



# UNIVERSITY OF THE PUNJAB

B.S. 4 Years Program / Eighth Semester – 2019

Paper: Solid State Physics-IV

Course Code: PHY-440 Part – I (Compulsory)

Time: 15 Min. Marks: 10

Roll No. in Fig. ....

Roll No. in Words. ....

Signature of Supdt.: .....

**ATTEMPT THIS PAPER ON THIS QUESTION SHEET ONLY.**

**Division of marks is given in front of each question.**

**This Paper will be collected back after expiry of time limit mentioned above.**

Q.1. Encircle the correct option.

(10x1=10)

- A) Cobalt single crystal has easy direction of magnetization along  
i)  $a$ -axis    ii)  $b$ -axis    iii)  $c$ -axis    iv) basal plane    v) none of these
- B) Inelastic scattering of neutron by a magnetic structure results in the  
i) absorption of a neutron    ii) creation of phonon wave    iii) creation of spin wave  
iv) creation of electro-magnetic wave    v) none of these
- C) Ferromagnet in its ground state has all spins parallel with exchange integral  $J$  always  
i) positive    ii) negative    iii) positive and negative integral values    iv) none of these
- D) Possible orientations of spin  $1/2$  nuclei when placed in magnetic field are?  
i) 0    ii) 1    iii) 2    iv) 3    v) none of these
- E) Due to interaction between excited nucleus and magnetic field caused by nuclei in molecules moving around in the sample, the relaxation process occurs which is named as?  
i) Spin-lattice relaxation    ii) Spin-spin relaxation    iii) Spin-orbit relaxation  
iv) None of these
- F) Iron has Curie temperature around  
i) 1170 °C    ii) 1070 °C    iii) 970 °C    iv) 770 °C    v) none of these
- G) For antiferromagnetism to occur, exchange integral  $J$  (according to *Heisenberg's Model*) is always  
i) positive    ii) negative    iii) infinite    iv) equal to zero    v) none of these
- H) Magnetic susceptibility  $\chi$  in antiferromagnetic materials  
i) decreases with temperature    ii) increases with temperature    iii) does not depend on temperature    iv) none of these
- I) The difference between the magnetic field necessary for resonance in the sample and in some arbitrary chosen compound is which of the following?  
i) Field shift    ii) Matrix effects    iii) Chemical shift    iv) Resonance shift
- J) Which of the following materials exhibit negative value of magnetic susceptibility  $\chi$ ?  
i) ferromagnets    ii) paramagnets    iii) diamagnets    iv) antiferromagnets  
v) none of these



**ATTEMPT THIS (SUBJECTIVE) ON THE SEPARATE ANSWER SHEET PROVIDED**

**Q.2** Give to the point answer / short description of each question. (4 × 5 = 20)

- a) Develop a mathematical relation between magnetic permeability  $\mu$  and magnetic susceptibility  $\chi$  of a magnetic material.
- b) How magnetization varies as a function of magnetic field strength in diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials? Give graphical representation only in each case.
- c) What is meant by magnon? Is magnon wave quantized? Explain briefly to support your answer.
- d) Discuss briefly how magnetic susceptibility  $\chi$  in diamagnetic, ferromagnetic and paramagnetic materials depend on temperature  $T$ . Explain  $\chi$ - $T$  behavior graphically in each case?
- e) What is meant by magnetic anisotropy? Explain the origin of magnetic anisotropies in magnetic materials?

**Q.3**

Derive magnon dispersion relation for anti-ferromagnet by taking into account the nearest neighbor interactions only and discuss its behavior for long wavelength limit. (10)

**Q.4**

Calculate an expression for domain wall energy  $\sigma_{dw}$  and minimum wall thickness  $\delta_{dw}$  required to overcome the magnetostatic effects in cubic ferromagnetic crystal, assuming  $N$  atoms in the transition layer. (10)

**Q.5**

Discuss nuclear magnetic resonance (NMR) and ferromagnetic resonance (FMR) phenomenon in detail. Explain for what kind of diagnostics the NMR and FMR techniques are used? (5+5)