2017/ODD/08/21/PHY–304
(A/B/C/D)/084

PG Odd Semester (CBCS) Exam., December—2017

PHYSICS

(3rd Semester)

Course No. : PHYCC–304

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Candidates are to answer *either* from Option—A *or* Option—B *or* Option—C *or* Option—D

OPTION—A

Course No. : PHYCC–304 (A)

(ASTROPHYSICS—I)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. *(a)* Discuss in brief the equatorial coordinate system. 9

(b) The RA and DEC of a star are + 07 h : 30 m : 30 s and – 20° : 45 : 30 . Determine the hour angle of star on

December 08, 2017 at 12 midnight. Also calculate the rising and setting time of the star on that day. The longitude of the place is 90° East. 5

2. *(a)* What is parsec? Draw a schematic diagram showing the definition of 1 parsec. Determine the distance to a star if the parallax of a star is 0 23 . 3

(b) What are apparent and absolute magnitudes of a star? Derive the relation between them. 2+2=4

(c) The apparent magnitude of Rigel is 6·67 and its distance is 860 lightyear. Determine its absolute magnitude. 4

(d) Define color index of a star. 3

UNIT—II

3. *(a)* What is a reflecting telescope? Discuss different types of reflecting telescope. Determine the plate scale of a telescope (f /10) whose diameter is 3 metre. 1+4+3=8

(b) Discuss briefly the working principle of a CCD. 6

4. *(a)* Calculate the diffraction limit of the IUCAA telescope of 2 metre diameter for 0 55 m. 2

(b) Discuss in brief the working principle of an X-ray telescope. 10

(c) Write any two advantages of a reflecting telescope over a refracting telescope. 2

UNIT—III

5. What is a binary star? Discuss the classification scheme of binary stars with example. The period of a visual binary is 100 years. Its parallax is 0 15 and its semi-major axis is 5 . Compute the total mass of the system. 1+10+3=14

6. *(a)* Explain how mass-luminosity relation can be used to compute the mass of stars. 4

(b) Derive equation of continuity in a fluid flow. Hence find out Jean's critical wavelength for an interstellar cloud at temperature T such that it collapses under gravity. 10

UNIT—IV

7. *(a)* Write down Saha's ionization equation and explain it. 7

(b) Explain HR diagram. Draw a neat sketch of this diagram showing the positions of *(i)* Sun, *(ii)* Polaris, *(iii)* Sirius B, *(iv)* Vega and *(v)* Barnard's star. 5+2=7

8. Explain the end states of stars. Describe the evolutionary stages of the following compact objects : 2+4+4+4=14

(a) Black hole

(b) White dwarf

(c) Neutron star

UNIT—V

9. Give a brief description of different hypotheses, that describe the origin and formation of the Sun and other members of solar system. Make a comparison between different hypotheses in the light of present observation. 7+7=14

10. *(a)* Discuss briefly different layers of solar atmosphere. 6

(b) What is a comet? How are comets classified? Discuss origin of comets. 1+3+4=8

OPTION—B

Course No. : PHYCC–304 (B)

(CONDENSED MATTER PHYSICS—I)

Answer **five** questions, selecting **one** from each Unit

UNIT—I

1. *(a)* Define stress and strain in a crystal. What do you understand by dilation in crystal? 3

(b) Prove that the elastic stiffness constants are symmetrical, i.e., C_{ij} C_{ji}. Show that cubic crystal has only three independent elastic constants. 11

2. Find the velocity of transverse wave in the [111] direction of a cubic crystal. 14

UNIT—II

3. *(a)* What are the assumptions of Einstein's theory to explain the variation of specific heat? Using Einstein's theory, find the expression of specific heat at low temperature. 10

(b) Diamond has charge q newton/m^2 and density kg/m^3. Show that Debye temperature is given by

$$_D \quad \frac{h}{K_B} \ (q / \ )^{1/2} (3 \ / 4 \ m)^{1/3}$$

Assume C_e C_t. 4

4. *(a)* State and prove Gruneisen relation for oscillator model. 6

(b) Find the lattice thermal expansion coefficient at low temperature. 8

UNIT—III

5. *(a)* Derive the expression for *(i)* electrical conductivity and *(ii)* thermal conductivity on the basis of classical electron theory and hence obtain Wiedemann-Franz law. 5

(b) Find the expression for density of states and hence Fermi energy of a metal. 9

6. Prove that Fermi energy at room temperature is given by

$$E_F \quad E_{F(0)} \ 1 \ \frac{2}{12} \ \frac{K_B T}{E_{F(0)}}^{2}$$

14

UNIT—IV

7. *(a)* Explain the difference between the Schottky and Frenkel defects. Show that equilibrium concentration (Schottky defect), $n \quad Ne^{\,E_v/2K_BT}$, $N \quad N$ in ionic crystals. 2+5=7

(b) What are the edge and screw dislocations? Calculate the elastic strain energy of screw dislocation. 2+5=7

8. *(a)* Explain the mechanism of diffusion through solids. Derive the Fick's law for macroscopic diffusion in solids. 2+8=10

(b) Describe how dislocations promote the growth of crystals. 4

UNIT—V

9. *(a)* What are liquid crystals? Write in short the applications of liquid crystals. 2+4=6

(b) What are thermotropic and lyotropic liquid crystals? Explain the Nematic and Sematic phases of thermotropic liquid crystals. 3+5=8

10. *(a)* Describe the properties of nanomaterials. Explain the bottom up and top down approach for synthesizing nanoparticles. 3+4=7

(b) What are the characterization tools for measuring nanostructures? Discuss the XRD technique to calculate the size of a nanoparticle. 3+4=7

OPTION—C

Course No. : PHYCC–304 (C)

(ADVANCE QUANTUM FIELD THEORY—I)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. State and prove Noether's theorem. Show that conservation of momentum is a consequence of the invariance of the Lagrangian under translation in space. 2+7+5=14

2. What are gauge transformations? Show that local gauge invariance of the Lagrangian for complex scalar field leads to the introduction of the electromagnetic field. 2+12=14

UNIT—II

3. Quantize the scalar field by imposing equal time commutation relations. 14

4. Discuss the quantization of the Dirac field. 14

UNIT—III

5. Discuss Lorentz gauge and Coulomb gauge. Quantize the electromagnetic field in the Lorentz gauge. 4+10=14

6. Discuss Gupta-Bleuler formalism in the theory of quantized electromagnetic field. 14

UNIT—IV

7. *(a)* Define S matrix. Show that S matrix is unitary. Define time ordering and normal ordering. 7

(b) State and prove Wick's theorem. 7

8. For the process

$$e\ (p_1)\quad e\ (p_2)\quad e\ (p_1)\quad e\ (p_2)$$

calculate $S^{(2)}$ using Wick's theorem. 14

UNIT—V

9. *(a)* Discuss Feynman rules. Draw Feynman diagram at lowest order at which scalar-scalar scattering takes place. 10

(b) Write a note on virtual particles. 4

10. Define Feynman amplitude. For an $e\ e \quad e\ e$ scattering process, obtain the scattering cross-section using lowest order diagrams. 4+10=14

OPTION—D

Course No. : PHYCC–304 (D)

(NON-LINEAR OPTICS AND LASER SPECTROSCOPY—I)

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. Deduce the equation for non-linear susceptibility describing second harmonic generation (SHG) of a classical anharmonic oscillator in centrosymmetric medium. 14

2. Show that the use of contracted matrix notation (d_{il}) reduces the number of independent elements required to describe $\chi^{(2)}_{ijk}$ to 10 when Kleinman symmetry is valid. 14

UNIT—II

3. *(a)* Solve coupled wave equation for second harmonic generation (SHG) in 'low depletion approximation' and obtain equation for second harmonic intensity. 10

(b) Define coherent length with expression. 4

4. *(a)* Considering sum frequency generation, show that phase matching is not possible in the region of normal dispersion. 4

(b) What are type I and type II phase matching? Discuss the methods employed to achieve phase matching in uniaxial crystals. 4+6=10

UNIT—III

5. What is self-phase modulation? Deduce the non-linear Schrödinger equation for an optical pulse propagation in dispersive, non-linear medium. 4+10=14

6. What is optical phase conjugation? Show that degenerate four-wave mixing (DFWM) can lead to conjugate of an incident wave. 4+10=14

UNIT—IV

7. *(a)* Analyze electrooptic effect in KDP crystal. 5

(b) Describe construction of electrooptic modulator with KDP crystal and explain the changes that occur on a light beam propagating through it. 5+4=9

8. *(a)* Give a qualitative description on the mechanism of photorefractive effect with illustration. 10

(b) Write the photorefractive equations of Kukhtarev et al. 4

UNIT—V

9. Find the steady-state solution to density matrix equation of motion for closed two-level system in presence of monochromatic field. Also calculate the polarization and derive the expression for susceptibility ( ). 9+5=14

10. Give the solution to Schrödinger equation for a two-level atom, for atom initially in the ground state. 14

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