J-92

ENTRANCE EXAMINATION, FEBRAURY 2015
QUESTION PAPER
Ph.D. (ACRHEM)

Marks: 75
Time: 2.00 Hrs. Hall Ticket No.:

Please confirm that
(a) This booklet has 12 pages (including 2 blank pages) printed clearly and numbered
(b) You are given a clean and clear OMR answer sheet.

Read **carefully all the instructions** given below and on the OMR sheet.

1. Please enter your Hall Ticket Number on Page 1 **(this sheet)** of this booklet **without fail.**
2. Please enter your Hall ticket number on the **OMR answer sheet without fail.**
3. All answers are to be marked on the OMR answer sheet following the instructions provided on the OMR answer sheet.
4. **No additional sheets will be provided.** Rough work is to be done in the booklet itself / space provided at the end of the booklet on pages 11&12.
5. **Handover the OMR answer** sheet at the end of the examination.
6. Question paper has two parts: **Part–A** and **Part–B.**
7. **Part–A** consists of 25 objective type questions of one mark each. **There is negative marking of 0.33 marks for every wrong answer.** The marks obtained by the candidate in this part will be used for resolving tie cases.
8. **Part–B** consists of 25 questions. Each correct answer carries two marks. There is no negative marking in this section.
9. Non-programmable calculators are permitted.
10. All symbols used in the text have their usual meanings.

PART A

1. A n–MOS transitor with a threshold voltage V_T= 0.8 V operates with Gate – Source voltage, V_{GS}, in the range of 1.5 to 4.0 V. The largest value of Drain – Source voltage, V_{DS}, for which the channel remains continuous is
   (A) 0.7 V (B) 2.5 V (C) 3.7 V (D) 2.3 V

2. Which one of the following is NOT true for an ideal operational amplifier (OP amp)?
   (A) It has infinite voltage gain
   (B) It has infinite input impedance
   (C) It has low common mode rejection ratio
   (D) It has infinite common mode rejection ratio

3. In a newton's rings experiment, what happens if the lens is slowly moved upwards?
   (A) The rings expand
   (B) The fringe width increases
   (C) The rings collapse to the centre
   (D) The fringe pattern loses circular shape

4. In an experiment to study the characteristics of a JFET, the following readings were obtained (V_{DS} is Drain-source voltage, V_{GS} is Gate-source voltage, I_D is Drain current)

V_{DS} (V)	3	10	10
V_{GS} (V)	0	0	-0.5
I_D (mA)	7	7.5	6.0

   The amplification factor of the JFET is
   (A) 22.5
   (B) 3
   (C) 60
   (D) 42

5. The probabilities that an electron occupies an energy level in a state that is above the Fermi level (E_F), are given as f_1, f_2, and f_3 respectively, at kT, 5 kT, and 10 kT. The approximate values of f_1, f_2, and f_3 are

   (A) 0.269, 6.7×10^{-3}, 4.5×10^{-5}
   (B) 4.5×10^{-5}, 6.7×10^{-3}, 0.269
   (C) 1.4, 6.7×10^{-2}, 4.5×10^{-4}
   (D) 1, 0.269, 6.7×10^{-3}

6. A crystal plane is formed by intersecting the three axes, a_1, a_2, a_3, at $4a_1$, $3a_2$, and $2a_3$. The corresponding miller indices of two planes are
   (A) (4 3 2) (B) (3 4 6) (C) (4 3 6) (D) (2 3 4)

7. The Fermi-Dirac distribution is given by

(A) $\frac{1}{e^{kT(E-E_F)}+1}$

(B) $\frac{1}{e^{kT(E+E_F)}+1}$

(C) $\frac{1}{e^{kT(E-2E_F)}+1}$

(D) $\frac{1}{e^{kT(2E-E_F)}+1}$

8. The c/a ratio and packing fraction of a hcp crystal are

(A) $\sqrt{\frac{8}{3}}, 0.74$

(B) $\sqrt{\frac{6}{3}}, 0.78$

(C) $\sqrt{\frac{8}{3}}, 0.58$

(D) $\sqrt{\frac{6}{3}}, 0.5$

9. The order, location of branch points and the number of sheets of the Riemann surfaces of W= $(Z - i)^{1/3}$ are
(A) Second order branch points at Z = i, with four sheets
(B) First order branch points at Z = i, with one sheets
(C) Third order branch points at Z = i, with three sheets
(D) Third order branch points at Z = i, with four sheets

10. Inter atomic forces in solids are
(A) Attractive only
(B) Repulsive only
(C) Neither attractive nor repulsive
(D) Both attractive and repulsive

11. The free electron theory of metals states that
(A) Kinetic energy of electron is zero
(B) Potential energy of electron is zero
(C) Both the kinetic energy and potential energy is zero
(D) Total energy is independent of temperature

12. The half-life of a radioactive element is 2 days. After how many days will $1/64^{th}$ of element will be left behind
(A) 10
(B) 120
(C) 12
(D) 20

13. The effective mass of an electron
   (A) Depends on effective charge only
   (B) Can never be negative
   (C) Can never be positive
   (D) Can be positive, negative as well as infinite

14. Where will the charge reside on the conductor?
   (A) Surface
   (B) Inside the conductor
   (C) Both inside and outside
   (D) No where

15. A vector $\bar{A}$ is a solenoidal if
   (A) $\nabla \times \bar{A} = 0$
   (B) $\nabla^2 \bar{A} = 0$
   (C) $\nabla \times (\nabla \times \bar{A}) = 0$
   (D) $\nabla . \bar{A} = 0$

16. Poisson and Laplace equations are
   (A) $\nabla^2 V = 0, \nabla^2 \emptyset = -\rho$
   (B) $\nabla^2 V = -\epsilon_0, \nabla^2 \emptyset = -\frac{\rho}{\epsilon_0}$
   (C) $\nabla^2 V = -\frac{\rho}{\epsilon_0}, \nabla^2 \emptyset = 0$
   (D) $\nabla^2 V = 0, \nabla^2 \emptyset = 0$

17. The diameter of hydrogen atom is
   (A) 10 nm (B) 0.1 nm (C) 1 nm (D) 0.01 nm

18. A S-polarized light falls on an optical system consisting of a half-wave plate and a polarizer. What happens to the output light if the half-wave plate is rotated along the axis passing through the propagation direction?
   (A) Polarization changes but intensity remains the same
   (B) Both intensity and the polarization changes
   (C) Intensity changes but polarization remains the same
   (D) Both intensity and polarization are unchanged

19. The condition which shows that magnetic monopole does not exist is
   (A) $\nabla \times \bar{B} = 0$
   (B) $\nabla . \bar{E} = -\frac{\partial \bar{B}}{\partial t}$
   (C) $\nabla^2 \bar{B} = 0$
   (D) $\nabla . \bar{B} = 0$

20. A wire under tension T emits a note of frequency υ, when plucked. If the tension in the wire is increased by ΔT, then the change in frequency Δυ of the note emitted by the wire is approximately equal to

(A) $\frac{\upsilon}{2}\frac{\Delta T}{T}$

(B) $\upsilon\sqrt{\frac{\Delta T}{T}}$

(C) $\frac{\upsilon}{2}$

(D) $2\upsilon\left(\frac{\Delta T}{T}\right)^2$

21. A particle of mass 'm' is moving in one dimension in an infinite square well with a wave function $\psi(x, t=0) = A(a^2 - x^2)$. What is the probability that a measurement of the energy will give the value $9h^2/8mL^2$

(A) $960/\pi^6$ (B) $1.31/\pi^3$ (C) $1.31/\pi^6$ (D) $960/\pi^3$

22. The steady state current in an LCR circuit with R = 25 Ohms, L = 15 Henry, C = 0.05 Farad, E_0 = 100 Volts and ω = 4 is

(A) (50 sin4t – 110 cos4t)/73
(B) (110 sin4t – 50 cos4t)/73
(C) (50 cos8t – 110 sin8t)/30
(D) (110 sin8t – 50 cos8t)/30

23. The electron concentration in four materials is 1) 10^{26} 2) 10^{24} 3) 10^{20} 4) $10^{16}/m^3$. Which material is most likely to have a wavelength in the IR region corresponding to its plasma frequency

(A) 3 (B) 1 (C) 2 (D) 4

24. An object acted upon by conservative force slides on a frictionless surface. If the co-ordinates are *x,y* and the potential energy function for the force is given by $U(x, y) = \frac{k}{2}(x^2 + y^2)$, what is the force acting on the object ?

(A) $-k(x\hat{\imath} + y\hat{\jmath})$
(B) $k(x\hat{\imath} + y\hat{\jmath})$
(C) $-kx$
(D) $-k(x + y)$

25. In a double slit interference experiment, one of the slits is covered with thin mica sheet of refractive index 1.58. The separation between the sources is 0.1 cm and the screen distance is 50 cm. If the central fringe shifts by 0.2 cm because of the introduction of the mica sheet, what is the thickness of the sheet?

(A) 250 μm
(B) 430 μm
(C) 250 μm
(D) 670 μm

PART B

26. If a 980 N person climbs slowly into a car of weight 1000 kg, its center of gravity sinks by 2.8 cm. When the car, with the person aboard, hits a bump, it starts oscillating up and down. If the shock absorber is modelled as a spring and the car and person are modelled as a single body, what is the frequency of oscillation?
(A) 1.11 Hz
(B) 90 Hz
(C) 0.9 Hz
(D) 240 Hz

27. What accelerating voltage is required to produce electrons with wavelength 10 pm from an electron gun used in Davisson-Germer experiment?
(A) 18 V
(B) 230 V
(C) 55 KV
(D) 15 KV

28. The efficiency of Carnot engine working between steam point and ice point is
(A) 20% (B) 27% (C) 34% (D) 50%

29. An electric current of 10A is maintained for 1 sec in a resistance of 25 ohms. The temperature of resistor is kept constant at 27^0 C. The entropy change of universe is
(A) 4.16 J/K
(B) 0
(C) 16.66 J/K
(D) 8.33 J/K

30. N particles are distributed among three states with energies $E_1 = 0$, $E_2 = KT$ and $E_3 = 3KT$. If total free energy of system is 1000 KT, what is the value of N
(A) 1246
(B) 1532
(C) 2454
(D) 2874

31. At what temperatures are the rates of spontaneous and stimulated emission are equal (assume $\lambda = 500$ nm)
(A) 41562 K
(B) 32456 K
(C) 28765 K
(D) 54336 K

32. Two Nicol prisms are arranged such that the amount of light transmitted through them is maximum. What will be the percentage reduction in intensity of incident light when the angle is rotated by 30^0?
(A) 50% (B) 25% (C) 75% (D) 45%

33. An ideal monatomic gas at 300 K expands adiabatically and reversibly to twice its volume. What is its final temperature?
(A) 289 K (B) 189 K (C) 389 K (D) 489 K

34. A crystal belongs to face centered cubic (FCC) lattice with four atoms in the unit cell. Determine the structure factor for (0 1 0) and (2 0 0) reflections
(A) (0, 4f) (B) (0, f) (C) (0, 2f) (D) (2f, 0)

35. Electrons are accelerated by 844 eV and reflected from a crystal. The reflection maximum occurs when the glancing angle is 58^0. The inter planar spacing in the crystal is:
(A) 0.25 Å (B) 0.7 Å (C) 0.5 Å (D) 0.248 Å

36. If the atomic radius for FCC type Pb is 0.175 nm, the volume of unit cell is?
(A) $100 \times 10^{-30}\, m^3$
(B) $1.21 \times 10^{-28} m^3$
(C) $1.21 \times 10^{-26} m^3$
(D) $1.5 \times 10^{-28} m^3$

37. At 0 K, $E_F = 7.05$ eV, find the Fermi energy at 235 K.
(A) 7.05 eV (B) 6.5599 eV (C) 6.00 eV (D) 7.0499 eV

38. Find the number of energy states available for the electrons in a cubical box of 0.01 m side lying below energy of 4 eV.
(A) 30.3×10^{15}
(B) 36.2×10^{21}
(C) 50.5×10^{22}
(D) 12.2×10^{22}

39. A metal has 3 valence electrons per atom. If its atomic weight is 0.03 $\frac{kg}{mol}$, density 3000 $\frac{kg}{m^3}$ and conductivity $3 \times 10^7 \frac{s}{m}$ then, what is the electron mobility if all the valence electrons are free?
(A) $1.7 \times 10^{-4} \frac{m}{s}$
(B) $1.7 \times 10^{4} \frac{m}{s}$
(C) $0.66 \times 10^{12} \frac{m}{s}$
(D) $0.66 \times 10^{-4} \frac{m}{s}$

40. One end of a spring is clamped horizontally to a wall and the other end is given a vibration in the same direction, such that motion of the free end is approximately simple harmonic. If the frequency of oscillations is 10 Hz and the amplitude is 4 mm, what is the velocity when the displacement of the free end is 2 mm?

(A) 0.182 m/sec
(B) 218 m/sec
(C) 262 m/sec
(D) 0.218 m/sec

41. Given displacement $\bar{D} = z\rho cos^2\emptyset \hat{a}_z \frac{C}{m^2}$, calculate the charge density at $(1, \frac{\pi}{4}, 3)$ and the total charge enclosed by the cylinder of radius 1 m with $-2 \leq z \leq 2\,m$

(A) $\frac{4\pi}{3}C$
(B) $4C$
(C) $6\pi C$
(D) $\frac{2\pi}{3}C$

42. A point charge of 3 μC is located at the origin in addition to the two charges $-4\ \mu C$ and $5\ \mu C$ located (2, −1, 3) and (0, 4, −2) respectively. Find the potential at (−1, 5, 2) assuming V(∞) = 0.

(A) 5 kV
(B) 10.3 kV
(C) 2 kV
(D) 2.5 kV

43. For the current density $\bar{J} = 10\ zsin^2\emptyset \hat{a}_\rho \frac{A}{m^2}$, find the current through the cylindrical surface $\rho = 2, 1 \leq z \leq 5\,m$.

(A) 754 A
(B) 12 A
(C) 120 A
(D) 725 A

44. In an one dimensional device, the charge density is given by $\rho_v = \rho_0 \frac{x}{a}$. If $\bar{E} = 0$ at $x = 0$, and $v = 0$ at $x = a$, find V and $\bar{E}$

(A) $v = \frac{\rho_0(a^3 - x^3)}{6\epsilon a}, \bar{E} = \frac{x^2\rho_0}{2\epsilon a}\hat{a}_x$
(B) $v = \frac{\rho_0 x^3}{6\epsilon a}, \bar{E} = \frac{x\rho_0}{2\epsilon a}\hat{a}_x$
(C) $v = \frac{\rho_0(a^2 - x^2)}{6\epsilon a}, \bar{E} = \frac{\rho_0}{2\epsilon a}\hat{a}_x$
(D) $v = \frac{\rho_0 a^3}{6\epsilon a}, \bar{E} = \frac{x^2\rho_0}{2\epsilon a}\hat{a}_y$

45. From dimensional analysis, the trajectory for a given value of energy release in a medium is given by $R_S = At^{0.4}$. What is the nature of the velocity of the wave with increasing distance and the deceleration parameter?

(A) Wave accelerates with deceleration parameter of 3/2

(B) Wave decelerates with deceleration parameter of -5/2

(C) Wave decelerates with deceleration parameter of -3/2

(D) Wave accelerates with deceleration parameter of 5/2

46. Jones and Mueller's matrices for homogenous left circular polarizer are

(A) $\frac{1}{2}\begin{bmatrix} 1 & -i \\ i & 1 \end{bmatrix}$ *and* $\frac{1}{2}\begin{bmatrix} 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 \end{bmatrix}$

(B) $\frac{1}{2}\begin{bmatrix} 1 & i \\ -i & 1 \end{bmatrix}$ *and* $\frac{1}{2}\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \end{bmatrix}$

(C) $\frac{1}{2}\begin{bmatrix} 1 & 0 \\ 0 & i \end{bmatrix}$ *and* $\frac{1}{2}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -1 & 0 \end{bmatrix}$

(D) $\frac{1}{2}\begin{bmatrix} 1 & 0 \\ 0 & -i \end{bmatrix}$ *and* $\frac{1}{2}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$

47. The current in the LCR circuit with zero initial current and charge with R = 6 ohm, L = 1 Henry, C = 0.05 Farad, E = 24 cos5t Volts is

(A) $e^{-4t}(4 \sin 3t - 3 \cos 3t) + 5 \cos 4t$

(B) $e^{-3t}(3 \sin 4t - 4 \cos 4t) + 4 \cos 5t$

(C) $e^{-5t}(5 \sin 5t - 4 \cos 5t) + 4 \cos 5t$

(D) $e^{-2t}(2 \sin 4t - 4 \cos 4t) + 3 \cos 4t$

48. A Hydrogen atom is in the ground state with a wave function $\psi_{1s}(r)$ of total energy E_S = -0.5 a.u. The classically forbidden region and the probability to find the electron in the region are

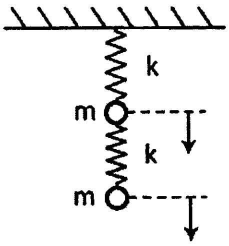
(A) $r \geq a_0$ and 0.119

(B) $r \leq 2a_0$ and 0.238

(C) $r \leq a_0$ and 0.119

(D) $r \geq 2a_0$ and 0.238

49. Two equal masses are connected as shown below with identical springs. Considering only vertical motion, the frequencies of normal modes of the system are



(A) $\sqrt{\frac{(3\pm\sqrt{5})k}{2m}}$

(B) $\sqrt{\frac{(2\pm\sqrt{8})k}{2m}}$

(C) $\sqrt{\frac{(1\pm\sqrt{3})k}{2m}}$

(D) $\sqrt{\frac{(9\pm\sqrt{7})k}{2m}}$

50. A boundary-value problem $\frac{d^2y}{dx^2} = y \; with \; \frac{dy(0)}{dx} = 0 \; and \; y(1) = 1$ with analytical solution given by y = (cosh x/cosh 1) is solved using finite difference method and cubic spline methods, respectively. The solutions y(0.5) for these methods, respectively, are

(A) 0.2066 and 0.6560
(B) 0.7266 and 0.9376
(C) 0.6560 and 0.2066
(D) 0.9376 and 0.7266