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UG/II/PHS/H/IV/17(Old)

2017

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

1. Answer any *two* questions : 15 × 2

(a) Discuss holonomic and non-holonomic constraints with proper example. $1\frac{1}{2} + 1\frac{1}{2}$

(Turn Over)

(2)

(b) Show that the transformation

$$Q = \text{Ln}[1 + \sqrt{q} \cos(p)] \quad \text{and}$$

$$P = 2\sqrt{q} \sin(p)[1 + \sqrt{q} \cos(p)]$$

is a canonical transformation. 5

(c) Calculate the generating function of third kind $F_3(Q, P)$ that generates the above transformation. 7

2. (a) Consider the nuclear reaction $x + X \rightarrow y + Y$, where the target nucleus X at rest and the product nucleus Y recoils at an angle θ w.r.t. direction of the projectile (x). Show that the threshold energy for endo-ergic process is given by

$$E_{\text{th}} = -Q \left(1 + \frac{M_x}{M_X} \right),$$

where M_x is the mass of projectile nucleus, M_X is the mass of the target nucleus and Q is the $-Q$ -value of the reaction (Small compared to M_x). 5

- (b) Deduce the condition for spontaneous symmetric fission of a nucleus of mass no. A and atomic no. z . Does it may occur in nature ? Justify your answer ? 5 + 5
3. (a) Establish the statistical definition of temperature, pressure, entropy and chemical potential. 8
- (b) Show that the lines in pure rotational spectrum of diatomic molecules are equispaced. 3
- (c) Deduce the expression for Einstein's A and B co-efficients. 4
4. (a) Write down the principle of operation of a cloud chamber. 3
- (b) Apply statistical mechanics to explain the Einstein's theory of specific heat of metal. 5
- (c) Explain in brief the origin of anomalous Zeeman effect. Find the maximum potential energy associated with the magnetic dipole moment of a $4p$ electron in an external magnetic field of 0.25 Wb/m^2 . 5 + 2

GROUP – B

Answer any five questions : 8 × 5

5. Give an account of the principle of working of a fixed frequency cyclotron. Deduce an expression for the energy of the accelerated particles in terms of equivalent voltage. 8

6. (a) Define ensemble. Show that for a two dimensional free electron gas the number of electrons per units area is given by

$$n = \frac{4\pi mkT}{h^2} \text{Ln} \left[e^{EF/kT} + 1 \right]$$

Symbols have their usual meaning. 2+2

- (b) What is an optical resonator? Discuss the role played by it in a laser system. 1+3

7. (a) What do you mean by weight diagram? Draw the baryon octet and meson octet properly mentioning the quantum numbers. 4

- (b) A particle of mass m moves inside a bowl. If

the surface of the bowl is given by the equation

$$z = \frac{1}{2}a(x^2 + y^2)$$

where a is a constant, then find the Hamiltonian of the particle. 4

8. (a) What do you mean by L-S coupling? If the first member of Balmer series of H-atom is 6563 Å, then calculate the same for deuterium. 4
- (b) Discuss in brief the Yukawa theory of Nuclear force. 4
9. (a) A cavity kept at 4000 K has a circular aperture 5.0 mm diameter. Calculate (i) the power radiated in the visible region (0.4 – 0.7 μm) from the aperture and (ii) the no. of photon emitted per second in the visible region. 4
- (b) Show that all the particles of a bosonic-gas tends to condense into the zero energy state at absolute zero temperature. 4

10. (a) What do you mean by cosmic ray shower ? Discuss the different mechanism involved for the production of air shower. 1 + 3
- (b) What is a cyclic co-ordinate ? Show that if q_k in a cyclic co-ordinate in Lagrangian, it will also be a cyclic co-ordinate in Hamiltonian. 2 + 2
11. (a) Discuss the fusion cycle responsible for energy generation in young stars. Calculate also the energy released in each cycle. 4
- (b) Describe the working principle of a modern rotary oil pump for production of high vacuum. Write down the advantages of a diffusion pump. 3 + 1
12. (a) What do you mean by bandwidth and channel capacity of an optical fibre ? The core diameter of a multimode fibre is $70 \mu\text{m}$ and the relative refractive index difference is of 1.5 %. It operates at a wavelength of $0.85 \mu\text{m}$. If the refractive index of the fibre is 1.46, calculate
- (i) The V-number of the fibre

(ii) The total no. of guided modes in the fibre. 2 + 2

- (b) If particle of mass m is constrained to move on an ellipse in a vertical plane, parametrized by $x = a \cos\theta$, $y = b \sin\theta$, $a \neq b$ and $a, b > 0$. The positive y -direction is the upward vertical. The particle is connected to the origin by a spring and subject to gravity. Write down the Lagrangian of the system and show that the Lagrange's equation of motion becomes

$$m(a^2 \sin^2 \theta + b^2 \cos^2 \theta) \ddot{\theta} = (a^2 - b^2)(K - m\dot{\theta}^2) \sin \theta \cos \theta - mgb \cos \theta.$$

K being the spring constant. 4

GROUP - C

Answer any five questions : 4 × 5

13. The Hamiltonian for a system has the form

$$H = \frac{1}{2} \left(\frac{1}{q^2 + p^2 q^4} \right) \quad 4$$

Find the equation of motion for q . Also find a canonical transformation that reduces H to the form of a harmonic oscillator. 4

14. What do you mean by Holography ? Write down the principle of operation of Holography. 4

15. Explain the reason behind the decrease in binding energy per nucleon at the lower end and upper end of the binding energy curve. 4

16. What do you mean by recovery time of a GM counter ? Deduce the expression for the resolving time of the GM counter. 1 + 3

17. Discuss pictorially the different types of vibration of CO_2 molecule. Which of them are microwave active and why ? 4

18. Construct the expression for thermodynamic probability of BE-statistic. Hence deduce the form of BE-distribution function. 1 + 3

19. Explain the drawbacks of the liquid drop model of nucleus. Discuss the origin of east-west asymmetry of the cosmic ray intensity. 2 + 2

(9)

20. The Hamiltonian of a simple pendulum consisting of a mass m attached to a massless string at length l is

$$H = \frac{P_{\theta}^2}{2ml^2} + mgl(1 - \cos\theta).$$

Calculate the value of $\frac{dL}{dt}$ where L denotes the Lagrangian of the system.

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