UG/II/PHS/H/IV/16(Old)

2016

PHYSICS

[Honours]

PAPER – IV

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

[OLD SYLLABUS]

GROUP – A

Answer any **two** questions : 15 × 2

1. (*a*) State the principle of virtual work of a system of '*n*' particles under holonomic constraints and establish d'Alembert's principle. 2 + 3

(*b*) If a Lagrangian does not contain time explicitly, show that the total energy is conserved. 4

(*c*) Use Lagrange's equation to calculate the frequencies of vibration of a double pendulum formed by two equal masses and equal lengths of string. 2 + 4

2. (*a*) Obtain an expression for rotational energy levels of a diatomic molecule and the frequency of rotational spectra. Show that the energy levels are not equally spaced but the frequencies are eqally spaced. 4 + 1

(*b*) "X-ray production is the inverse of photo-electric effect." Justify. 2

(*c*) What is betatron ? Derive the betatron condition for successful acceleration of electrons. 1 + 4

(*d*) Deduce the expression for the energy gained by an electron in a betatron. 3

3. (*a*) What do you mean by the Quencing of G-M counter ? Why is it essential ? How is it achieved internally ? 4

(*b*) What is intermodal dispersion and cross talk in fiber optic communication ? How it can be minimized ? 4

(*c*) Write down briefly with energy level diagram the working principle of a He-Ne laser. 4

(*d*) Why population inversion is not possible with only two atomic levels ? 3

4. (*a*) What is Zeeman effect ? Explain why normal Zeeman effect occurs only in atoms with even number of electrons. 2 + 2

(*b*) Draw a neat diagram to illustrate the Zeeman splitting of D_1 and D_2 lines of sodium. 3

(*c*) Develop the semi-empirical mass formula discussing the physical basis of each term. 5

(*d*) Evaluate the temperature at which there is one percent probability that a state with an energy 0·5eV above the Fermi-energy will be occupied by an electron. 3

GROUP – B

Answer any **five** questions : 8 × 5

5. (*a*) What is canonical transformation ? Show that the transformation

$$Q = \tan^{-1}\frac{q}{p},\ P = \frac{1}{2}p^2 \sec^2 q$$

is a canonical transformation. Find also the corresponding generating function. 2 + 2 + 2

(*b*) What are cyclic coordinates ? Show that the momenta conjugate to cyclic coordinates are conserved. 2

6. (*a*) What is the binding energy and packing fraction ? Draw the binding energy per nucleon *vs.* mass number curve and explain the stability of nucleus. 1 + 1 + 2 + 1

(*b*) Calculate binding fraction 16_0. Given $M(^1H) = 1{\cdot}007825\ u$, $M(^1n) = 1{\cdot}008665\ u$, $M(16_0) = 15{\cdot}994915\ u$ and $1u = 931{\cdot}5$ MeV. 3

7. What is standing wave in optical resonator ? Find out the expression for frequency separation between two consecutive modes. Calculate the number of modes in the wavelength range 2 nm centred about the wavelength 50 nm. The length of the optical resonator is 30 cm. 2 + 4 + 2

8. (*a*) What do you mean by acceptance angle and numerical aperture of a step index fiber ? Find their expressions. 1 + 1 + 3

(*b*) Find the numerical aperature and the acceptance angle of a step index fiber when refractive index of the core is 1·51 and that of material used for cladding is 1·47. 3

9. (*a*) What do you mean by nuclear fusion ? Write down the C-N cycle for the energy generation in stars are also estimate the nuclear energy released in each cycle. 1 + 2 + 1

(*b*) Discuss the variation of cosmic ray intensity with latitude and explain its cause. 4

10. (*a*) Imagine a crystalline solid consisting of a large number of atoms which vibrate around their mean positions. Construct the partition function of the system. Hence calculate the mean energy $< E >$ and specific heat at constant volume C_v. Find out how C_v varies in the high and low temperature limits. 2 + 2 + 2

(*b*) Find out how 4 fermions can be distributed in 5 degenerate microstates. 2

11. (*a*) Describe the working principle of Bainbridge's mass spectrograph. How is the nuclear mass determined using the spectrograph. 6

(*b*) What is the origin of γ-decay ? 2

12. (*a*) What is Raman effect ? Why are stoke's lines brighter than antistoke's lines ? 2 + 2

(*Continued*)

(*b*) Consider the following reactions. Consider the conservation laws and state why they are allowed or why they are not. 4

(*i*) $p + e^- \rightarrow n + \nu_e$ allowed

(*ii*) $p + p^- \rightarrow \Pi^+ + e^-$ not allowed

(*iii*) $e^+ + e^- \rightarrow p^+ + p^-$ not allowed

(*iv*) $\Pi^- + p \rightarrow n + \Pi^o$ allowed

GROUP – C

Answer any **five** questions : 4×5

13. Suppose F and G are two arbitrary functions of Canonical variables p's and q's prove that the Poisson bracket of them is invariant under canonical transformation. 4

14. (*a*) What is ionization chamber ? 1

(*b*) What is Pirani gauge ? How does it work ? 1 +2

15. Deduce Boltzman's entropy probability relation

$$S = k \log_e \Omega(E)$$

where S is entropy, $\Omega(E)$ is the number of microstates in the energy interval between E and $E + \delta E$ and k is a constant. 4

16. Explain Giger-Nuttal law relating to the range of particle is α-ray disintegration and half-life period. 4

17. Discuss the success and limitations of the single particle shell model. 4

18. Show that average energy of a conduction electron in a metal at $T = 0$ is $\langle F_0 \rangle = \frac{3}{5} E_{F_0}$, where E_{F_0} is the Fermi energy at $T = 0$. 4

19. Why homonuclear molecules (H_2, N_2, O_2 etc) do not show rotational spectra ? 4

20. What is population inversion ? How is the population inversion achieved in He-Ne Laser ? 2 + 2
