Reg. No. :.....

Entrance Examination for M.Phil. Admission in Physics, April 2018

University of Calicut

Department of Physics

Maximum Marks: 100 Duration: 2 hours.

Part A

Answer All Questions. No negative marks. Each question carries 2 marks.
Circle the most appropriate choice **in the given answer sheet**.

1. $xdx + ydy + zdz = 0$ is the first order differential equation of
   A. Sphere B. Right circular cone C. Cylinder D. Ellipsoid

2. $\int_c z^2 e^{\frac{1}{z}} dz = ?$ where c is $\mid z \mid = 1$
   A. $i3\pi$ B. $-i3\pi$ C. $\frac{i\pi}{3}$ D. None of these

3. The condition for a matrix

$$\mathbf{M} = \begin{pmatrix} \alpha + i\gamma & -\beta + i\delta \\ \beta + i\delta & \alpha - i\gamma \end{pmatrix}$$

   to be a unitary matrix
   A. $\alpha^2 + \beta^2 = \gamma^2 + \delta^2$ B. $\alpha^2 + \beta^2 = -(\gamma^2 + \delta^2)$ C. $\alpha^2 + \beta^2 + \gamma^2 + \delta^2 = 1$
   D. $\alpha^2 + \beta^2 = 2(\gamma^2 + \delta^2)$

4. If

$$f(x) = \begin{cases} 0 & \text{for x<3} \\ x - 3 & \text{for x}\geq 3 \end{cases}$$

   then the Laplace transform of $f(x)$ is
   A. $s^{-2}e^{3s}$ B. $s^2 e^{-3s}$ C. s^{-2} D. $s^{-2}e^{-3s}$

5. A particle of mass m slides under gravity on a smooth wire of shape Z=coshx, where X-axis is horizontal and the Z-axis is vertically upwards. The Lagrangian of the motion of the particle
   A. $\frac{1}{2}m\dot{x}^2 \cosh^2 x - mg\cosh x$ B. $\frac{1}{2}m\dot{x}^2 \sinh^2 x - mg\cosh x$ C. $\frac{1}{2}m\dot{x}^2 \sinh^2 x + mg\cosh x$ D. $\frac{1}{2}m\dot{x}^2 \cosh^2 x + mg\cosh x$

6. Consider the Lagrangian of the system is given by $L(q,\dot{q},t) = \frac{1}{2}G(q,t)\dot{q}^2 + F(q,t)\dot{q} - V(q,t)$. The corresponding Hamiltonian is
   A. $\frac{1}{2}G(q,t)\dot{q}^2$ B. $\frac{1}{2}G(q,t)\dot{q}^2 - F(q,t)\dot{q} + V(q,t)$ C. $\frac{1}{2}G(q,t)\dot{q}^2 + V(q,t)$
   D. $\frac{1}{2}G(q,t)\dot{q}^2 - F(q,t)\dot{q}$

7. Consider the following statements and identify the CORRECT ONE. (I) The Hamiltonian of the system is an integral of motion if potential energy doesn't depend on time. (II) Hamiltonian of the system is equal to the total energy, if the PE doesn't depend on generalized velocity. (III) Law of conservation of energy holds good when PE is the function of position only.
A. I,II and III B. I and II only C. I and III only D. I only

8. It is given that the field is $\vec{E}(z,t) = 50\cos(\omega t - \beta z)\hat{i}$ V/m in free space. What is the average power crossing a circular area of radius 2.5m in the plane z = constant (Given that $\sqrt{\frac{\mu_0}{\varepsilon_0}} = 120\pi\Omega$)
A. 56.2 W B. 12.6 W C. 65.2 W D. 24.6 W

9. An electric dipole is placed in non- uniform electric field. It experiences
A. Only a force but no torque B. Only a torque but no force C. No torque and no net force D. Both a torque and a net force

10. A particle of mass, m moves freely inside a potential well of length, a. The initial wave function at t=0 is:$\psi(x,0) = \frac{A}{\sqrt{a}}\sin(\frac{\pi x}{a}) + \sqrt{\frac{3}{5a}}\sin(\frac{3\pi x}{a}) + \frac{1}{\sqrt{5a}}\sin(\frac{5\pi x}{a})$. Then, average energy of the system is:
A. $\frac{29\pi^2\hbar^2}{10ma^2}$ B. $\frac{19\pi^2\hbar^2}{10ma^2}$ C. $\frac{17\pi^2\hbar^2}{10ma^2}$ D. $\frac{21\pi^2\hbar^2}{10ma^2}$

11. Consider the two wave functions $\psi_1(x) = (\frac{2}{a^2\pi})^{1/4}exp(\frac{-x^2}{a^2})$, $\psi_2(x) = (\frac{32}{a^2\pi})^{1/4}xexp(\frac{-x^2}{a^2})$. Then the value of $<\psi_2|\hat{P}_x|\psi_1>$ is
A. $\frac{\hbar}{a}$ B. 0 C. $i\hbar$ D. $\frac{\hbar}{2a}$

12. The value of $\left[e^{\frac{2\pi ix}{a}}, e^{\frac{iap}{\hbar}}\right]$ where a is a real number is:
A. 0 B. $e^{\frac{2\pi ix}{a}}e^{\frac{iap}{\hbar}}(2\pi i)$ C. $\pi i(e^{\frac{2\pi ix}{a}+iap\hbar})$ D. 1

13. The pressure for a noninteracting Fermi gas with internal energy U at temperature T is
A. P=2/3(U/V) B. P=3/2(U/V) C. P=5/3(U/V) D. P=1/2(U/V)

14. For an energy state E of a photon gas, the density of states is proportional to
A. $E^{1/2}$ B. E C. E^2 D. $E^{3/2}$

15. The decimal equivalent of the hexadecimal number E5 is
A. 279 B. 229 C. 427 D. 3000

16. If a zener diode (V_Z=5V and I_Z=10mA) is connected in series with a resistance and 20V is applied across the combination, then the maximum resistance one can use without spoiling zener action is
A. 20 kΩ B. 15 kΩ C. 10 kΩ D. 1.5 kΩ

17. A single electron orbits a stationary nucleus of charge +Ze. It requires 47.2 eV to excite the electron from the second Bohr orbit to the third orbit. The value of Z is:
A. 5 B. 6 C. 4 D. 3

18. Which one of the following molecules does not exhibit a rotational spectrum?
A. H_2 B. CO C. HCl D. HBr

19. A nucleus with A=235 splits into two nuclei whose mass numbers are in ratio 2:1, the radii of the two nuclei(in fm) are:(Take R_0=1.4fm)
A. 5.89, 6.55 B. 5.99, 7.55 C. 6.89, 7.66 D. 1.23, 3.12

20. The asymmetry term in the Weizsacker semi empirical mass formula is because of:
A. non-spherical shape of the nucleus B. non-zero spin of the nucleus C. unequal number of protons and neutrons inside the nucleus D. odd number of protons inside the nucleus

21. An anti-neutrino has:
A. Positive helicity and zero spin and linear momentum. B. Negative helicity and its spin and linear momentum are in opposite directions. C. Negative helicity and its spin and linear momentum are in same directions. D. Positive helicity and its spin along that of its linear momentum.

22. The Miller indices of a plane are (3,2,6). The intercept made by the plane on the three crystallographic axes are:
A. (2a,3b,c) B. (a,b,c) C. (a,2b,3c) D. None of these

23. The energy required to create a lattice vacancy in a crystal is equal to 1 eV. The ratio of the number densities of vacancies n(1200 K)/n(300 K) when the crystal is at equilibrium at 1200 K and 300 K, respectively, is approximately
A. exp(−30) B. exp(−15) C. exp(15) D. exp(30)

24. Schottky defect is:
A. missing of an atom or ion from normal lattice site B. shifting of position of an atom or ion in normal lattice C. bending of atom or ion D. None of the above

25. Energy production in the interior of Sun is through
A. Proton-Proton cycle B. Carbon-Nitrogen-Oxygen Cycle C. Both A and B
D. None of these

Part B

Answer any 10 questions. Each question carries 5 marks.

1. What are superconductors ?. Explain Type 1 and Type 2 superconductors and Meissner effect.

2. For a system
$$\ln Z = \frac{12\pi^5 k^3 V T^3}{60 h^3 c^3}$$

where Z is partition function; V volume, and T is temperature. Find the pressure, and energy density for the system.

3. Suppose ^{73}Br has a ground state of $J^P = (1/2)^-$ and the first two excited states are at $J^P = (5/2)^-$ (with an energy of 26.92 keV) and $J^P = (3/2)^-$ (with an energy of 178.1 keV). (a) Assuming the extreme single particle shell model, give the most probable shell occupancies for the nucleus in the ground state and first excited state. (b) Give two reasonable configurations for the second excited state. How could you distinguish these two cases using gamma spectroscopy? (c) List the allowed gamma transitions between the three states. (i.e., M2 or ...) (d) Estimate the live time of the $(3/2)^-$ state.

4. In consideration of the conservation laws, state whether the following reactions are allowed or forbidden, and for which interactions. Explain your reasoning.
(a) $\pi^0 \to e^+ + e^-$ (b) $\Xi^- \to \Lambda + \pi^-$ (c) $\pi^+ + p \to K^+ + \Sigma^+$ (d) $\pi^- + p \to K^- + \Sigma^+$

5. A coconut is dropped from a height of 60 m. One second later a second coconut is thrown down with an initial velocity. Both coconuts reach the ground at the same time. What was the initial velocity of the second coconut ?

6. Use the Hamilton–Jacobi method for solving the Kepler problem in a central force field of the form $V(r) = -K/r$.

7. State and prove the Fourier convolution theorem.

8. Obtain the orthogonality relation for the Legendre functions.

9. Obtain the Clebsch-Gordon coefficients for the coupling of two spin half particles.

10. Obtain the Lagrangian density, conjugate momentum and Hamiltonian of Schrödinger fields.

11. Show that the Lorentz gauge condition $\nabla.\vec{A} + \mu\epsilon\frac{\partial V}{\partial t} = 0$ is another way of stating the continuity condition.

12. Two sets of input signals to a differential amplifier, (a) $V_1 = +50\mu V$ and $V_2 = -50\mu V$ and (b) $V_1 = +1050\mu V$ and $V_2 = +950\mu V$. If the CMRR is 100, Calculate the percentage difference in output voltage obtained for the two sets of input signals.

13. CO_2 has a fundamental vibrational mode at 662 cm^{-1}. Calculate the postion of Raman line when irradiated with 541 nm of Hg spectra.

14. Discuss Hall effect and its experimental importance.

15. Show that 2-dimensional Bose- Einstein condensation is not possible for a free particle.