**THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA, VADODARA**

# Ph. D. ENTRANCE TEST (PET) –27th January 2019

**Signature of Invigilators**

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**Roll. No.** | | | | | | |

(in figures as in Hall Ticket)

**Roll No.** _____

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**(in words)**

## Physical Sciences
## (19/29)

**Maximum Marks: 50No. Of Printed Pages :8**

**Instruction for the Candidate:**

1. Write your Roll Number in the space provided on the top of this page.
2. This paper consists of **FIFTY (50)**multiple choice type questions. Each Question carries**ONE (1)** mark.
3. At the commencement of examination, the question booklet will be given to you. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as below:
    a. To have access to the Question Booklet, tear off the paper seal on the edge of this cover page, Do not accept a booklet without sticker seal and do not accept an open booklet.
    b. Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faculty booklets due to pages/questions missing or duplicate or not in serial order or any other discrepancy should be got replaced immediately by a correct booklet from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given.
    c. After this verification is over, the Test Booklet Number should be entered on the OMR Answer Sheet and the OMR Answer Sheet Number should be entered on this Test Booklet.
4. Each item has four alternative responses marked (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.

5. Your responses to the items are to be indicated on the OMR Answer Sheet under Paper – II only. If you mark your response at any place other than in the circle in the OMR Answer Sheet, it will not be evaluated.
6. Read instructions given inside carefully.
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. You have to return the original 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 and duplicate copy of OMR Answer Sheet on conclusion of examination
10. Use only Blue/ Black Ball point pen.
11. Use of any calculator or log table etc., is prohibited.
12. There shall be no negative marking.

# Physical Sciences
## (19/29)

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

01) In which of the following method, we approximate the curve of solution by the tangent in each interval.
A) Newton's method
B) Picard's method
C) Runge-Kutta method
D) Euler's method

02) Match the following:

| | |
|---|---|
| a) Newton-Raphson | 1) Integration |
| b) Runge-kutta | 2) Root finding |
| c) Gauss-seidel | 3) Ordinary Differential Equations |
| d) Simpson's Rule | 4) Solution of system of Linear Equations |

**The correct sequence is**
A) a2-b3-c4-d1
B) a3-b2-c1-d4
C) a1-b4-c2-d3
D) a4-b1-c2-d3

03) The number of evaluation of functions per iteration in the case of Newton-Raphsonmethod of root finding is
A) 1
B) 2
C) 3
D) zero

04) The equation $\sin x = (x-1)^2 + 0.5$ has
A) No real roots
B) One real root
C) two real roots
D) Infinitely many real roots

05) If r is position vector with magnitude r then the value of $\nabla r^n$ is
A) $nr^{n-2}\mathbf{r}$
B) $nr^{n-1}\mathbf{r}$
C) $nr^{n-1}$
D) $nr^{n-2}r$

06) For an N x N matrix consisting of all ones,
A) all eigenvalues = 1
B) all eigenvalues = 0
C) one eigenvalue = N, the others = 0
D) the eigenvalues are 1, 2, …., N

07) If $\vec{F}$ is a constant vector and $\vec{r}$ is the position vector then $\vec{\nabla}(\vec{F}\cdot\vec{r})$ would be
A) $\vec{F}$
B) $(\vec{\nabla}\cdot\vec{r})\vec{F}$
C) $(\vec{\nabla}\cdot\vec{F})\vec{r}$
D) $\vec{r}\cdot\vec{F}$

08) For Bessel's Function following is the correct relation
A) $J_{n-1}(x) = (-1)^n J_n(x)$
B) $J_{n-1}(x) = J_n(x)$
C) $J_{n-1}(x) = (1/2)^n J_n(x)$
D) $J_{n-1}(x) = (1/3)^n J_n(x)$

09) The work done by a force in moving a particle of mass $m$ from any point $(x, y)$ to a neighboring point $(x + dx, y + dy)$ is given by $dW = 2xy\,dx + x^2dy$. The work done for a complete cycle around a unit circle is
A) 2
B) 0
C) 1
D) $2\pi$

10) Exchanging the left and right state in the scalar product yields the complex conjugate of the original scalar product.
A) Unitary Symmetry
B) Hermitian Symmetry
C) Inverse Symmetry
D) Periodic Symmetry

11) The binding energy of the hydrogen atom (electron bound to proton) is 13.6 eV. The binding energy of peritoneum (electron bound to positron) is
A) 13.6 / 2 eV
B) 13.6 / 1810 eV
C) 13.6 ×2 eV
D) 13.6 × 1810 eV

12) The operator $\left(\frac{d}{dx} - x\right)\left(\frac{d}{dx} + x\right)$ is equivalent to

A) $\frac{d^2}{dx^2} - x\frac{d}{dx}x^2 + 1$

B) $\frac{d^2}{dx^2} - x^2$

C) $\frac{d^2}{dx^2} - x^2 + 1$

D) $\frac{d^2}{dx^2} + x^2$

13) The lowest quantum mechanical energy of a particle confined in a one-dimensional box of size $L$ is 1 eV. The energy of the quantum mechanical ground state for a system of three non-interacting spin $\frac{1}{2}$ particles is

A) 10 eV

B) 3eV

C) 2 eV

D) 6 eV

14) The Hamiltonian H of a system having two states $\phi_1$and $\phi_2$is such that $H\psi_1 = iE\psi_2$and $\psi_2 = -iE\psi_1$ . The lowest energy of the system correspond to the state is

A) $\frac{1}{\sqrt{2}}(\psi_2 - i\psi_1)$

B) $\frac{1}{\sqrt{2}}(\psi_2 - \psi_1)$

C) $\frac{1}{\sqrt{2}}(\psi_2 + i\psi_1)$

D) $\frac{1}{\sqrt{2}}(\psi_2 + \psi_1)$

15) 15. The quantum mechanical operator for the momentum of a particle moving in one dimension is given by

A) $i\hbar\frac{d}{dx}$

B) $-i\hbar\frac{d}{dx}$

C) $i\hbar\frac{d}{dt}$

D) $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$

16) The Lagrangian of the system is given by,

$$L = \frac{1}{2}(M+m)\dot{x}^2 + ml\cos\theta\dot{x}\dot{\theta} + \frac{1}{2}ml^2\dot{\theta}^2 - \frac{1}{2}kx^2 + mgl\cos\theta$$

Where x and $\theta$ are the generalized coordinates. The equation of motion are:

A) $M\ddot{x} + ml\cos\theta\ddot{\theta} - ml\sin\theta\dot{\theta}^2 = -kx, \cos\theta\ddot{x} + l\ddot{\theta} = -g\sin\theta$

B) $(M+m)\ddot{x} + ml\cos\theta\ddot{\theta} - ml\sin\theta\dot{\theta}^2 = -kx, \sin\theta\ddot{x} + l\ddot{\theta} = -g\cos\theta$

C) $M\ddot{x} + ml\sin\theta\ddot{\theta} - ml\cos\theta\dot{\theta}^2 = -kx, \cos\theta\ddot{x} + l\ddot{\theta} = -g\sin\theta$

D) $(M+m)\ddot{x} + ml\cos\theta\ddot{\theta} - ml\sin\theta\dot{\theta}^2 = -kx, \cos\theta\ddot{x} + l\ddot{\theta} = -g\sin\theta$

17) Let T be the total kinetic energy, $\vec{P}$ be the total momentum and $\vec{L}$ be the total angular momentum of a system of two bodies. In an inelastic collision of the two bodies;

A) T, $\vec{P}$ and $\vec{L}$ are all conserved

B) None of T, $\vec{P}$ and $\vec{L}$ are conserved

C) T is not conserved, $\vec{P}$ and $\vec{L}$ are conserved

D) T is conserved, $\vec{P}$ and $\vec{L}$ are not conserved

18) The Lagrangian for a simple pendulum is given by

$$L = \frac{1}{2}ml^2\dot{\theta}^2 - mgl(1 - \cos\theta)$$

The Hamilton's equations are given by,

A) $\dot{P_\theta} = -mgl\sin\theta;\ \dot{\theta} = \frac{P_\theta}{ml^2}$

B) $\dot{P_\theta} = mgl\sin\theta;\ \dot{\theta} = \frac{P_\theta}{ml^2}$

C) $\dot{P_\theta} = -m\ddot{\theta};\ \dot{\theta} = \frac{P_\theta}{m}$

D) $\dot{P_\theta} = -\frac{g}{l}\theta;\ \dot{\theta} = \frac{P_\theta}{ml}$

19) A particle is moving under the action of a generalized potential $V = (1+\dot{q})/q^2$; the magnitude of the generalized force is

A) $2(1+\dot{q})/q^3$

B) $2(1-\dot{q})/q^3$

C) $2/\mathrm{q}^3$

D) $\dot{q}/q^3$

20) Two particles each of rest mass *m* collide head-on and stick together. Before collision, the speed of each mass was 0.6 times the speed of light in free space. The mass of the final entity is

A) $\frac{5m}{4}$
B) $2m$
C) $\frac{5m}{2}$
D) $\frac{25m}{8}$

21) If a parallel RLC circuit is excited with a source of 8v, 50 Hz and the circuit has an inductor of 1mH, capacitor of 1μF and a resistor of 50Ω, then the power loss that occurs in the circuit is:

A) 6.4mW
B) 3.2mW
C) 12.8mV
D) None of the mentioned

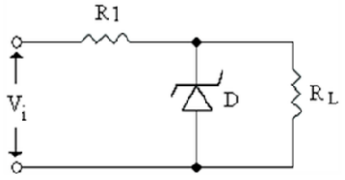
22) In a certain series resonant circuit, $V_C$ = 125 V, $V_L$ = 125 V, and $V_R$ = 40 V. The value of the source voltage is

A) 290 V
B) 210 V
C) 125 V
D) 40 V

23) A 24 Ω resistor, an inductor with a reactance of 120 Ω, and a capacitor with a reactance of 120 Ω are in series across a 60 V source. The circuit is at resonance. The voltage across the inductor is

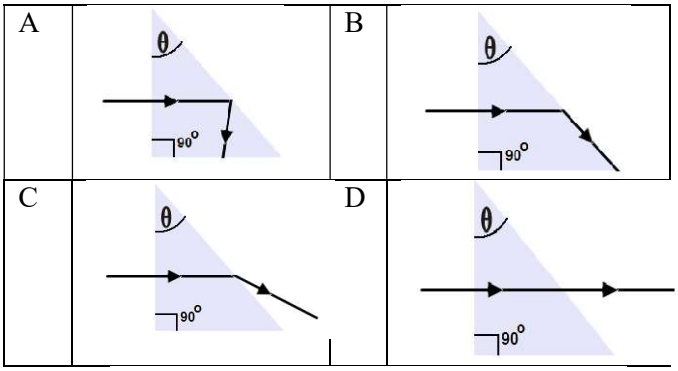
A) 60V
B) 600V
C) 340V
D) 300V

24) In the voltage regulator shown below, if the current through the load decreases,




A) The current through R1 will
B) The current through R1 will decrease
C) zener diode current will increase.
D) zener diode current will decrease

25) A light ray is incident on a glass prism with one angle of 90°and the other angle θ. If θ is less than the critical angle for glass-air boundary, which of the following is correct for the emerging ray from the opposite face of the prism?




26) In the decay process, the transition , is $2^+ \rightarrow 3^+$

A) allowed both by Fermi and Gamow-Teller selection rule
B) allowed by Fermi and but not by Gamow-Teller selection rule
C) not allowed by Fermi but allowed by Gamow-Teller selection rule
D) not allowed both by Fermi and Gamow-Teller selection rule

27) Match the reactions on the left with the associated interactions on the right.

| | |
|---|---|
| (1) $\pi^+ \rightarrow \mu^+ + \nu_\mu$ | i. Strong |
| (2) $\pi^0 \rightarrow \gamma + \gamma$ | ii. Electromagnetic |
| (3) $\pi^0 + n \rightarrow \pi^- + p$ | iii. Weak |

A) (1, iii), (2, ii), (3, i)
B) (1, i), (2, ii), (3, iii)
C) (1, ii), (2, i), (3, iii)
D) (1, iii), (2, i), (3, ii)

28) The first three energy levels of $_{90}Th^{228}$ are shown below

$4^+$_____ 187 keV
$2^+$_____ 57.5 keV
$0^+$_____ 0 keV

The expected spin-parity and energy of the next level are given by

A) (6+; 400 keV)
B) (6+; 300 keV)
C) (2+; 400 keV)
D) (4+; 300 keV)

29) X-rays with $\lambda = 100 \times 10^{-12}$ m are scattered from electrons in a Carbon target. The scattered radiation is viewed at 143° to the incident beam. The Compton shift will be? (Sec 143° = -1.25)
A) $4.4 \times 10^{-12}$ m
B) $4.4 \times 10^{-13}$ m
C) $4.4 \times 10^{-14}$ m
D) $4.4 \times 10^{-15}$ m

30) A proton is accelerated to a kinetic energy of 1 GeV. What is its momentum, expressed in units of MeV/$c$?
A) 896.2 MeV/$c$
B) 1096.2 MeV/$c$
C) 1296.2 MeV/$c$
D) 1696.2 MeV/$c$

31) The energy of a rotating molecule is
A) $h^2 J^2(J+1)^2/ 2I$
B) $\hbar^2 J^2(J+1)^2/ 2I$
C) $h^2 J (J+1)/ 2I$
D) $\hbar^2 J (J+1)/ 2I$

32) Which of the following has body centered cubic structure?
A) Polonium
B) Copper
C) Nickel
D) Tungsten

33) Which one of the following is the property of an ionic compound?
A) High melting and boiling points
B) Low melting and boiling points
C) Weak inter-atomic forces
D) Non-conductors of electricity

34) Which of the following covalent compounds conduct electricity?
A) Silica
B) Graphite
C) Diamond
D) Hydrogen chloride

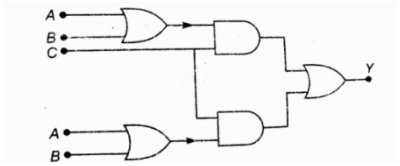
35) Consider a system whose three energy levels are given by 0, $\varepsilon$ and $2\varepsilon$. The energy level $\varepsilon$ is two-fold degenerate and the other two are non-degenerate. The partition function of the system with is given by $\beta = 1/K_BT$
A) $1+2e^{-\beta\varepsilon}$
B) $2e^{-\beta\varepsilon}+ e^{-2\beta\varepsilon}$
C) $(1+ e^{-\beta\varepsilon})^2$
D) $1 + e^{-\beta\varepsilon}+ e^{-2\beta\varepsilon}$

36) The entropy function of a system is given by $S(E) = aE(E_0 – E)$ where a and $E_0$ are positive constants. The temperature of the system is
A) negative for some energies
B) increases monotonically with energy
C) decreases monotonically with energy
D) Zero

37) Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwellian distribution law of velocities. Vessel A contains only $O_2$, B only $N_2$ and C a mixture of equal quantities of $O_2$ and $N_2$. If the average speed of the $O_2$ molecules in vessel A is $V_1$, that of the $N_2$ molecules in vessel B is $V_2$ the average speed of the $O_2$ molecules in vessel C is
A) $\frac{(V_1+V_2)}{2}$
B) $V_1$
C) $(V_1V_2)^{1/2}$
D) $\sqrt{\frac{3kT}{m}}$

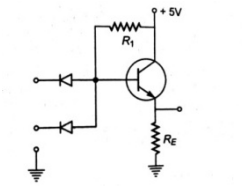
38) In a first order phase transition, at the transition temperature, specific heat of the system
A) diverges and its entropy remains the same
B) diverges and its entropy has finite discontinuity
C) remains unchanged and its entropy has finite discontinuity
D) has finite discontinuity and its entropy diverges

39) What should be the input in the given circuit to get output one




A) 110
B) 101
C) 100
D) 010

40) The circuit shown is a




A) NAND gate
B) NOR gate
C) OR gate
D) AND gate

41) What is the Excess-3 code of $159_{10}$ ?
A) 0100 1000 1100
B) 1011 1010 0100
C) 0111 0110 1100
D) 0100 1001 1101

42) As the modulation index of an FM signal with sinusoidal modulation is increased from zero to three, the power in the carrier component will
A) Increase continuously
B) Decrease continuously
C) First increase, attain maximum and then decreases
D) first decreases, become zero and then increases

43) $q_1$ and $q_2$ are the generalized co-ordinates and $p_1$, $p_2$ are the corresponding generalized momentum. The Poisson bracket [X,Y] of X= $q_1^2 + q_2^2$ and Y = $2p_1 + p_2$ is
A) $(q_1^2 + q_2^2)\, p_1$
B) $3(q_1^2 + q_2^2)$
C) $4\, q_1 + 2\, q_2$
D) None of the above

44) A particle of mass m moves under the action of a central force whose potential is $V(r) = kmr^3$ (r>0). If the orbit is a circle of radius $\boldsymbol{a}$, the angular momentum about origin is
A) $ma\sqrt{3ka}$
B) $ma^2\sqrt{ka}$
C) $ma^2\sqrt{3ka}$
D) $ma\sqrt{ka}$

45) Two particles of equal mass have velocities $\vec{v}_1 = 2\hat{\imath}$ m/s and $\vec{v}_2 = 2\hat{\jmath}$ m/s. First particle has an acceleration $\vec{a}_1 = 3\hat{\imath} + 3\hat{\jmath}$ m/$s^2$, while the acceleration of the second particle is zero. The center of mass of two particles moves in a
A) circle
B) parabola
C) ellipse
D) straight line

46) If $\oint \vec{\boldsymbol{F}}.\overrightarrow{\boldsymbol{dr}} = \iint (\boldsymbol{curl}\vec{\boldsymbol{F}})\,.\,\hat{\boldsymbol{n}}\mathrm{ds}$ , where $\vec{\boldsymbol{F}}$(x,y,z) is a vector function and has continuous first partial derivatives in a domain in a space containing S which is simple closed curve, it is known as;
A) Green's Theorem
B) Gauss Theorem
C) Stokes's Theorem
D) Divergence Theorem

47) Electromagnetic wave equation in coulomb gauge will be;
A) $\nabla^2\vec{A} - \varepsilon_0\mu_0\frac{\partial^2\vec{A}}{\partial t^2} = -\mu\overrightarrow{J_T}$ and $\nabla^2\varphi - \varepsilon_0\mu_0\frac{\partial^2\varphi}{\partial t^2} = -\rho/\varepsilon_0$
B) $\nabla^2\vec{A} - \varepsilon_0\mu_0\frac{\partial^2\vec{A}}{\partial t^2} = -\mu\overrightarrow{J_T}$ and $\nabla^2\varphi = \rho/\varepsilon_0$
C) $\nabla^2\vec{A} = -\mu\overrightarrow{J_T}$ and $\nabla^2\varphi - \varepsilon_0\mu_0\frac{\partial^2\varphi}{\partial t^2} = -\rho/\varepsilon_0$
D) $\nabla^2\vec{A} - \varepsilon_0\mu_0\frac{\partial^2\vec{A}}{\partial t^2} = \mu\overrightarrow{J_T}$ and $\nabla^2\varphi - \varepsilon_0\mu_0\frac{\partial^2\varphi}{\partial t^2} = \rho/\varepsilon_0$

48) The range of frequencies *f,* for which the $TE_{11}$ mode will propagate with the dimensions for the above given wave guide, is
A) 6.0 GHz < $f$ <7.5 GHz
B) 7.5 GHz < $f$ <9.0 GHz
C) 7.5 GHz < $f$ <12.0 GHz
D) 7.5 GHz < $f$

49) 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

50) Which of the following is a crystalline solid?
A) Anisotropic substances
B) Isotropic substances
C) Supercooled liquids
D) Amorphous solids

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**Rough Work:**