

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA, VADODARA

Ph. D. ENTRANCE TEST (PET) – 7<sup>th</sup> August 2022

Signature of Invigilator

Roll.  
No.

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Paper - II  
Physical Sciences (22/29)

Maximum Marks: 50

No. Of Printed Pages: 8

Instruction for the Candidate:

1. This paper consists of **FIFTY (50)** multiple choice type questions. Each Question carries **ONE (1)** mark.
2. There is no Negative Marking for Wrong Answer.
3. A separate OMR Answer Sheet has been provided to answer questions. Your answers will be evaluated based on your response in the OMR Sheet only. No credit will be given for any answering made in question booklet.
4. Defective question booklet or OMR if noticed may immediately replace by the concerned invigilator.
5. Write roll number, subject code, booklet type, category and other information correctly in the OMR Sheet else your OMR Sheet will not be evaluated by machine.
6. Select most appropriate answer to the question and darken appropriate oval on the OMR answer sheet, with black / blue ball pen only. **DO NOT USE PENCIL** for darkening. In case of over writing on any answer, the same will be treated as invalid. Each question has exactly one correct answer and has four alternative responses (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.  
**Example:** (A) ● (B) ● (C) ● (D) ● where (B) is correct response.
7. Rough Work is to be done in the end of this booklet.
8. If you write your Name, Roll Number, Phone Number or put any mark on any part of the OMR Answer Sheet, except for the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, such as change of response by scratching or using white fluid, you will render yourself liable to disqualification.
9. Calculators, Log tables any other calculating devices, mobiles, slide rule, text manuals etc are **NOT** allowed in the examination hall. If any of above is seized from the candidates during examination time; he/ she will be immediately debarred from the examination and corresponding disciplinary action will be initiated by the Center Supervisor as deemed fit.
10. **DO NOT FOLD** or **TEAR** OMR Answer sheet as machine will not be able to recognize torn or folded OMR Answer sheet.
11. **You have to return the OMR Answer Sheet to the invigilator at the end of the examination compulsorily** and must not carry it with you outside the Examination Hall. You are however, allowed to carry original question booklet on conclusion of examination.



**Paper - II**  
**Physical Sciences (22/29)**

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- 01) A nonsingular matrix possesses
- A) unique inverse
  - B) two inverses
  - C) no inverse
  - D) many inverses
- 02) If  $P_n(x)$  is Legendre Polynomial of order  $n$ , the  $P_n'(x)$  is equal to
- A)  $(-1)^{n+1} P_n'(x)$
  - B)  $(-1)^n P_n'(x)$
  - C)  $(-1)^n P_n(x)$
  - D)  $P_n''(x)$
- 03) The number of non-vanishing terms in the Fourier series of  $\cos^2(\theta)$  in the interval (-

- 16) A wire with circular cross-section is made up of copper, which has about  $8.5 \times 10^{28}$  electrons/m<sup>3</sup>. This wire carries a current of 7.7A. If the drift velocity of electrons in this wire is 0.5mm/s, what is the diameter of the copper wire?  
 A) 0.4mm  
 B) 0.8mm  
 C) 1.2mm  
 D) 1.6mm
- 17) Un-polarized Electromagnetic radiation of wavelength 632nm travels from dielectric medium of refractive index 1.33 to another dielectric medium. The incident angle at which the reflected light will be completely plane polarized is 49°. The refractive index of the second medium is  
 A) 1.47  
 B) 1.50  
 C) 1.53  
 D) 1.61
- 18) Electron plasma is formed in a metal-dielectric interface with number density  $0.61 \times 10^{28}$ /m<sup>3</sup>. Find the corresponding (a) plasma frequency and (b) the energy of the plasmon. A beam of broadband light is incident on the plasma at an angle of 45°. (c) Find the wavelength that will lead to plasma oscillations (Given:  $m_e = 9.1 \times 10^{-31}$ kg,  $\epsilon_0 = 8.85 \times 10^{-12}$ F/m).  
 A)  $4.4 \times 10^{15}$  rad/s, 2.90eV, 605nm  
 B)  $7.00 \times 10^{14}$  rad/s, 0.46eV, 3818nm  
 C)  $4.4 \times 10^{15}$  rad/s, 2.90eV, 428nm  
 D)  $7.00 \times 10^{14}$  rad/s, 0.46eV, 3051nm
- 19) Let  $|n\rangle$  and  $|p\rangle$  denote the isospin states with  $T_3 = 1/2$ ,  $T_3 = 1/2$  and  $T_3 = 1/2$ ,  $T_3 = -1/2$  of a nucleon respectively. Which one of the following two nucleon states has  $T_3 = 0$  and  $T = 0$   
 A)  $\frac{1}{\sqrt{2}}(|nn\rangle + |pp\rangle)$   
 B)  $\frac{1}{\sqrt{2}}(|nn\rangle - |pp\rangle)$   
 C)  $\frac{1}{\sqrt{2}}(|np\rangle + |pn\rangle)$   
 D)  $\frac{1}{\sqrt{2}}(|np\rangle - |pn\rangle)$
- 20) Calculate the phase velocity of a wave represented by;  $y(x) = 2.1 \sin [1.4 \times 10^{14} x - 3.2 \times 10^7 t]$   
 A)  $4.375 \times 10^7$  m/s  
 B)  $2.525 \times 10^7$  m/s  
 C)  $1.778 \times 10^6$  m/s  
 D)  $9.188 \times 10^6$  m/s

- 21) If a particle is represented by the normalized wave function given by  

$$\psi(x) = \begin{cases} \frac{\sqrt{15}}{4} (x^2 - 2) & \text{for } 0 \leq x \leq 2 \\ 0 & \text{otherwise} \end{cases}$$

The uncertainty  $\Delta p$  in its momentum is...

- A)  $\frac{2h}{5a}$   
 B)  $\frac{5h}{2a}$   
 C)  $\frac{5h}{2a}$   
 D)  $\frac{10h}{a}$
- 22) A delta-function bump at  $x = a$  point of the infinite square well of width  $2a$  is defined as  $V(x) = \frac{\alpha}{\epsilon} \delta(x - a)$ , with  $\epsilon$  as a constant. Find the first-order correction to the ground state energy.  
 A)  $\frac{3\alpha}{2a}$   
 B)  $\frac{2\alpha}{3a}$   
 C)  $\frac{\alpha}{2a}$   
 D)  $\frac{3\alpha}{a}$
- 23) A spin 1/2 particle is in the state  $\chi = A \begin{pmatrix} 1 \\ 2 + i \end{pmatrix}$ . Find the probability of getting  $S_z = -\hbar/2$  if  $S_x$  is measured.  
 A) 1/6  
 B) 1/2  
 C) 4/6  
 D) 5/6
- 24) If  $\psi_{nlm}$  denotes the eigen function of the Hamiltonian with a potential  $V(r) = -\frac{1}{r}$ , then the expectation value of the operator  $L_x^2 + L_y^2$  in the state  $\psi = \frac{1}{\sqrt{5}} [3\psi_{211} + \psi_{210} + \sqrt{15}\psi_{21-1}]$  is;  
 A)  $39 \hbar^2/25$   
 B)  $26 \hbar^2/25$   
 C)  $13 \hbar^2/25$   
 D)  $2 \hbar^2$
- 25) A canonical ensemble represents:  
 A) A system under constant external pressure  
 B) An isolated system in equilibrium  
 C) A system which can exchange particles as well as energy  
 D) A system in contact with heat reservoir with no exchange of particles

- 26) Bose-Einstein condensation temperature  $T_B$  refers to the temperature below which
- An assembly of Bose gas condenses to liquid state
  - There is an appreciable occupation of the ground state in an electron system
  - There is significantly large occupancy of the ground state in a system of bosons
  - The boson essentially behave like fermions
- 27) White dwarfs have;
- Degenerate electron gas at very high temperature
  - Degenerate electron gas at very low temperature
  - Non-degenerate electron gas at very high temperature
  - Non-degenerate electron gas at very low temperature
- 28) Consider a system of 3 fermions which can occupy any of the 4 available energy states with equal probability. The entropy of the system is
- $k_b \ln 2$
  - $2 k_b \ln 2$
  - $2 k_b \ln 4$
  - $3 k_b \ln 4$
- 29) Electronic contribution of specific heat varies linearly with temperature for
- Three-dimensional electron gas
  - Two-dimensional electron gas
  - One-dimensional electron gas
  - All of the above
- 30) The voltage after which the diode current exponentially increases with forward bias is NOT known as
- Offset voltage
  - Threshold potential
  - Firing potential
  - Peak forward voltage
- 31) In a JFET, when drain voltage is equal to pinch-off voltage, the depletion layers ...
- almost touch each other
  - have large gap
  - have moderate gap
  - none of the above
- 32) The bandwidth of the differential amplifier increases, if the value of
- Open loop voltage gain decreases
  - Closed loop voltage gain decreases
  - Differential voltage gain decreases
  - All of the mentioned
- 33) Which of the following is not a configuration of a smart sensor?
- Transducer
  - Network interface
  - Processor
  - None of the mentioned
- 34) An electron collides with a hydrogen atom excites it to  $n=3$ . How much energy was given in this inelastic collision?
- 13.6 eV
  - 16.8 eV
  - 12.1 eV
  - 1.51 eV
- 35)  $\lambda_p$  is the wavelength of the series limit of  $B$  B
- $\lambda_p$  will be
- 16/25
  - 25/36
  - 9/25
  - 9/16
- 36) The magnetic moment of an atom in the state  $^3P_0$  is
- 0
  - 1
  - 2
  - 3
- 37) The number of Zeeman component for  $^2P_{3/2}$   $^2S_{1/2}$  is
- 3
  - 6
  - 9
  - 12
- 38) In absence of magnetic field, the direction of orbital magnetic quantum number,  $m_l$
- In the direction of the angular momentum  $l$
  - In the direction perpendicular to the angular momentum  $l$
  - No unique assignment of the direction for  $m_l$
  - None of these
- 39) The direction of the magnetic moment vector for an atomic orbit is
- Normal to the plane of the orbit and parallel to  $l$
  - Normal to the plane of the orbit and anti-parallel to  $l$
  - Tangent to the orbit
  - In the direction of the motion of the orbiting electron

- 40) Tight binding approximation is applicable to  
 A) all solids  
 B) solids with weak potential  
 C) solids with strong periodic potential  
 D) electron gas.
- 41) Plasma is a medium with equal number of Positive and Negative charges, of which ----- charge type is mobile.  
 A) at least One  
 B) both  
 C) no  
 D) ion
- 42) The Splitting of a resonance peak on either side of the Zero velocity in Mossbauer spectra represents  
 A) A Magnetic splitting  
 B) A splitting due to electric and magnetic field interactions  
 C) Quadrupole Splitting  
 D) Isomer shift
- 43) A quanta of thermal energy is termed as  
 A) Photon  
 B) Polaritron  
 C) Phonon  
 D) Quanta
- 44) In the case of Wigner-Seitz cellular method crystalline wave function is written as  
 A) Linear combination of atomic functions  
 B) Collinear combination of atomic function  
 C) Complementary combination of atomic function  
 D) Non-linear combination of atomic functions.
- 45) What is the lattice constant for FCC crystal having atomic radius 1.476 Å?  
 A) 1.476 Å  
 B) 4.1748 Å  
 C) 5.216 Å  
 D) 0 Å
- 46) Which of the following set of properties belongs to the Higgs Boson?  
 A) Zero electric charge, zero mass, zero spin  
 B) +1 electric charge, finite mass, zero spin  
 C) -1 electric charge, zero spin, zero colour charge  
 D) Zero electric charge, zero colour charge, zero spin
- 47) Consider a nucleus with N neutrons and Z protons. If  $m_p$  and  $m_n$  represent the mass of the proton, the mass of the neutron and the binding energy of the nucleus respectively and  $c$  is the velocity of light in free space, the mass of the nucleus is given by  
 A)  $N m_n + Z m_p + \frac{BE}{c^2}$   
 B)  $N m_n + Z m_p - \frac{BE}{c^2}$   
 C)  $N m_n + Z m_p - \frac{BE}{c}$   
 D)  $N m_n + Z m_p - \frac{BE}{c^2}$
- 48) The Muon has mass 105 MeV/c<sup>2</sup> and mean life-time 2.2 μs in its rest frame. The mean distance traversed by a muon of energy 315 MeV before decaying is approximately.  
 A) 3 × 10<sup>5</sup> m  
 B) 2.2 cm  
 C) 1.82 km  
 D) 9.8 μm
- 49) The strangeness quantum number is conserved in  
 A) strong, weak and electromagnetic interactions  
 B) weak and electromagnetic interactions only  
 C) strong and weak interactions only  
 D) strong and electromagnetic interactions only
- 50) The reaction  $n + \mu^+ + e^- + \gamma$   
 A) Is forbidden because of the law of charge conservation  
 B) Is forbidden because of the law of energy-momentum conservation  
 C) Is forbidden because of the law of angular momentum conservation  
 D) Is allowed
- \*\*\*\*\*



**Rough Work:**