THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA, VADODARA

Ph. D. ENTRANCE TEST (PET) 2025

Signature of Invigilator

Roll. No. | | | | | | |

Paper - II
Physical Sciences

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: Ⓐ ● Ⓒ Ⓓ 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

Note: This paper contains **FIFTY (50)** multiple-choice questions. Each Question carries **ONE (1)** mark.

01) The eigenvalues of the matrix
A = $\begin{bmatrix} \cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix}$ are:
A) $e^{\pm 2\, i\theta}$
B) $e^{\pm\, i\theta/2}$
C) $e^{\pm i\theta}$
D) $e^{\pm\, 3\, i\theta}$

02) If, $\vec{r}$ = x$\hat{\imath}$+y$\hat{\jmath}$+z$\hat{k}$ is a position vector, then curl $\vec{r}$ will be:
A) 3
B) r^3
C) r^{-1}
D) zero

03) The flux leaving any closed surface per unit volume in a vector field $\vec{A}$ is called:
A) grad $\vec{A}$
B) curl $\vec{A}$
C) flux $\vec{A}$
D) div $\vec{A}$

04) Which of the following function of complex variable z = x + iy is analytic?
A) Re z
B) log z
C) z^{-1}
D) $|z|$

05) The number of non-vanishing terms in the Fourier series of $\cos^2\Theta$ in the interval $(-\pi, \pi)$ is:
A) 4
B) 3
C) 2
D) 1

06) The independent solutions of the equation $\frac{d^2y}{dx^2}$ - $3\frac{dy}{dx}$ + 2y = 0 are:
A) Sin 2x and cos 2x
B) $\frac{1}{x}$ and x^2
C) e^{2x} and e^{x}
D) e^{2x} and e^{-x}

07) A small ball strikes at one end of a stationary uniform frictionless rod of mass m and length l which is free to rotate in gravity free space. The impact is elastic. Instantaneous axis of rotation of the rod will pass through
A) Its centre of mass
B) The centre of mass of rod plus ball
C) The point of impact of the ball on the rod
D) The point which is at a distance 2/3 from the striking end.

08) Two events separated by a spatial distance 9×10^9 m are simultaneous in one inertial frame. The time interval between these two events in a frame moving with a constant speed 0.8 c (where c is speed of light) is
A) 60 s
B) 40 s
C) 20 s
D) 0 s

09) The Lagrangian for a particle is given by L = $\dot{q}^2 - q\,\dot{q}$. Which of the following statement is true?
A) This is free particle
B) The particle is experiencing velocity dependent damping
C) The particle is executing simple harmonic motion
D) The particle is under constant acceleration

10) In a most extreme case, which one of the following quantity is not a second order tensor?
A) Stress
B) Strain
C) Moment of inertia
D) Pressure

11) If the Lagrangian of a dynamical system in the two dimension is L = $\frac{1}{2}m\,\dot{x}^2 + m\,\dot{x}\dot{y}$. Then the Hamiltonian is
A) H = $\frac{1}{m}P_xP_y + \frac{1}{2m}P_y^2$
B) H = $\frac{1}{m}P_xP_y + \frac{1}{2m}P_x^2$
C) H = $\frac{1}{m}P_xP_y - \frac{1}{2m}P_y^2$
D) H = $\frac{1}{m}P_xP_y - \frac{1}{2m}P_x^2$

12) GROUP 1 contains x and y components of the electric field and GROUP 2 contains the type of polarization.

GROUP - 1	**GROUP - 2**
P. $E_x = E_0/2 \cos(\omega t + kz)$ $E_y = E_0 \sin(\omega t + kz)$	1. Linearly polarized
Q. $E_x = E_0 \sin(\omega t + kz)$ $E_y = E_0 \cos(\omega t + kz)$	2.Circularly polarized
R. $E_x = E_0 \sin(\omega t + kz)$ $E_y = E_2 \sin(\omega t + kz)$	3. Unpoolarized
S. $E_x = E_0 \sin(\omega t + kz)$ $E_y = E_0 \sin(\omega t + kz + \pi/4)$	4. Elliptically polarized

The correct set of matches is

A) P → 4, Q → 2, R → 4, S → 1
B) P → 1, Q → 3, R → 1, S → 4
C) P → 4, Q → 2, R → 1, S → 2
D) P → 3, Q → 1, R → 3, S → 2

13) A medium ($\varepsilon_r > 1$, $\mu_r = 1$, $\sigma > 0$) is semitransparent (poor conductor) to an electromagnetic wave when
A) Conduction current > > displacement current
B) Conduction current < < displacement current
C) Conduction current = displacement current
D) Both conduction current and displacement current are zero.

14) The dispersion relation for an electromagnetic wave travelling in a plasma is given by $\omega^2 = c^2k^2 + \omega_p^2$, where c and ω_p are constants, in this plasma the group velocity is
A) Proportional to but not equal to phase velocity
B) Inversely proportional to the phase velocity
C) Equal to the phase velocity
D) A constant

15) Choose the correct statements for a wave propagating in air filled rectangular waveguide
A) Guided wavelength is never less than free space wavelength
B) Phase velocity is never less than the free space velocity
C) Wave impedance is never less than the free space velocity
D) Both (a) and (b)

16) In the conversion of line integral of H into surface integral which theorem is used?
A) Green's theorem
B) Gauss's theorem
C) Stokes's theorem
D) It cannot be converted

17) For an electromagnetic wave incident from one medium to a second medium, total internal reflection takes place when
A) Angle of incidence is equal to the Brewster angle with Electric field perpendicular to the plane of incidence
B) Angle of incidence is equal to the Brewster angle with Electric field parallel to the plane of incidence
C) Angle of incidence is equal to the critical angle with the wave moving from denser to rarer medium
D) Angle of incidence is equal to the critical angle with the wave moving from the rarer to denser medium.

18) Two spin -1/2 fermions having spins $\underline{S}_1$ and $\underline{S}_2$ interact via a potential $V(r) = \underline{S}_1 \cdot \underline{S}_2 V_0(r)$. The contributions of this potential in the singlet and triplet states respectively, are
A) -3/2 $V_0(r)$ and 1/2 $V_0(r)$
B) 1/2 $V_0(r)$ and -3/2 $V_0(r)$
C) 1/4 $V_0(r)$ and - 3/4 $V_0(r)$
D) -3/4 $V_0(r)$ and 1/4 $V_0(r)$

19) A particle of mass m is confined in an potential well $V(x) = 0$ for $0 < x < L$ and $= \infty$, otherwise. It is subjected to a perturbed potential $V_p(x) = V_0 \text{ SIN}(2\pi x/L)$ within the well. Let $E^{(1)}$ and $E^{(2)}$ be corrections in ground state energy and first and second order in V_0, which of the following is correct?
A) $E^{(1)} = 0$ and $E^{(2)} < 0$
B) $E^{(1)} > 0$ and $E^{(2)} = 0$
C) $E^{(1)} = 0$ and $E^{(2)}$ depends on the right of V_0
D) $E^{(1)} < 0$ and $E^{(2)} < 0$

20) Which of the following wave function can be solutions of Schrodinger's equation for all values of x ($x > 0$)?
A) $\Psi = A \sec(x)$
B) $\Psi = A \tan(x)$
C) $\Psi = A\, e^{x**2}$
D) $\Psi = A\, e^{-x**2}$

21) The Dirac equation predicts
   A) The spin angular momentum but not the existence of antiparticles
   B) Both spin angular momentum and existence of antiparticles
   C) The existence of antiparticles but not angular momentum
   D) None of the above

22) The correct statement for Born approximation is/are
   A) It is applicable when potential function V is small
   B) In this case, the distance between scatterer and scattering is not large.
   C) The amplitude of scattered wave is very small by incident wave amplitude
   D) All of the above

23) First law of thermodynamics is also known as
   A) Law of thermal equilibrium
   B) Law of conservation of energy
   C) Law of entropy
   D) Law of temperature

24) For an isolated system
   A) $\Delta U>0$
   B) $\Delta U<0$
   C) $\Delta U=0$
   D) $\Delta U=$Infinity

25) Which thermodynamic process has constant pressure?
   A) Isothermal
   B) Adiabatic
   C) Isochoric
   D) Isobaric

26) Electrons follow
   A) Maxwell - Boltzman statistics
   B) Bose - Einstein statistics
   C) Fermi- Dirac statistics
   D) None of above

27) What is the value of entropy at absolute zero temperature for a perfect crystal
   A) Infinity
   B) 1
   C) 0
   D) -1

28) Width of the depletion layer in PN junction diode is of the order of:
   A) 10^{-6} m
   B) 10^{-9} m
   C) 10^{-3} m
   D) 10^{-12} m

29) A field-effect transistor (FET):
   A) uses a forward-biased PN junction
   B) has a very high input resistance
   C) depends on minority carrier flow
   D) uses a high concentration emitter junction

30) The negative feedback in an amplifier:
   A) increases the voltage gain
   B) does not affect the voltage gain
   C) reduces the voltage gain
   D) can convert it into an oscillator if the amount of feedback is sufficient

31) Which one of the following in NOT a photonic device:
   A) Light Emitting Diode
   B) Photodiode
   C) GM counter
   D) Solar cell

32) Two resistances 100 Ω ± 5 Ω and 150 Ω ± 15 Ω are connected in series. If the deviations are standard deviations, the resultant resistance can be expressed as:
   A) 250 Ω ± 20 Ω
   B) 250 Ω ± 10 Ω
   C) 250 Ω ± 15.8 Ω
   D) 250 Ω ± 10.6 Ω

33) In nuclear instrumentation which of the following are the heaviest and slow moving particles:
   A) Neutrons
   B) Alpha particles
   C) Beta particles
   D) Gamma rays

34) The direction of the magnetic moment vector for an atomic orbit is
   A) Normal to the plane of the orbit and parallel to *l*
   B) Normal to the plane of the orbit and anti-parallel to *l*
   C) Tangent to the orbit
   D) In the direction of the motion of the orbiting electron

35) The magnetic moment of an atom in the state $^3P_0$ is
   A) 0
   B) 1
   C) 2
   D) 3

36) Wavelength of the radiation emitted when the electron in H atom jumps from n=∞ to n=2 is:
A) 356 Å
B) 356 nm
C) 565 Å
D) 565 nm

37) An electron collides with a hydrogen atom in its ground state and excites it to a state of n=3. How much energy was given to the hydrogen atom?
A) 13.6 eV
B) 16.8 eV
C) 12.1 eV
D) 1.51 eV

38) The wavelength will be minimum for the transition
A) n=5 to n=4
B) n=4 to n=3
C) n=3 to n=2
D) n=2 to n=1

39) Energy levels for an atom are primarily determined by
A) Nuclear spin
B) Electron spin
C) Coulomb interaction between electrons and nucleus
D) Magnetic interactions

40) Velocity of an electron at the boundary of first Brillouin zone for a crystal having having band structure E= E(**k**), where E has some functional dependence on k is
A) Zero
B) Infinity
C) finite + value
D) finite negative value

41) In a two-dimensional Kroning Penny model the total number of possible wavefunctions is equal to
A) twice the number of unit cells
B) number of unit cells
C) half the number of unit cells
D) independent of number of unit cells

42) In the case of Bargg's scattering from periodic lattice, any allowed d**k** (where d**k** is changed in wave vectors k and k') must be equal to
A) Some Position vector R
B) Some Reciprocal lattice vector **G**
C) Position as well as Reciprocal vectors
D) None of the above

43) Elastic stiffness constants have dimension
A) Force/area
B) energy/volume
C) both force/area and energy/volume
D) none in the group

44) The potential energy of a diatomic molecule in terms of interatomic distance R is given by
$U(R) = -A/R^m + B/R^n$
Where, A, B, m.n are constants characteristics for MX- molecules. Attractive and repulsive exponents are related through.
A) n<<m
B) n<m
C) n>m
D) n>>m

45) The effective mass of an electron in a semiconductor can be
A) negative near bottom of the band
B) A scalar quantity with small magnitude
C) Zero at the centre of the band
D) negative near top of the band

46) If a nucleus has mass number 'A' then its radius is proportional to:
A) A
B) $A^{⅔}$
C) $A^{⅓}$
D) A^{-1}

47) Which of the following nucleus has maximum average binding energy per nucleon?
A) ${}^{12}_{6}C$
B) ${}^{56}_{26}Fe$
C) ${}^{4}_{2}He$
D) ${}^{208}_{92}Pb$

48) Baryon number and strangeness of a quark are B and S respectively. The hypercharge of that quark will be:
A) B - S
B) S – P
C) B + S
D) (B + S)/2

49) Which of the following is an example of Beta decay:
A) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + e^- + \bar{\nu}$
B) ${}^{14}_{6}C \rightarrow {}^{13}_{7}N + e^- + \bar{\nu}$
C) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + e^- + \nu$
D) ${}^{14}_{6}C \rightarrow {}^{13}_{7}N + e^- + \nu$

50) Total energy of relativistic particle with kinetic energy K is given by:

A) $K + m_0c^2$

B) $K - m_0c^2$

C) $2 (K + m_0c^2)$

D) $2 (K - m_0c^2)$

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Rough Work: