PHY 502 Reg No.....

CREDIT BASED FIFTH SEMESTER B.Sc. DEGREE EXAMINATION OCTOBER 2012

PHYSICS

PAPER V: SOLID STATE PHYSICS

Duration: 3 Hours **Max Marks: 80**

PART –A

1. (a) **Answer any TEN of the following.** 1X10=10

a) Define molar specific heat of a solid.
b) What is the average kinetic energy of free electrons at zero Kelvin in terms of Fermi energy?
c) What are Bosons?
d) Draw the energy band diagram for an insulator.
e) What is the principle of a solar cell?
f) Give the symbol for a pnp transistor.
g) What is high temperature super conductivity?
h) What is Fermi level?
i) What are hard X-rays?
j) What is Bravais lattice?
k) What is a black body?
l) What is the role of chromium atoms in Ruby Laser?

(b) **Answer any FIVE questions of the following.** 2X5=10

a) Write the conditions under which quantum statistics reduces to classical statistics.
b) What are the assumptions of Debye's theory of specific heats of solids?
c) What is doping? Why is it done?
d) Give any two applications of LED.
e) Draw a labeled diagram of a Coolidge tube.
f) Mention four characteristics of laser as a source of light.

PART-B

UNIT-I

Answer any TWO from the following: 10x2=20

2. (a) Derive expression for specific heat of solids using Einstein's theory.

(b) The Debye temperature for carbon is 2230K. Calculate the specific heat per kmol at 10K. Also calculate the highest lattice vibration frequency.

Given: $h = 6.625 \times 10^{-34}$ J.S. & $K = 1.38 \times 10^{-23}$ J/K. (6+4)

3. (a) Obtain an expression for Fermi energy at OK assuming the expression for density of states.

(b) Copper has a density of 8.95×10^3 Kg/m^3 and atomic weight 63.54. Calculate the Fermi energy at zero Kelvin. Avogadro Number = 6.023×10^{26} / K mol. (6+4)

4. (a) What is Hall effect? Explain the experimental method to find the Hall coefficient.

(b) The Hall voltage for the metal sodium is 0.001mV, measured at I = 100mA, B = 2 Tesla and the thickness of the specimen is 0.05mm. Calculate

(i) the number of carriers per cubic metre in sodium

(ii) the mobility of the electrons in sodium using its electrical conductivity , σ for sodium $4.18 \times 10^{-8}\ ohm^{-1}m^{-1}$ (6+4)

UNIT-II

Answer any TWO of the following. **10x2=20**

5. (a) With the help of an energy band diagram explain the effect of forward bias on a pn diode.

   (b) Energy gap in a semiconductor is 1.2 eV. What is the ratio between its conductivity at 400 K and 300 K. (6+4)

6. (a) Draw and explain the output characteristics of an npn transistor in the CE mode.

   (b) Mobilities of electrons and holes in a sample of intrinsic germanium at 300K are $0.36\ m^2V^{-1}S^{-1}$ and $0.17\ m^2V^{-1}S^{-1}$ respectively. If the carrier concentration is $2.4 \times 10^{19}/m^3$, Calculate the conductivity of the sample. (6+4)

7. (a) Explain any two important properties of superconductors.

   (b) The conductivity of germanium at 20°C is $2\Omega^{-1}\ m^{-1}$. What is conductivity at 40°C?

   Given: Energy gap = 0.72eV, Boltzmann constant = $1.38 \times 10^{-23}J/K$

   (6+4)

UNIT-III

Answer any TWO of the following. **10x2=20**

8. (a) State and arrive at Bragg's law for X-ray diffraction in crystals.

   (b) A X-ray tube operates at 40KV. Find the maximum speed of electrons striking the anticathode and shortest wavelength of X-rays produced. (6+4)

9. (a) Derive Planck's law of radiation using Einstein's A and B coefficients.

   (b) The Bragg glancing angle is 35.22° for second order maximum for monochromatic X-rays reflected from a crystal having interplanar distance 2.67 A.U. Calculate the wavelength of X-rays. Also calculate the highest reflecting order that could be observed with this radiation. (6+4)

10. (a) Explain the working of a He – Ne laser using energy level diagram.

    (b) The energy band gap in a $Ga-As$ semiconductor laser is 2.27eV. Find the wavelength of the laser light emitted. How many photons are emitted per sec if the optical power is 1mW? (6+4)

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PHY 502.1 Reg No.....

CREDIT BASED FIFTH SEMESTER B.Sc. DEGREE EXAMINATION OCTOBER 2013

PHYSICS

PAPER V: SOLID STATE PHYSICS

Duration: 3 Hours **Max Marks: 80**

PART –A

1. (a) **Answer any TEN of the following.** **1X10=10**

a) Define molar specific heat of a solid.
b) Define Fermi energy.
c) Define Hall Coefficient.
d) Where does the Fermi level lie in the case of P type of semiconductor at low temperature?
e) What is Zener breakdown?
f) Why Si is not used in LED?
g) What are X-rays?
h) Why hydrogen atom cannot emit x-rays?
i) What is lattice constant?
j) Give two examples for type I superconductor
k) Define spin exchange interaction.
l) Define critical current.

(b) **Answer any FIVE questions of the following.** **2X5=10**

a) What are the assumptions of classical free electron theory?
b) Give the significance of Hall effect?
c) Draw a circuit for studying the characteristics of Zener diode.
d) Mention the seven crystal systems.
e) Explain Meissner effect.
f) Explain Weiss modifications for the Langevin's theory.

PART-B

UNIT-I

Answer any TWO of the following: **2x10=20**

2. (a) Derive an expression for specific heat of solids at low and high temperature using Einstein's theory.

(b) Calculate the molar specific heat at constant volume for Ag at 100K. Given Debye temperature for Ag is 215K. R = 1.99K cal/K mole K. **(6+4)**

3. (a) Get an expression for Fermi energy at OK assuming the expression for density of energy states.

(b) Calculate the Fermi energy at OK for Potassium. Atomic weight of potassium is 39 and density 860 Kg/m3. Avagadro's number 6.023×10^{26} per Kmol. **(6+4)**

4. (a) Describe the experimental method to find the Hall Coeffcient.

(b) The Hall voltage of metal sodium is 0.001 mV; measured at I = 100 mA; Magnetic field = 2 Tesla and width of the specimen is 0.05 mm. Calculate the mobility of electron in sodium with electrical conductivity $2.09 \times 10^7 mhom^{-1}$. (6+4)

UNIT-II

Answer any <u>TWO</u> of the following. **10x2=20**

5. (a) With the help of energy band diagram explain the effect of forward bias and reverse bias on a pn diode.

   (b) The saturation current density of a p-n junction Ge diode is 200 mA/m^2 at 300 K. Find the voltage that would have to be applied to cause a forward current density of $10^5 A/m^2$ to flow. (6+4)

6. (a) Derive an expression for the electrical conductivity of an intrinsic semiconductor.

   (b) Energy gap in Si semiconductor is 1.1 eV. What is the ratio between its conductivity at 500 K and 400 K? (6+4)

7. (a) With a neat diagram, explain the working of a solar cell.

   (b) The resistances of an intrinsic semiconductor is 1100Ω at 323 K and 600 Ω at 343K. Find its energy gap. (6+4)

UNIT-III

Answer any <u>TWO</u> of the following. **10x2=20**

8. (a) State and arrive at Bragg's law for X-ray diffraction in crystals.

   (b) The spacing between principal planes of Nacl Crystal is 2.52Å. If the first order Bragg reflection occurs at an angle of 10°, what is the wavelength of X-rays? (6+4)

9. (a) Explain BCS theory of superconductivity.

   (b) Lattice constant of a cubic lattice is a. Calculate the spacing between (2 1 1), (0 0 1), (1 1 0), (1 0 0), (1 1 1) and (10 1) planes. (6+4)

10. (a) Give an account for the quantum theory of paramagnetism and obtain an expression for it.

    (b) A X-ray tube operates at 50KV. Find the maximum speed of electrons striking the anticathode and shortest wavelength of X-rays produced. (6+4)

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PHY 502.1 **Reg No.....**

CREDIT BASED FIFTH SEMESTER B.Sc. DEGREE EXAMINATION OCTOBER 2014

PHYSICS

PAPER VI: SOLID STATE PHYSICS

Duration: 3 Hours **Max Marks: 80**

PART –A

1. (a) Answer any TEN of the following. **1X10=10**

a) Give the nature of particles which satisfies BE distribution law.
b) Define molar specific heat at constant volume.
c) Mention any one limitation of Einstein's theory of specific heat of a solid.
d) Define Hall effect.
e) Define Fermi level at T > OK.
f) Why semiconductor behaves as insulator at T = OK?
g) What is acceptor level?
h) Mention any one limitation of free electron theory.
i) What is photovoltaic effect?
j) Give one application Zener diode.
k) State Mosley's law.
l) What is DC Josephson effect?

(b) Answer any FIVE questions of the following. **2X5=10**

a) What are Antiferromagnetism and Ferrimagnetism?
b) Write a note on high temperature super conductivity.
c) Name the seven crystal systems with their unit cells.
d) Give the principle involved in the working of solar cell.
e) Distinguish between p-type and n-type semiconductors.
f) Graphically, compare Dulong-Petit's theory, Einstein's theory and Debye's theory of specific heat of a solid.

PART-B

UNIT-I

Answer any TWO of the following: **2x10=20**

2. (a) Name the three statistical distribution laws used in Physics and give the comparison between them.

(b) A copper slab of size $10mm \times 2mm \times 0.1mm$ has a current of 1A along its length. It is in a magnetic field of 1 Tesla with the field perpendicular to $3mm \times 10mm$ face. Calculate the current density and Hall voltage if $R_H = 0.55m^3 / C$. **(6+4)**

3. (a) By assuming the expression for number of modes of vibration, derive an expression for specific heat of a solid using Debye's theory.

(b) Debye's temperature for sodium metal is 160K. Calculate its molar specific heat at 15K. Given $R = 8.314 JK^{-1}mol^{-1}$. **(6+4)**

4. (a) Assuming the expression for density of energy state, derive expressions for Fermi energy and average energy at absolute zero.

   (b) The Fermi energy of silver is 5.51 eV at absolute zero. Find

   i) Average energy of free electrons in silver at O K.

   ii) Speed of electrons with above average energy.

   Given: $K = 1.38 \times 10^{-23} JK^{-1}$ $h = 6.625 \times 10^{-34} JS$ **(6+4)**

UNIT-II

Answer any <u>TWO</u> of the following. **10x2=20**

5. (a) Show that the Fermi level lies midway between valence band and conduction band in an intrinsic semiconductor.

   (b) Calculate the current produced in a small Germanium plate of area $1cm^2$ and thickness 0.3mm when p.d. of 2V is applied across its faces.
   Given: Concentration of electrons $2 \times 10^9 m^{-3}$ and mobilites of holes and electrons are $0.17 m^2 V^{-1} S^{-1}$ and $0.36 m^2 V^{-1} S^{-1}$ respectively. **(6+4)**

6. (a) Explain the mechanism of emission of light by a LED.

   (b) Find the resistance of intrinsic silicon rod 1 cm long, 1 mm wide and 1 mm thick at 300 K.

   Given: $n_e = 2.5 \times 10^{19} m^{-3}$, $\mu_e = 0.39 m^2 V^{-1} S^{-1}$ and $\mu_h = 0.1 m^2 V^{-1} S^{-1}$ at $300K$
   (6+4)

7. (a) Using energy band diagram and V-I characteristics explain forward and reverse bias of p n diode.

   (b) In an intrinsic semiconductor the energy gap is 1.1eV. What is the ratio between its conductivity at 700 K and that at 300 K.

   Given : $K = 1.38 \times 10^{-23} JK^{-1}$ **(6+4)**

UNIT-III

Answer any <u>TWO</u> of the following. **10x2=20**

8. (a) Describe the construction and working of a Coolidge tube.

   (b) X-rays incident on a crystal with interplanar distance 0.265 nm produce the first three orders of reflection at glancing angles of 8.6°, 17.5° and 26.7° respectively. Show that these observations are in conformity with Bragg's law. **(6+4)**

9. (a) Explain any two important properties of super conductors.

   (b) A monochromatic X-ray beam of wavelength $0.7A^\circ$ undergoes first order Bragg reflection from the plane (3, 6, 2) of a cubic crystal at a glancing angle of $39^\circ 7' 19''$. Calculate the lattice constant. **(6+4)**

10. (a) Describe the Langevin's theory of paramagnetism and obtain an expression for paramagnetic susceptibility.

    (b) Find the shortest wavelengths of X-ray produced for the X-ray tube to operate at 30KV and 40 KV. Compare the results. **(6+4)**

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PHY 502.1 **Reg No.....**

CREDIT BASED FIFTH SEMESTER B.Sc. DEGREE EXAMINATION OCTOBER 2015

PHYSICS

PAPER VI: SOLID STATE PHYSICS

Duration: 3 Hours **Max Marks: 80**

PART –A

1. (a) Answer any <u>TEN</u> of the following. **1X10=10**

a) What are Bosons?
b) State Dulong- Petit's law.
c) What is Debye frequency?
d) Write the relation between Hall Coefficient and electron mobility.
e) What is acceptor level?
f) How the conductivity of a semiconductor does vary with temperature?
g) What do you mean by forward biasing of a P-N diode?
h) Where does the Fermi level lie in the case of an intrinsic semiconductor?
i) What happens to transition temperature as the isotopic mass of mercury increase?
j) State Duane-Hunt Law.
k) What is Josephson Effect?
l) How many crystal systems are possible in a crystal structure?

(b) Answer any <u>FIVE</u> questions of the following. **2X5=10**

a) Explain Boltzmann tail with the help of a graph.
b) Give two differences between an N-type and P-type semiconductor.
c) Give any two applications of LED.
d) State Moseley's law and give its significance.
e) Write a note on high temperature superconductivity.
f) What is diamagnetism? Why diamagnetic materials have negative susceptibility?

PART-B

UNIT-I

Answer any TWO of the following: **2x10=20**

2. (a) Derive expression for specific heat of solids using Einstein's theory.

   (b) Debye's temperature for sodium metal is 150 K. Calculate its molar specific heat at 10K. Given: $R = 8.31 \times 10^3 J\ K^{-1} Mol^{-1}$ **(6+4)**

3. (a) Compare Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

   (b) Calculate Hall Coefficient and Hall mobility for sodium.
   Given : density of sodium = $970\ kgm^{-3}$, electrical conductivity = $2.1 \times 10^7 ohm^{-1} m^{-1}$.
   Atomic weight of sodium = 23. **(6+4)**

4. (a) Assuming the expression for density of energy state, derive expressions for Fermi energy and average energy at absolute zero.

   (b) Copper has density $8.95 \times 10^3\ kg\ m^{-2}$ and electrical conductivity $6.4 \times 10^7\ ohm^{-1} m^{-1}$ at room temperature. Calculate i) Relaxation time ii) Fermi energy at T = O K

   Given: Atomic Weight of Copper = 63.54, Avogadro number = 6.02×10^{26} per K mole

   Charge of an electron = $1.6 \times 10^{-19} C$, Mass of an electron = $9.1 \times 10^{-31}\ kg$ **(6+4)**

UNIT-II

Answer any <u>TWO</u> of the following. **10x2=20**

5. (a) Obtain an expression for electrical conductivity of an intrinsic semiconductor.

   (b) The energy gap in Ge is 0.75eV. Compare the intrinsic conductivity of Ge at 300 K and that at 330 K. Given Boltzman constant = $1.38\times10^{-23}\,J\,K^{-1}$. **(6+4)**

6. (a) With a neat diagram, explain the principle of solar cell.

   (b) Calculate the electrical conductivity of pure silicon at room temperature.

   Given: Electron mobility = 1500 $cm^2V^{-1}s^{-1}$, Hole mobility = 500 $cm^2V^{-1}s^{-1}$

   Carrier concentration = 1.6×10^{10} per c.c. **(6+4)**

7. (a) With the help of energy band diagram explain the effect of forward bias on a P-N diode.

   (b) The resistivity of Ge at $27^{\circ}C$ is $0.47\,\Omega\,m$ Calculate the intrinsic carrier density.

   Given : $\mu_e = 0.38\ m^2V^{-1}s^{-1}$ and $\mu_h = 0.18\ m^2V^{-1}s^{-1}$ **(6+4)**

UNIT-III

Answer any <u>TWO</u> of the following. **10x2=20**

8. (a) Describe Bragg's X-ray spectrometer. How it is used to determine the wavelength of X-rays.

   (b) An X-ray machine has an accelerating voltage of 25 kV. Find the shortest wavelength present in the X-ray spectrum and also evaluate its frequency as well as energy of the photon.

   Given: Plancks' Constant = $6.625\times10^{-34}\,J\,s$, Charge of an electron = $1.6\times10^{-19}C$

   Velocity of light = $3\times10^{8}\ m\,s^{-1}$ **(6+4)**

9. (a) Explain Meissner effect and the action of external magnetic field on a superconductor.

   (b) If X-ray of wavelength 0.06 nm are diffracted at an angle 8° in the first order. What is the spacing between the adjacent planes of the crystal? At what angle will be second order maximum occurs. **(6+4)**

10. (a) Describe the Langevin's theory of para-magnetism and obtain an expression for paramagnetic susceptibility.

    (b) X-ray of wavelength $0.71\overset{0}{A}$ are reflected from the (110) plane of rock salt crystal whose lattice constant is $2.82\overset{0}{A}$. Calculate the glancing angle corresponding to second order. **(6+4)**

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PHY 502.1 Reg. No. .....

CREDIT BASED FIFTH SEMESTER B.Sc. DEGREE EXAMINATION APRIL 2016
PHYSICS
Paper – VI: Solid State Physics

Time: 3 Hrs. **Max. Marks: 80**

PART – A

I. A. Answer any TEN of the following: **10×1=10**

i. What are Bosons?
ii. What is doping?
iii. What is high temperature super conductivity?
iv. Define spin exchange interaction.
v. What is the principle of a solar cell?
vi. What is Fermi level?
vii. Define molar specific heat of a solid.
viii. What is an extrinsic semiconductor?
ix. Mention any two uses of x-ray.
x. Define transition temperature.
xi. What is the difference between pn junction diode and zener diode?
xii. What are phonons?

B. Answer any FIVE questions of the following: **5×2=10**

i. Give two differences between an n-type and p-type semiconductor.
ii. Explain about antiferro-magnetism and ferrimagnetism.
iii. Compare F.D. and B.E. statistics.
iv. Draw the circuit symbol of solar cell and give one application of PN diode.
v. State Moseley's law and give its significance.
vi. Give any two limitations of classical free electron theory.

PART – B
UNIT - I

Answer any TWO of the following: **2×10=20**

2. a) Get an expression for Fermi energy at OK assuming the expression for density of energy states.
   b) Debye temperature for a crystal is 2000K and its density is 3500 kgm $^{-3}$. Assuming that the transverge and longitudinal components of velocities are equal, calculate the velocity of sound in the crystal.
   Given:- Atomic weight = 12, Avogadro number = 6.023×10^{26} kg^{-1} mole^{-1}
   K = 1.38×10^{-23}JK^{-1}, h = 6.625×10^{-34} Js. **(6+4)**

3. a) Show that both FD and BE statistics reduce to MB statistics at low densities and high temperature.
   b) Calculate the Hall constant and Hall mobility for sodium.
   Given: Atomic weight of sodium = 23, Density = 970 kg m $^{-3}$
   conductivity = 2.1×10^{7} ohm^{-1} m^{-1}. **(6+4)**

4. a) Derive expression for specific heat of solids using Debye's theory, assuming the expression for the number of possible modes of vibrations.
   b) Estimate the relaxation time of conduction electrons in silver from the following data:
   Resistivity = 1.6×10^{-8} ohm Atomic weight = 107.88, Density = 10.5×10^{3} kg m $^{-3}$, Avogadro number = 6.023×10^{26} kg^{-1} $mole^{-1}$, mass of electron = 9.1×10^{-31}kg. Charge of electron = 1.6×10^{-19}C. **(6+4)**

UNIT – II

Answer any TWO of the following: **2×10=20**

5. a) With necessary diagram and V – I characteristic explain the effect of reverse bias of a Zener diode. Write any one application of Zener diode.
   b) In an intrinsic semiconductor the energy gap is 1.2eV. What is the ratio between its conductivity at 600K and that at 300K? Given:- $K=1.38\times10^{-23}JK^{-1}$. **(6+4)**

6. a) With diagram, explain the classification of solids on the basis of band theory.
   b) The resistivity of Germanium at 27°C is 0.47Ωm. Assuming electron and hole mobilities as $0.38m^2V^{-1}s^{-1}$ and 0.18 $m^2V^{-1}s^{-1}$ respectively, calculate the intrinsic carrier density. **(6+4)**

7. a) Explain the mechanism of emission of light by LED.
   b) Calculate the conductivity of silicon, doped with 10^{21} atoms m^{-3} of boron if the mobility of holes is $0.048m^2V^{-1}s^{-1}$. **(6+4)**

UNIT – III

Answer any TWO of the following: **2×10=20**

8. a) Explain Meissner effect and the action of external magnetic field on a superconductor.
   b) An x-ray tube operate at 40kV. Find the maximum speed of electrons striking the anticathode. Find the value of shortest wave length of x-ray produced.

9. a) Explain the origin of diamagnetism in materials. Obtain an expression for diamagnetic susceptibility using the Lagevin's theory.
   b) A monochromatic x-ray beam of wavelength 0.7Å undergoes first order Bragg reflection from the plane (3 0 2) of a cubic crystal at a glancing angle of $39°7^{1}$. Calculate the lattice constant. **(6+4)**

10. a) Describe the construction and working of Coolidge tube.
    b) First order Bragg's reflection occurs when a monochromatic beam of X-rays of wavelength 0.675Å is incident on a crystal at a glancing angle of $4°51^{1}$. What is the glancing angle for 3rd order Bragg's reflection to occur? **(6+4)**

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