DHWU

M.Sc. (2nd Year) 3rd Semester Examination, 2018

Subject : Physics

1st Paper : Phy /Th / 3S / 301

(Condensed Matter Physics)

Time : 2 Hours **Full Marks : 40**

The figures in the margin indicate full marks.

Group - A

(Question no. 1 is compulsory and answer any two from the rest)

1. a) Prove that 5 fold rotational symmetry does not exist perfectly crystalline solids.

   b) What is Debye's T^3 Law ? 2+2=4

2. a) Sodium chloride (NaCl) has a cubic lattice with four Na^+ ions and four Cl^- ions per unit cell. In addition, Na^+ ions occupy the corner of a unit cell as well as the centre of the plane, where as Cl^- ions occupy the centre of a cube as well as the midpoint of each edge-line. This structure can also be produced in the following way ; Na^+ ions form fcc lattice and the face-centering translations can reproduce all positions of Cl^- ions , when applied to Cl^- ions located at $\left(\frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\right)$. As a result, any of the Na^+ ions is surrounded by six Cl^- ions and the reverse relationship is recognized co-ordinates of the eight ions in the unit cell of NaCl are given as follows.

$$Na^+\left(0\ 0\ 0\right)\left(\frac{1}{2}\ \frac{1}{2}\ 0\right)\left(\frac{1}{2}\ 0\ \frac{1}{2}\right)\left(0\ \frac{1}{2}\ \frac{1}{2}\right)$$

$$Cl^-\left(0\ \frac{1}{2}\ 0\right)\left(\frac{1}{2}\ 0\ 0\right)\left(0\ 0\ \frac{1}{2}\right)\left(\frac{1}{2}\ \frac{1}{2}\ \frac{1}{2}\right)$$

   i) Compute the structure factor F_{hkl} , assuming that the scattering factors of Na and Cl are expressed by f_{Na} and f_{CL} , respectively.

   ii) Compute the structure factors of planes (111) and (200)

   b. Describe the Einstein model of lattice heat capacity. Discuss the success and failure of this model.

(2+2)+(3+1)=8

Please Turn Over

3. a) Derive the dispersion relationship for a 1-dimentional vibrating monoatomic crystal and discuss the nature of optical and acoustic modes. Show that the group velocity vanishes at the zone boundary.

   b) An X-ray beam of wavelength 0.71 $\AA$ is diffracted by a cubic KCl crystal of density 1.09×10^3 kgm^{-3}. Calculate the interplanar spacing for (2 0 0) plane and the glancing angle for the second order reflection from these planes. The molecular weight of Kcl is 74.6 amu and Avogardo's number is 6.023×10^{23} kg^{-1} mole^{-1} and atomic distance is 6.29×10^{-10} m. (3+1)+(2+2)=8

4. a) The atomic radius of Sodium is 1.86 $\AA$. Calculate the Fermi energy at K=0. Consider the number of valence electron in a unit cell of Na is 2, mass of the election is 9.1×10^{-31} kg and Planck's constant = $6.62607004 \times 10^{-34}$ m^2 kg/s.

   b) Draw a sterographic projection of P_{222} and find out its equivalent points. 4+(2+2)=8

Group - B

(Question no. 6 is compulsory and answer any two from the rest)

5. a) Calculate the value of London penetration depth λ_0 at 0K for lead whose density is 11.3×10^3 kg/m^3 and atomic weight is 207.19.

   b) Define the terms spin-spin relaxation and spin-lattice relaxation of a paramagnetic system. 2+2=4

6. a) How do specific heat and thermal conductivity very with temperature for a superconductor?

   b) Explain the two component model of a superconductor. Arrive at Londons' equation and hence explain Meissner effect. 2+(1.5+3+1.5)=8

7. a) What is the Schottky defect ? How does it differ form the Frenkel defect ? Show that number of Frenkel defects in equilibrium at a given temperature is proportional to $(NN')^{1/2}$
   where terms have their usual meanings.

b) Show that pauli spin paramagenetism of a free electron metal is given by

$$\chi_p = \frac{3n\mu_0\mu_B^2}{2k_BT_F}$$, terms have their usual meanings.

8. a) A ferromagnetic material with J=3/2 and g=2 has a Curie temperature of 125 K. Calculate the intrinsic flux density near 0 K. Also, calculate the ratio of the magnetization at 300 K in the presence of an external field of 1 m T to the spontaneous magnetization at 0 K.

b) How cooper pairs are formed in superwnductors ?

c) What is the principle of electron spin resonance ? 4+2+2=8

DHWU

M.Sc. (2nd Year) 3rd Semester Examination, 2018

Subject : Physics

2nd Paper : Phy /Th / 3S / 302

(Nuclear Physics)

Time : 2 Hours **Full Marks : 40**

The figures in the margin indicate full marks.

Group - A

(Question no. 1 is compulsory and answer any two from the rest)

1. a) Find the binding energy per nucleon of $^{31}_{15}P$ in MeV. Given mass of $^{31}_{15}P$ to be 30.973763 amu, M_H=1.007825 amu and M_n=1.008665 amu. 2

   b) What is the difference between allowed Gamow Tellor transition and allowed Fermi Transition? 2

2. a) Using the semi empirical binding energy formula, find the atomic number of the most stable nucleus for a given mass number A. Hence explain which is the most stable nucleus among $^{6}_{2}He$, $^{6}_{2}Be$ and $^{6}_{3}Li$.

   b) Show that in calculating the nuclear force by central force field will not produce the correct result. (3+1)+4=8

3. a) In Gamow's Theory of Alpha Decay show that half-life ($t_{\frac{1}{2}}$) and alpha disintegration energy (Q) are inversely relating.

   b) As^{77} has an isomeric state $^{9^-}_{2}$ of energy 475 keV, which undergoes radioactive transition to $^{3^-}_{2}$ ground state and to $^{3^-}_{2}$ excited state of energy 265 keV. Two γ - rays of energy 265 and 210 keV are observed. State the nature of the transation. 5+3=8

4. a) At low energy (1 MeV), no excited state exists in np scattering. Explain your views.

   b) In low energy ***n-p*** scattering, graphically represent the wave function for both attractive and repulsive potential, for a given l value and explain.

   c) What do you mean by nuclear force? 2+4+2=8

Please Turn Over

Group - B

(Question no. 6 is compulsory and answer any two from the rest)

5. a) Draw the Feynman diagram for the weak decay : $\Lambda^0 \quad p + \pi^-$ (Symbols carry their usual meaning.)

   b) The first three energy levels of $^{228}_{90}Th$ are given below :

   $(0^+, 0\ keV)$; $(2^+, 57.5\ keV)$ and $(4^+, 187\ keV)$ Find the expected spin-parity and energy of the next level.

6. a) State whether the following interactions are possible or not. If possible comment on their nature.

   i) $\pi^- + p \quad K^0 + \Sigma^0$; ii) $\Sigma^- \quad p + e + \bar{\nu}_e$

   b) In any stable nucleus N > Z condition must be satisfied. Explain it in the light of shell structure of a nucleus.

   c) An excited state of $^{41}_{20}Ca$ is found to be $^{3^+}_{2}$ an it is located around 2.1 MeV. Justify the statement. (2+2)+2+2=8

7. a) Write down the asymmetry term of Bethe Weizsacker mass formula. Derive this expression from Fermi Gas Model.

   b) Draw the meson octet and write down the relevant quantum number of the members of the octet. (1+3)+4=8

8. a) Estimate the range of weak interaction assuming $W^{\pm}$ to be the mediator of the interaction (Given $m_w = 80 GeV$)

   b) Why was color quantum number introduced in particle physics ?

   c) The 1st excited state (2^+) of an e-e nucleus is found to be lying around 100 KeV. Find the moment of inertia of the corresponding nucleus.

   d) Considering the shape oscillation of a nucleus estimate the frequency of oscillation for 1st exited state of a nucleus. 2+2+2+2=8

DHWU

M.Sc. (2nd Year) 3rd Semester Examination, 2018

Subject : Physics

3rd Paper : Phy /Th / 3S / 303

(Atomic and Molecular Physics)

Time : 2 Hours **Full Marks : 40**

The figures at the end of question indicate full marks.

*(Use **separate Answer Script** for each group)*

Group - A

(Answer Question no. 1 and any two from the rest)

1. a) Find the magnetic moment in Bohr magneton of an atom in the state $^3P_2$. In how many sub-states will the state split if the atom is put in a weak and strong magnetic field ?

   b) Explain, why $\Delta Z=2$ only contribute to obtain pure Raman rotational spectra. 2+2=4

2. a) Obtain an expression for the correction to energy of hydrogen atom due to anomalous Zeeman effect.

   b) What is Paschen-Bach effect ? Show that all the spectral lines in this effect are split into three components just as in the normal Zeeman effect. 5+(1+2)=8

3. a) What is meant by the term polarizability ?

   b) State the selection rules for Raman scattering.

   c) Find the energy expression for pure rotational Raman spectra and hence draw the digram for transition rules for Stokes and anti-Stokes lines.

   d) Why homo-nuclear diatomic molecules do not give any microwave spectra, but give rotational Raman spectra ? 1+1+(3+1)+2=8

4. a) A hydrogen atom is kept in an electromagnetic field. Using the perturbed Hamiltonian, calculate the transition rate for stimulated emission.

   b) Obtain an expression for the line shape function for Doppler broadening and show its nature graphically. Compare it with the collision broadening. 4+(3+1)=8

Please Turn Over

Group - B

(Answer question no. 5 and any two from the rest)

5. a) Write down the non-degenerate level arising out of ^3P term. What is its total no. of degeneracy?

   b) Why the removal of an electron from O_2 molecule increases the dissociation energy?

   2+2+4

6. a) Find the intensity ratio of fundamental series due to following transitions of an alkali atom: $^2F_{5/2} \leftarrow {}^2D_{5/2}$ (I_1), $^2F_{7/2} \leftarrow {}^2D_{5/2}$ (I_2), $^2F_{5/2} \leftarrow {}^2D_{3/2}$ (I_3) and $^2F_{7/2} \leftarrow {}^2D_{3/2}$ (I_4).

   b) Assuming appropriate potential for an anharmonic oscillator find an expression of the vibrational wave number.

   c) Show that 1st overtone rotational band has frequency approximately 2 times that of fundamental band.

   3+3+2=8

7. a) Obtain ground state of C_2 molecule. Mention the nature of bond in this molecule.

   b) For a diatomic vibrating-rotator, obtain the general expression for the wave number of P and R branches.

   c) The first line in the rotational spectra of CO molecule has a wave number of 3.8424 cm^{-1}. Find the C-O bond length.

   2+4+2=8

8. a) Obtain L-S coupled spectroscopic levels arising out the electronic configuration $2p^5 3s$.

   b) Obtain Deslandres formula for vibrational course structure in electronic transition and obtain the wave number of (0,0) transition.

   c) The fundamental band of HCL is centered at 2886 cm^{-1}. Assuming that the internuclear distance is 1.276 A^0, calculate the wave number of the first two lines of each of the P and R branches of HCl.

   2+3+3=8

DHWU

M.Sc. (2nd Year) 3rd Semester Examination, 2018

Subject : Physics

4th Paper : Phy /Th / 3S / 304

(Astrophysics)

Time : 2 Hours **Full Marks : 40**

The figures in the margin indicate full marks.

Group - A

(First question is compulsory and answer any two from the remaining three questions.

1. a) At a place of latitude $35^0 35'$ N, a star crosses the meridian at $55^0 55'$ south of the Zenith. Find its declination.

   b) Consider a celestial sphere of radius R. Now, if we can have two great circles of that celestial sphere with radii R_1 and R_2 then establish a relation between R, R_1 and R_2.

   2+2=4

2. a) What do you mean by the length unit 'Parsec'? Establish the relations between – (i) Parsec and Astronomical Unit, ii) Parsec and light-year.

   b) The Zenith distance of a stat is $28^0 37'$ N. Find its polar distance at a place with latitude $23^0 40'$N.

   c) Consider a Neutron Star with mas $M = 1.4 M_\odot$ ($M_\odot$ means one solar mass) and radius of 10km. Estimate the total gravitational potential energy of this star.

   (1½+½+1)+3+2=8

3. Write a short note on any two of the following :-

   i) Star formation

   ii) Neutron star

   iii) Celestial coordinate system 2x4=8

4. a) Find the solution of the following *Lane-Emden's* equation, $\frac{1}{x^2}\frac{d}{dx}\left(x^2\frac{dy}{dx}\right)+y^n=0$, with polytropic index n=0, subjected to the appropriate boundary conditions and discuss about the characteristics of this polytrope. The Symbols carry their usual meanings here.

Please Turn Over

b) Define *Jeans mass* of a star and show that the Jeans density inversely varies with the square of the Jeans mass. (3+1)+(2+2)=8

Group - B

First question is compulsory and answer any two from the remaining three questions.

5. a) If the scale factor is defined as $a(t)=1-e^{-\alpha t}$, then find the value of the deceleration parameter $q(t)$. [Given that α is a very small positive constant parameter]

b) Find the metric tensor in $3-D, E^3$ space for the following coordinates $x = p+q, y = p-q$ and $z = r$. 2+2=4

6. a) What are Cepheid variabables ?

b) Show that in a flat FRW universe the bolometric luminosity distance to a galaxy observed with redshift z is.

$$d_L(z) = \frac{c\left(z+\frac{z^2}{2}+\cdots\right)}{H_0},$$

for curvature dominant universe. The symbols carry their usual manings.

c) Compare the Debye lengths (for electrons) of the two glow discharge plasma systems with number densities and temperatures are respectively as ; $n=10^{16}\ m^{-3}$, $T=9\times10^3$ K and $n=10^{18}\ m^{-3}$, $T=1.024\times10^4$K.

d) If the Hubble parameter is defined as $H=\sqrt{1-4a^{-2}}$, then find the time parameter in terms of the scale factor (a). 1+3½+1½+2=8

7. Write a short note on any two of the followings :-

i) Gravitational redshift

ii) Leakage potential

iii) Magnetic viscosity and Reynolds number. 2x4=8

8. a) What is the difference between plasma frequency and electron plasma wave ?

b) Find the dispersion relation of the electron plasma wave for a 1 – D plasma system and show that for the cold electrons there is no electron plasma wave present in the system.

2+(5+1)=8