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

2017

PHYSICS

[Honours]

PAPER – IV

Full Marks : 90

Time : 4 hours

*The figures in the right hand margin indicate marks*

[NEW SYLLABUS]

GROUP – A

Answer any two questions : 15 × 2

1. (a) Write down the D'Alembert's Principle and hence deduce the Lagranges equation of motion for a conservative system. 2 + 4
- (b) What is the advantage of Lagrangian formulation over the newtonian formulation ? 2

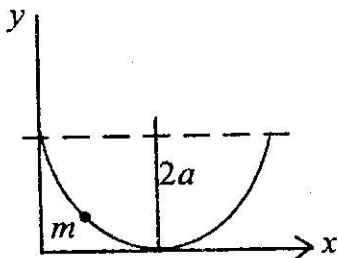
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(c) Show that

$$q \rightarrow Q = \log \left( \frac{\sin hq}{p} \right), \quad p \rightarrow P = p \frac{\cos hq}{\sin hq}$$

is a canonical transformation. If the original Hamiltonian is  $H = \frac{1}{2} p^2$ , find the Hamiltonian in the new co-ordinates. 2 + 2

(d) A bead of mass  $m$  slides without friction on a frictionless wire in the shape of a cycloid with equation  $x = a(\theta - \sin\theta)$ ,  $y = a(1 + \cos\theta)$  where  $0 \leq \theta \leq 2\pi$ . Find the Lagrangian and Lagrange's equation of motion. 3



2. (a) Deduce the quantization condition for the electron orbits in atom according to the Bohr-Sommerfeld model. 3

- (b) Explain the origin of fine structure in Hydrogen spectra. 2
- (c) Deduce the expression for orbital magnetic moment of an electron and hence explain the concept of space quantization. 4
- (d) In the lowest  $^4P$  term of Nitrogen the  $^4P_{5/2}$  and  $^4P_{1/2}$  levels are separated by 0.01 eV. Estimate the field required to exhibit the Paschen-Back effect in this term and comment on its realizability. 3
- (e) Rotational spectral lines are examined in the hydrogen-deuterium molecule. If the internuclear distance is 0.075 nm, estimate the wave length of radiation arising from the lowest levels. In which part of the electromagnetic spectrum does this lie? 2 + 1
3. (a) What do you mean by mass parabola? Deduce the equation for mass parabola. How does it explain the stability of a nucleus against  $\beta^+$  and  $\beta^-$  decay? 1 + 2 + 2

- (b) What do you mean by transient and secular equilibrium? Show that under secular equilibrium the rate of decay of daughter nuclei become just equal to its rate of production from the parent nuclei.  $2 + 2 + 2$
- (c) Explain the nuclear magic numbers as suggested theoretically using simple harmonic potential model among the nucleons. Why does they differ from the actual magic numbers?  $3 + 1$
4. (a) Deduce the expression for pinch-off voltage in junction field effect transistor.  $4$
- (b) Explain the principle operation of D-MOS. Discuss why N-MOS is superior over P-MOS.  $3 + 1$
- (c) Calculate the efficiency of a class-B push-pull amplifier.  $4$
- (d) Give a quantitative measure of the Miller effect in a two stage RC coupled amplifier

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with  $h_{ie} = 1\text{k}\Omega$   $h_{fe} = 50$  and  $R_L = 10.3\text{ k}\Omega$ .  
Also calculate the gain-band width product  
for such an amplifier. [Given the upper half  
power frequency = 2.5 MHz.] 2 + 1

### GROUP – B

Answer any five questions : 8 × 5

5. (a) Explain the Dirac theory of pair-production. 3  
(b) Find out the eigen frequencies of small  
oscillation of a pair of coupled pendulum  
(identical). 5
6. (a) Discuss the various type of  $\alpha$  particle  
spectra with the proper explanation of their  
origin. 4  
(b) Show that a rigid rotator in the ground state  
is not rotating. What is the average period  
of rotation of HCl molecule if it is in the  
 $J = 1$  state ( $J$  being the rotational quantum  
number). 2 + 2

7. (a) Obtain the Lagrangian and equation of motion for a mass ' $m$ ' suspended to a spring of force constant ' $k$ ' and allowed to swing vertically. 4
- (b) What do you mean by spatial coherence? Explain the principle of working of a semiconductor laser. 2 + 2
8. (a) Draw the circuit diagram of a free-running multivibrator and hence calculate the frequency of oscillation produced by it. 2 + 3
- (b) What do you mean by the  $\alpha$ -particle model of a nucleus? Calculate the ground state spin parity of  $O^{17}$ ,  $Al^{27}$ ,  $K^{39}$  and  $Zn^{67}$ . 1 + 2
9. (a) Find out the expression for coulomb energy term and asymmetry energy term of nucleus. 2 + 2
- (b) Explain what is meant by the term quantum defect, used in the description of alkali spectra. The sodium atom has atomic

number  $z = 11$ . Find the quantum defect of the ground level of Na, given that the first ionization potential is 5.14 eV. 2 + 2

10. (a) A particles of mass  $m$  moves inside a bowl. If the surface of the bowl in given by the equation

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

where  $\alpha$  is constant, then find the Hamiltonian of the particle. 4

- (b) Draw a master-slave JK flipflop system. Explain its operation. What do you mean by edge triggering ? 1 + 2 + 1

11. (a) State the differences between fluorescence and Raman scattering. Does a homonuclear diatomic molecule is amenable to Raman spectroscopy ? 2 + 1

- (b) What do you mean by binding fraction and packing fraction ? Show that they are complementary to each other. 2 + 3

12. (a) Draw the circuit diagram of a RC-phase shift oscillator. Find out the expression for the frequency of oscillation in this oscillator. Find also the condition to achieve the sustained oscillation. 2 + 3 + 1
- (b) A typical diatomic molecule rotates at a rate of  $10^{11}$  rev  $S^{-1}$ . How many vibration does it undergo during one revolution? (Given spring constant  $k = 1000$  N.m $^{-1}$  and reduced mass  $\mu_{red} = 10\mu$ ). 2

GROUP – C

Answer any five questions : 4 × 5

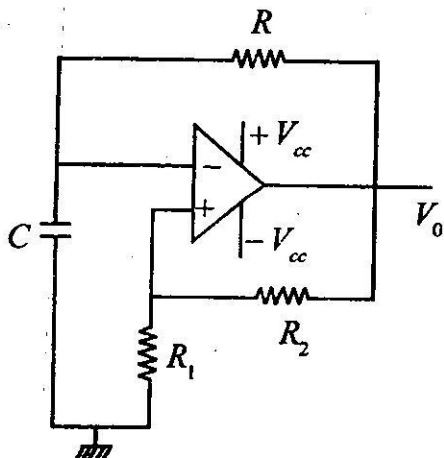
13. Illustrate the Gamow's explanation of Geiger-Nuttal law. What do you mean by the internal conversion process? 3 + 1
14. Define parity and isospin of a nucleus. Explain whether the Raman effect in an elastic or inelastic process. 3 + 1
15. Show that Poisson's Bracket remains invariant



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under canonical transformation. What do you mean by slew rate of an OP-AMP ? 3 + 1

16. A square wave generator using OP-AMP is shown in the following figure



Calculate the time period of output signal for  $C = 0.1 \mu\text{F}$ ,  $R = 5 \text{ k}\Omega$ ,  $R_1 = 30 \text{ k}\Omega$  and  $R_2 = 15 \text{ k}\Omega$ .

show that the total degeneracy of the energy level  $E_n$  of hydrogen atom is  $2n^2$ . 2 + 2

17. Discuss the effect of negative feedback on the frequency distortion in an amplifier. Deduce the selection rules for nuclear transition involving  $\beta$ -decay. 4

18. Write down the Euler's equation. A wide container with a small orifice in the bottom is filled with water and kerosene. If the water column measures 60 cm and kerosene 40 cm, calculate the efflux velocity of water. Specific gravity of water is 1.0 and that of kerosene as 0.8 and neglect viscosity. 4
19. Explain the Hund's rule. Apply this rule to find out the ground state of system with two non-equivalent  $p$ -electrons. 4
20. What do you mean by mirror nuclei? In case of fine structure of atom show that doublet separation increases with the increase in atomic no. Write down the wave function of helium atom for  $2^3_s$  and  $2^1S$  states. 1 + 2 + 1
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