4 *essay questions. Each answerable within* 30 *minutes*)

Answer any **two** *questions.*

Each question carries a weightage of 6.

13. Derive the equation for thermodynamic probability of an ideal gas from micro-canonical ensemble. Hence derive thermodynamics of the system.

Turn over

14. State and prove Equipartition law and Virial theorem using canonical ensemble formalism. Illustrate with examples.

15. Derive the equation of state and number density of Bose systems in terms of g functions. Hence work out the thermodynamic functions.

16. Work out the temperature dependent paramagnetic susceptibility of ideal Fermi systems.

(2 × 6 = 12 weightage)

Section C

(6 *problem questions. Each answerable within* 15 *minutes*)

Answer any **four** *questions.*

Each question carries a weightage of 3.

17. From the extensive nature of entropy and multiplicative nature of thermo dynamical probability Ω. Show that entropy of a system is related to Ω by the relationship $S = k \ln \Omega$.

18. Show that canonical distribution is a Gaussian. Hence find out its dispersion.

19. Derive the density matrix for a system in canonical ensemble.

20. For an MB gas in quantum mechanical canonical ensemble derive the partition function in terms of thermal wave length.

21. Derive Stefan's law from Plank's radiation law.

22. Show that electron gas in Cu is degenerate at room temperature 30° C. Density of Cu = 8.5×10^{18} m^{-3} and Molar mass 63.546 g/mol.

(4 × 3 = 12 weightage)

C 24006 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2017

(CUCSS—PG)

Physics

PHY 2C 07—STATISTICAL MECHANICS (4C)

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What is an Ensemble ? Distinguish between microstates and macrostate.
2. Explain the concept of equal apriori probability.
3. Explain the postulate of random Phases.
4. Explain Gibb's Paradox.
5. Define Density Matrix.
6. State and explain Liouville's theorem.
7. Show that $S = -k \bar{z_r} (P_r \log P_r)$.
8. Prove that the phase space area equivalent to one Eigen state of a linear harmonic oscillator is 'h'.
9. Bring out the statistical origin of the third law of thermodynamics.
10. Differentiate the three kinds of statistics.
11. How is fugacity of a system related to q potential ?
12. Show that virial for a free particle is 2 T where T is the kinetic energy.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Using the grand partition function derive the general form of q potential for M.B., B.E. and F.D. statistics.
14. Give the thermodynamics of an ideal Bose Gas and derive the condition for Bose Einstein Condensation.

Turn over

15. Derive an expression for the equation of state of an ideal Fermi gas at :

    (a) High temperature and low density.

    (b) Low temperature and high density.

16. Describe the classical treatment of paramagnetism and derive Carie's law.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

17. What is Gibb's Paradox ? How is it revolved ?

18. Obtain the expression for the partition function of a linear harmonic oscillator in Canonical ensemble.

19. Show that the partition function $Q_N(V, T)$ of an extreme relativistic gas consisting of N monoatomic molecules with the energy momentum relationship $E = P_C$ is $Q_N(V, T) = \frac{1}{N!}\left[\left\{8\pi V\left(\frac{kT}{hc}\right)^3\right\}\right]^N$.

20. Two particles are to be distributed in 3 cells. How many micro states are possible if the particles are :

    (a) Bosons.

    (b) Fermions.

    (c) Boltzons.

21. Find Helmholtz's free energy of a Bose system of N particles with fugacity Z and temperature T.

22. What is Brownian motion ? Give Einstein's concept of explaining Brownian Motion.

(4 × 3 = 12 weightage)

C 63096 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2014

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

1. Differentiate between microstate and macro state with reference to an ensemble?
2. Explain the postulate of random phases.
3. What is Gibbs paradox?
4. State and explain Liouville's theorem.
5. Show that $S = -k\sum_r (p_r \ln p_r)$
6. Prove that phase space area equivalent to one Eigen state of a linear harmonic oscillator is h?
7. Using equipartition theorem, find c_v of a monoatomic ideal gas?
8. A Bose system consists of 5 particles and 4 available energy states. How many macro states are possible?
9. What is meant by Fermi energy?
10. Bring out the statistical origin of Third law of thermodynamics?
11. How is fugacity of a system related to q potential?
12. Show that number of states in unit volume of phase space is $1/h^3$.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*

13. Discuss various ensembles in statistical mechanics. Show that for a perfect gas, root mean square fluctuation in number density is proportional to $\frac{1}{\sqrt{N}}$.

Turn over

14. Using grand partition function derive the general form of 'q' potential for M.B, B.E and F.D statistics
15. Outline the thermodynamics of an ideal Bose gas and derive the condition for the onset of Bose-Einstein condensation

16. Obtain the equation of state of an ideal Fermi gas at 1)High temperature and low density 2)Low temperature and high density

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*

17.Show that in canonical ensemble formulation, internal energy of the system is $\partial[A\beta]/\partial\beta$ where A is Helmholtz free energy.

18. Average energy of harmonic oscillator is $E=(n+\frac{1}{2})hw/2\pi$ where n=0,1,2.....Find the partition function of the oscillator?

19. Prove that expectation value of a physical quantity G is $\frac{Tr(\rho G)}{Tr(G)}$

20. Two particles are to be distributed in 3 cells. How many micro states are possible if the particles are 1) Bosons 2)Fermions 3)Boltzons

21. Find Helmholtz's free energy of a Bose system of 'N' particles with fugacity 'z' and temperature 'T'?

22. A system has 2 particles, each of which can be in any one of 3 quantam states of energies 0,E and 3E. System is in contact with a heat reservoir at T. Find the partition functions if the particles obey 1)B.E statistics and2) F.D statistics?

(4 × 3 = 12 weightage)

C 83630 (Pages : 2) Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2015

(CUCSS)

Physics

PHY 2C 07 – STATISTICAL MECHANICS (4C)

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question carries a weightage of 1.

1. What is the difference between a micro state and a macro state?
2. Explain degenerate state and statistical weight factor.
3. State the postulates of equal a priori probability.
4. What is the criterion for classifying particles into bosons and fermions?
5. Draw the phase diagram for a particle free to move in one dimension.
6. What is grand partition function?
7. What is the thermodynamic meaning of Fermi energy?
8. Define virial co-efficient.
9. Explain Gibbs paradox.
10. Name and explain the statistics obeyed by free electrons in metals.
11. Explain the term fugacity.
12. Why the electrons in a metal do not contribute to its specific heat at room temperature?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*

Each question carries a weightage of 6.

13. Derive Liouville's theorem and explain its consequences.
14. Explain microcanonical ensemble. Find the quantum states and the phase space of linear harmonic oscillator.

Turn over

15. Describe the thermodynamic behaviour of an ideal Bose gas.

16. Give a theoretical description of Pauli paramagnetism.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*

Each question carries a weightage of 3.

17. A Maxwell-Boltzmann system of N particles exists in any of the three non-degenerate states–E, 0, E. Find the entropy of the system at OK.

18. Find C_v of a monoatomic ideal gas using equi-partition theorem.

19. For a gas obeying Maxwell velocity distribution, obtain the most probable speed of the molecules.

20. Prove that the phase space area equivalent to one Eigen state of a linear harmonic oscillator is h.

21. Find the fluctuation in the number of particles in a perfect gas obeying F D statistics.

22. A cubic meter of atomic hydrogen at STP contains about 2.6×10^{25} atoms. Find the number of atoms in their first excited state at 1000 K.

(4 × 3 = 12 weightage)

C 4675 (Pages : 2)

Name.....

Reg. No.....

SECOND SEMESTER M.Sc. DEGREE EXAMINATION, JUNE 2016

(CUCSS)

Physics

PHY 2C 07—STATISTICAL MECHANICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries a weightage of 1.

1. Define micro canonical ensemble.
2. Explain degenerate state and statistical weight factor.
3. What is the difference between Bose particles and Fermi particles with respect to their spin and wave function ?
4. Define density matrix.
5. Draw the phase diagram for a particle free to move in one dimension.
6. What is grand partition function ?
7. What is the thermodynamic meaning of Fermi energy ?
8. Explain Bose-Einstein condensation.
9. Explain Gibbs paradox.
10. Give the statistical definition of entropy.
11. What is the relation between fugacity and q potential ?
12. Why the electrons in a metal do not contribute to its specific heat at room temperature ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries a weightage of 6.

13. Derive Liouville's theorem and explain its consequences.

Turn over

14. Explain the quantum mechanical ensemble theory. Explain density matrix.

15. Describe the thermodynamic behaviour of an ideal Bose gas.

16. Explain Pauli paramagnetism and obtain the expression for susceptibility.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries a weightage of 3.

17. Calculate the number of micro-states for four particles having a total energy of 6 E, the energy levels are equally spaced.

18. Atomic weight of Li is 6.94 and its density is 530 kg/m^3. Calculate the Fermi energy and Fermi temperature of electrons.

19. Show that when $g_1 >> n_1$ the B.E. distribution formula reduces to M.B. distribution.

20. Prove that the phase space area equivalent to one Eigen state of a linear harmonic oscillator is h.

21. Find the Fluctuation in the number of particles in a perfect gas obeying F.D. statistics.

22. A particle of unit mass is executing S.H.M. Find its trajectory in the phase space.

(4 × 3 = 12 weightage)