Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Condensed Matter Physics I **Semester: II**
Program: MSc (Physics) **Time: 03 hours**
Course Code: PHYS 8018 **Max. Marks: 100**

Instructions:

- All questions are compulsory (**Q9** and **Q11** have an internal choice).
- Scientific calculators can be used for calculations.

SECTION A
(5Q x 4M = 20 Marks)

S. No.		Marks	CO
Q1	How does the Hartree-Fock theory account for the electron-electron interaction?	**4**	**CO1**
Q2	Draw the diagrams to illustrate the emission and absorption of phonons in the context of electron-phonon interaction.	**4**	**CO1**
Q3	Explain Jahn-Teller effect.	**4**	**CO2**
Q4	Draw and explain the Doniach-phase diagram.	**4**	**CO3**
Q5	How does the quantum Hall effect differ from the classical Hall effect?	**4**	**CO5**

SECTION B

(4Qx10M= 40 Marks)

Q6	What is the benefit of occupation number representation over a Slater determinant? Write Slater determinant for a system of N particles.	**10**	**CO1**
Q7	Discuss the Weiss model of antiferromagnetism.	**10**	**CO2**

Q8	Discuss the essential features of an integral quantum Hall effect. Illustrate with the help of a diagram.	**10**	**CO5**
Q9	Illustrate the crystal electric field splitting of free *d*-ions in octahedral and tetrahedral environments. **OR** Illustrate the magnetic susceptibility of a single crystal with the help of a diagram for an antiferromagnetic material. Why is the susceptibility along the easy axis different from that along the hard axis?	**10** **10**	**CO2**
SECTION-C **(2Qx20M=40 Marks)**			
Q10	a) Describe the important properties of a topological insulator. b) Illustrate the Weyl semi-metal behavior with the help of an experimental observation.	**10** **10**	**CO4**
Q11	a) What do you understand by a quantum phase transition? Discuss the scaling behaviour near a quantum critical point. b) What is meant by the statement: "the time reversal symmetry is an antiunitary operator". How does the action of time reversal differ in the case of integer and half-integer spin? **OR** a) What do you understand by parity transformation? What is the difference between the pseudo-vectors and pseudo-scalars? Illustrate with example. b) Discuss the properties of heavy fermion and non-Fermi liquid systems.	**10** **10** **10** **10**	**CO3**