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Test Registration No.: _____



The Maharaja Sayajirao University of Baroda
Faculty of Science

M.Sc. ENTRANCE EXAMINATION - 2022

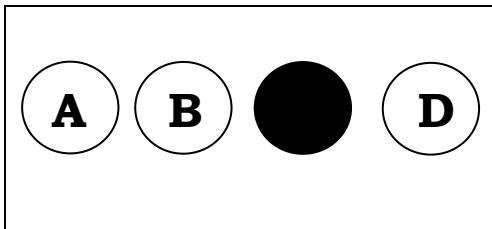
SUBJECT: PHYSICS
DAY: MONDAY

TIME : 2:30 TO 4:00 pm
DATE: 04 - 07 - 2022

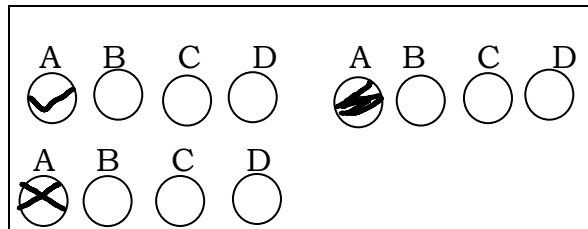
Important Instructions:

1. This test booklet is to be opened only when instructed by the invigilators to do so.
2. This booklet carries **50** questions in 9 printed pages. All carry equal marks.
3. For every correct answer, candidate will earn **2 mark**, for every wrong answer **25%** mark will be deducted.
4. Test Registration Number must be entered correctly in the OMR answer sheet, as advised by the invigilators. The Question Booklet code (A/B/C/D) must also be mentioned on the OMR answer sheet (if not printed already) as instructed.
5. Answers must be marked in the OMR answer sheet using a black or dark blue ball point pen only. The circle should be filled in completely, leaving no gaps.
6. Gadgets (Mobile phones, pagers, ear phones, music players, calculators smart watches etc.) are strictly prohibited in the exam hall. If any candidate is found in possession of any of these at his/her exam seat, he/she is liable to be disqualified.
7. In case of tie in the marks the merit will be considered based on total marks in qualifying examination.

Correct way of marking answer:



Incorrect way of marking answer:



Invigilator's Signature: _____

USEFUL PHYSICAL CONSTANTS

1. Acceleration due to gravity, $g = 9.81 \text{ m/sec}^2$
2. Avogadro number, $N_A = 6.022 \times 10^{23} / \text{mol}$
3. Boltzmann constant, $K_B = 1.38 \times 10^{-23} \text{ J/K}$
4. Charge of electron, $e = 1.38 \times 10^{-19} \text{ C}$
5. Gravitational constant, $G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$
6. Mean radius of the earth, $R_e = 6.37 \times 10^6 \text{ m}$
7. Permittivity of vacuum, $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$
8. Permeability of vacuum, $\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$
9. Planck's constant, $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$
10. Rest mass of electron, $m_e = 9.11 \times 10^{-31} \text{ kg}$
11. Rest mass of neutron, $m_n = 1.67 \times 10^{-27} \text{ kg}$
12. Rest mass of proton, $m_p = 1.67 \times 10^{-27} \text{ kg}$
13. Speed of light in vacuum, $C = 3 \times 10^8 \text{ m/s}$
14. Stefan – Boltzmann constant, $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ k}^4$
15. Universal gas constant, $R = 8.31 \text{ J/mol} \cdot \text{k}$

- A particle of mass m is observed from an inertial frame of reference and is found to move in a circle of radius r with a uniform speed v . The centrifugal force on it is

(a) Zero (b) mv^2/r towards centre
 (b) mv^2/r away from the centre (d) mv^2/r along the tangent through the particle.
- If Laplace equation satisfies, then which of the following statement will be true?

(a) Potential will be zero (b) Current will be infinite
 (c) Resistance will be infinite (d) Voltage will be same
- Whenever the Lagrangian for a system does not contain a coordinate explicitly,

(a) q_k is cyclic coordinate (b) p_k is cyclic coordinate
 (c) p_k the generalized momentum, is a constant of motion (d) both (a) & (c)
- If a rigid body is rotating with an angular velocity ω about an instantaneous axis through a fixed point in the body, the angular momentum vector \mathbf{J} about the same point

(a) Will be always in the direction of ω (b) May be in the direction of ω
 (c) May have different direction to that of ω (d) Both (b) & (c)
- A planet of mass m moves in the inverse square central force field of the sun of mass M . If the semi-major and semi-minor axes of the orbit are a and b , respectively, the total energy of the planet is:

(a) $-GMm \left(\frac{1}{a+b} \right)$ (b) $-GMm \left(\frac{a^2-b^2}{a+b} \right)$
 (c) $-GMm \left(\frac{1}{a} - \frac{1}{b} \right)$ (d) $-GMm \left(\frac{1}{b} - \frac{1}{a} \right)$
- A proton from outer space is moving towards earth with velocity $0.99C$ as measured in Earth's frame. A spaceship travelling parallel to the proton, measures proton's velocity to be $0.97C$. The approximate velocity of the spaceship, in the earth's frame is

(a) $0.2C$ (b) $0.3C$ (c) $0.4C$ (d) $0.5C$
- You feel lighter in the water than on land because

(a) Gravity is not as strong in the water
 (b) The buoyant force of the water counters some of your weight
 (c) Your mass is less in the water than on the land
 (d) You are trying to stay afloat
- For a Fermi gas of N particles in three dimension at $T = 0K$, the Fermi energy E_f is proportional to

(a) $N^{2/3}$ (b) $N^{3/2}$ (c) N^3 (d) N^2

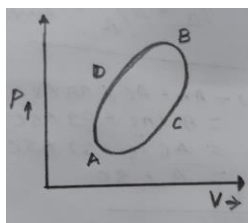
9. At room temperature, the speed of the sound in air is 340 m/s. An organ pipe with both ends open has a length $L = 29$ cm. An extra hole is created at the position $L/2$. The lowest frequency of the sound produced is

- (a) 293 Hz (b) 586 Hz (c) 1172 Hz (d) 2344 Hz

10. Which of the following integrals depends only on the initial and final states of a Thermodynamic system (i.e., independent of the path of transformation)?

- (a) $\int P dV$ (b) $\int dQ$ (c) $\int dQ/T$ (d) $\int T^2 dS$

11. In the P – V diagram shown below, the work done by the system of gases along the path ACB is



- (a) Smaller than the work done along ADB
 (b) Greater than the work done along ADB
 (c) Equal to the work done along ADB
 (d) Equal to the work done along BCA

12. The Gibb's function G in thermodynamics is defined as $G = H - TS$ ($H =$ enthalpy, $T =$ temperature, $S =$ entropy). In an isothermal, isobaric, reversible process, which statement is true for G

- (a) Remains constant but not zero (b) Varies linearly
 (c) Varies non – linearly (d) Is zero

13. Fermi – Dirac statistics is for the

- (a) Distinguishable particles (b) Symmetrical particles
 (c) Particles with half integral spin (d) Particles with integral spin

14. The ensemble average of a physical quantity is equal to its time average. This is true for

- (a) A micro canonical ensembles (b) Canonical ensembles
 (c) Grand canonical ensembles (d) All of the above

15. Which of the following is due to inhomogeneous refractive index of earth's atmosphere?

- (a) Red colour of the evening Sun (b) Blue colour of the sky
 (c) Oval shape of the evening Sun (d) Large apparent size of the evening Sun

16. In a Young's double slit experiment, the separation between the two slit is d and the wavelength is λ . The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct statement of the following:
- (a) If $d = \lambda$, the screen will contain only one maximum.
 - (b) If $\lambda < d < 2\lambda$, at least one more maximum (besides the central maximum) will be observed on the screen.
 - (c) Both (a) and (b)
 - (d) If the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit 1, the intensities of the observed dark and bright fringes will increase.
17. In single – slit Fraunhofer diffraction, the width of central maximum is greatest for the colour.
- (a) Violet
 - (b) Red
 - (c) Yellow
 - (d) Equal for all
18. The circularly polarized light is incident normally on a quarter wave plate. The emergent light will be
- (a) Plane polarized
 - (b) Circularly polarized
 - (c) Elliptically polarized
 - (d) Unpolarized
19. The wavelength of a photon and the de Broglie wavelength of an electron and Uranium atoms are identical. Which one of them will have highest kinetic energy?
- (a) Photon
 - (b) Electron
 - (c) Uranium atom
 - (d) Nothing can be predicted
20. When ${}_4^7\text{Be}$ transforms into ${}_3^7\text{Li}$, it does so by
- (a) Emitting an α particle only
 - (b) Emitting an electron only
 - (c) Emitting a neutron only
 - (d) Electron capture by the nucleus with emission of neutrino
21. Nucleus A has a half-life T and nucleus B has a half-life $2T$. Initially the number of nuclei of type A equals the number of nuclei of type B . After a certain time, 10% of the nuclei of type B remain. At this same time, what fraction of the nuclei of type A remains?
- (a) 5%
 - (b) 1%
 - (c) 0.01%
 - (d) 20%
22. At high temperatures, which material is best choice to be used as coolant in a Nuclear reactor?
- (a) Water
 - (b) Heavy water
 - (c) Molten Potassium
 - (d) Molten Carbon

23. Diamond lattice can be considered as a combination of two f_{cc} lattices displaced along the body diagonal by one quarter of its length. There are eight atoms per unit cell. The packing fraction of the diamond structure is
- (a) 0.48 (b) 0.74 (c) 0.34 (d) 0.68
24. In a simple cubic structure of lattice constant a , one plane among a set of parallel planes intercepts x , y and z axis $2a$, a , and a respectively. The inter planar spacing is
- (a) $a\sqrt{6}$ (b) a (c) $a/\sqrt{6}$ (d) $a/3$
25. Which of the following statement is correct for $NaCl$ crystal structure?
- (a) It is a face – centred cubic lattice with two atom basis
 (b) It is a simple cubic lattice with two atom basis
 (c) It is a face – centred cubic lattice with one atom basis
 (d) It is a simple cubic lattice with one atom basis
26. The X – ray diffraction pattern of a material contains only reflections with all – even or all – odd Miller indices. Then the crystal will be
- (a) Simple cubic (b) Hexagonal
 (c) Face centred cubic (d) Body centred cubic
27. In the basic band structure theory of crystalline solids. Which of the following leads to the energy gaps in the allowed electronic energy values?
- (a) Bragg reflection (b) Electron spin
 (c) Electron – Phonon interaction (d) Electron – Electron interaction
28. Thermal neutrons (energy = 300, $K_B = 0.025$ eV) and sometimes used for structural determination of materials. The typical lattice spacing of a material for which these can be used is
- (a) 0.01 nm (b) 0.05 nm (c) 0.1 nm (d) 0.15 nm
29. A particle is confined inside a one – dimensional box of length L and left unperturbed for a long time. In the most general case, the wave function must be
- (a) The ground state of energy
 (b) Periodic, where L equals an integer number of periods
 (c) A linear superposition of the energy Eigen functions.
 (d) Any one of the energy Eigen functions.

30. Photoelectric effect supports quantum nature of light because

- (a) There is a minimum frequency below which no photoelectrons are emitted.
- (b) The maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity.
- (c) Electric charge of the photoelectrons is quantized.
- (d) All of the above.

31. If $\psi(x, t) = A \sin(xp/\hbar) \exp(Et/\hbar)$ is the wave function of a particle of mass m in one dimension, where p and E are the momentum and energy respectively then which of the following cannot be an outcome of a measurement?

- (a) The momentum of the particle is p
- (b) Energy of the article is $p^2/2m$
- (c) Momentum is p^2 .
- (d) Momentum is zero.

32. To operate a $n - p - n$ transistor in active region, the emitter – base and collector – base junction respectively, should be

- (a) Forward biased and reverse biased
- (b) Forward biased and forward biased
- (c) Reversed biased and forward biased
- (d) Reverse biased and reverse biased

33. A charge Q is at the centre of two concentric spheres. The outward electric flux through the inner sphere is Φ , while that through the outer sphere is 2Φ . The amount of charge contained in the region between the two spheres is

- (a) $2Q$
- (b) Q
- (c) $-Q$
- (d) $-2Q$

34. Which of the following are essential for maintaining oscillations in an oscillator?

- 1. Positive feedback
- 2. Design of load (turned or phase shifting network)
- 3. Non – linear biasing circuit
- 4. High gain amplifier

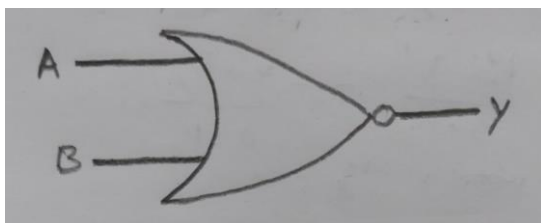
Select the correct answer using the codes below (codes)

- (a) 1,2,3 and 4
- (b) 1 and 4
- (c) 2,3 and 4
- (d) 1,2 and 3

35. The binary number 110000111101 corresponds to a hexadecimal number

- (a) CFD
- (b) D3C
- (c) DBF
- (d) C3D

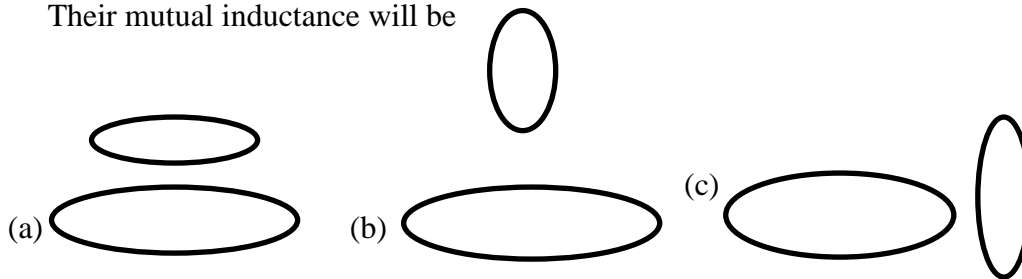
36. The minimum number of NAND gates required to design a given circuit



- (a) 3
- (b) 5
- (c) 6
- (d) 4

37. Two circular coils can be arranged in any of the three situations shown below.

Their mutual inductance will be



(a) Maximum in situation (a)

(b) Maximum in situation (b)

(c) Maximum in situation (c)

(d) The same in all situations

38. The partial differential equation $\partial^2 u / \partial t^2 - C^2 \{ \partial^2 u / \partial x^2 + \partial^2 u / \partial y^2 \} = 0$, where $C \neq 0$ is known as

(a) Heat equation

(b) Poisson's equation

(c) Wave equation

(d) Laplace equation

39. Which of the following is incorrect for the matrix

$$M = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

(a) It is its own inverse

(b) It is its own transpose

(c) It is non-orthogonal

(d) It has Eigen value ± 1

40. When the conduction current density and displacement current density are same, the dissipation factor will be

(a) $\text{Curl}(\underline{\mathbf{H}}) = \underline{\mathbf{J}}$

(b) $\text{Curl}(\underline{\mathbf{J}}) = \underline{\mathbf{dD}}/\underline{\mathbf{dt}}$

(c) $\text{Curl}(\underline{\mathbf{H}}) = \underline{\mathbf{D}}$

(d) $\text{Curl}(\underline{\mathbf{J}}) = \underline{\partial \mathbf{B}}/\underline{\partial t}$

41. If $\int \underline{\mathbf{H}} \underline{\mathbf{dl}} = 0$, then which statement will be true?

(a) $\mathbf{E} = -\text{Grad}(\mathbf{v})$

(b) $\mathbf{B} = -\text{Grad}(\mathbf{D})$

(c) $\mathbf{H} = -\text{Grad}(\mathbf{V}_m)$

(d) $\mathbf{D} = -\text{Grad}(\mathbf{A})$

42. What is the radius of a water drop with a charge $-e$ that would remain just suspended in the earth's electric field of 120 V m^{-1} , which is directed downwards.

(a) 77.6 nm

(b) 77.6 m

(c) 7.76 mm

(d) 0.776 mm

43. The difference between fermions and bosons is that bosons do not obey

(a) Aufbau principle

(b) Pauli exclusion principle

(c) Hund's rule of maximum multiplicity

(d) Heisenberg's uncertainty principle

44. Calculate $\int_c 4y \, dx + 2z \, dy + 6y \, dz$ where c is the curve of intersection of $x^2 + y^2 + z^2 = 6z$ and $z = x + 3$.
- (a) $34\sqrt{2} \pi$ (b) $32\sqrt{6} \pi$ (c) $36\sqrt{2} \pi$ (d) $36\sqrt{6} \pi$
45. The speed of an electron, whose de Broglie wavelength is equal to its Compton wavelength, is (C is the speed of light)
- (a) C (b) $C/\sqrt{2}$ (c) $C/2$ (d) $C/3$
46. A blackbody at temperature T emits radiation at a peak wavelength λ . If the temperature of the blackbody becomes $4T$, the new peak wavelength is
- (a) $(1/256)\lambda$ (b) $(1/164)\lambda$ (c) $(1/16)\lambda$ (d) $(1/4)\lambda$
47. In a streamline flow,
- (a) The moments of all the particles arriving at a given point are the same
 (b) The speed of the particle always remains the same
 (c) The kinetic energies of all the particles arriving at a given point are the same
 (d) Both (a) & (c)
48. Which of the following is not the standard form of a sine wave?
- (a) $Y = A\sin 2\pi(t/T - x/\lambda)$ (b) $Y = A\sin(\nu t - kx)$
 (c) $Y = A\sin\omega(t - x/v)$ (d) $Y = A\sin k(\nu t - x)$
49. An ideal flow of any fluid must satisfy
- (a) Bernoulli's theorem (b) Pascal law
 (c) Continuity equation (d) Boundary layer theory
50. The probability of transmission through a potential barrier of height V , and width a of the barrier
- (a) Decreases exponentially with the width a of the barrier
 (b) Does not depend on the width of the barrier
 (c) Is directly proportional to the width a of the barrier
 (d) Is inversely proportional to the width a of the barrier.