BIRLA INSTITUTE OF TECHNOLOGY
MESRA – 835215, RANCHI, INDIA

UG

Name: …… Roll No.: ……..

Branch: …… Signature of Invigilator: ……

Semester: VIth Date: 10/05/2022 (MORNING)

Subject with Code: **EC363 NANOELECTRONICS**

Marks Obtained	Section A (30)	Section B (20)	Total Marks (50)

INSTRUCTION TO CANDIDATE

1. The booklet (question paper cum answer sheet) consists of two sections. First section consists of MCQs of 30 marks. Candidates may mark the correct answer in the space provided / may also write answers in the answer sheet provided. The Second section of question paper consists of subjective questions of 20 marks. The candidates may write the answers for these questions in the answer sheets provided with the question booklet.
2. The booklet will be distributed to the candidates before 05 minutes of the examination. **Candidates should write their roll no. in each page of the booklet.**
3. Place the Student ID card, Registration Slip and No Dues Clearance (if applicable) on your desk. All the entries on the cover page must be filled at the specified space.
4. Carrying or using of mobile phone / any electronic gadgets (except regular scientific calculator)/chits are strictly prohibited inside the examination hall as it comes under the category of unfair means.
5. No candidate should be allowed to enter the examination hall later than 10 minutes after the commencement of examination. Candidates are not allowed to go out of the examination hall/room during the first 30 minutes and last 10 minutes of the examination.
6. Write on both side of the leaf and use pens with same ink.
7. The medium of examination is English. Answer book written in language other than English is liable to be rejected.
8. All attached sheets such as graph papers, drawing sheets etc. should be properly folded to the size of the answer book and tagged with the answer book by the candidate at least 05 minutes before the end of examination.
9. The door of examination hall will be closed 10 minutes before the end of examination. Do not leave the examination hall until the invigilators instruct you to do so.
10. Always maintain the highest level of integrity. Remember you are a BITian.
11. Candidates need to **submit the question paper cum answer sheets before leaving the examination hall**.

BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS:BTECH **SEMESTER : VI**
BRANCH: ECE **SESSION: SP/22**

SUBJECT: EC363 (S) NANOELECTRONICS (SPL)

TIME: 2Hrs **FULL MARKS: 50**

INSTRUCTIONS:

1. The question paper contains 2 Sections (Section A and B).
2. Section A contains 30 multiple choice questions of 1 mark each. All questions are compulsory. Do not overwrite or put multiple ticks. Put one single tick appropriately in front of the correct answer. Any ambiguity in the tick will result in zero marks.
3. Section B contains 4 questions of total 20 marks. All questions are compulsory.
4. The missing data, if any, may be assumed suitably.
5. Standard values of constants must be assumed in the numerical type questions.

SECTION A [30]

Q1. Energy (in eV) for electron of wavelength 490nm is _____ .

a. 4eV
b. 2.5eV
c. 0.25eV
d. 0.4eV

Q2. In quantum dots, If the radius is smaller than the excition Bohr radius then we will get ___.

a. No Confinement
b. Weak Confinement
c. Medium Confinement
d. Strong Confinement

Q3. Exactly what is a “Hole” in semiconductor terminology?

a. Another name for a positron.
b. A bound state of an electron.
c. A fictitious particle that is really just an empty state in a nearly empty band
d. An impurity (in small concentration) in the crystal lattice

Q4. Assume that HeNe laser pointer outputs 10mW of power at 632nm. Then the energy per photon and the number of photons per second, N are _____.

a. 1.96 eV, $\sim 3 \times 10^{16}$ photons/s.
b. 3.145×10^{-19} J, $\sim 3 \times 10^{15}$ photons/s.
c. 1.96 eV, $\sim 3 \times 10^{15}$ photons/s.
d. 3.145×10^{-19} J, $\sim 3 \times 10^{14}$ photons/s.

Q5. The bandgap is an important property of a semiconductor, but the type of bandgap is also important. Which of the three semiconductors, Ge, Si, and GaAs, has a direct bandgap?

a. Ge
b. Ge and Si
c. GaAs
d. Ge and GaAs

Q6. Double derivative operator if applied on Sin(4x).Calculate its Eigen value.

a. -8
b. -32
c. -16
d. Correct answer not given

Q7. The velocity of interest for a wavepacket that is spreading while propagating in space is its:

a. Drift velocity
b. Phase velocity
c. Group velocity
d. Dispersion velocity

Q8. Consider an electron confined to an infinite potential well having length 2nm. What wavelength photons will be emitted from transitions between the lowest three energy levels (level 3 to 1, level 3 to 2 and level 2 to 1 respectively).

a. 0.75, 0.47, 0.28
b. 0.28, 0.75, 0.47
c. 0.88,0.32, 0.56
d. 0.75, 0.47,0.32

Q9. If Fermi wavelength is very very smaller than any one dimension then we have _____.

a. A Quantum Dot
b. An effectively two dimensional system
c. A Quantum well
d. 1-Dimensional electron gas

Q10. A 3eV electron is to be confined in a square quantum dot of side L. What should be L in order for the electron's energy levels to be well-quantized?

a. $L \leq 0.708$ nm
b. $L \geq 0.708$ nm
c. $L = 0.708$ nm
d. Sufficient data not given

Q11. A tunnel junction can be schematically represented as :

a. A series combination of capacitor and tunnelling resistance
b. A parallel combination of capacitor and tunnelling resistance
c. A parallel combination of inductor and tunnelling resistance
d. A series combination of inductor and tunnelling resistance

Q12. The maximum kinetic energy that can be observed for emitted electrons when photons having wavelength, $\lambda = 248$ nm are incident on a metal surface with work function 4.8eV is _____ .

a. 0.4 eV
b. 0.3 eV
c. 0.2 eV
d. 0.1 eV

Q13. The drawback associated with the shrinking of conventional device dimensions include:

a. Device Cost
b. Time to manufacture
c. Heat Dissipation
d. None

Q14. Consider a (n, 0) zigzag carbon nanotube that has radius 0.3523 nm. What is the value of the index 'n'?

a. 9
b. 0.9
c. 8
d. 0.8

Q15. In Paramagnetic material, atoms have a small net _____ due to incomplete cancellation of _____.

a. Magnetic moment, angular and spin momentums.
b. Piezoelectric effect, angular and spin momentums.
c. Pyro magnetic effect, linear, and spin momentums.
d. Magnetic moment, linear and spin momentums.

Q16. Consider a proton having kinetic energy 2:5eV. What size space does the proton need to be confined in order to observe clear energy discretization?

a. 181 nm
b. 0.0181 nm
c. 0.181 nm
d. Sufficient data not given

Q17. For a tunnel junction with C= 5fF and Rt= 0.1 MΩ, what is the RC time constant? What does this value mean for the tunnel junction circuit?

a. 0.5 nanoseconds, characteristic time between two collisions
b. 0.5 nanoseconds, characteristic time between the tunneling events
c. 5 nanoseconds, characteristic time for capacitor charging and discharging
d. 5 nanoseconds, characteristic time between the tunneling events

Q18. Characteristic time to flip its spin is known as _____.

a. Spinning time
b. Flipping time
c. Relaxation time
d. Spin –flip time

Q19. Consider an electron in a room of size 10^{-9} x 10^{-9} x 10^{-9} m^3. Assume that within the room potential energy is zero, and that the walls and ceilings of the room are perfect (so that the electron cannot escape from the room). If the electron's energy is approximately 5 eV, What is the state index, $n = (n_x^2 + n_y^2 + n_z^2)^{0.5}$? What is the approximate energy difference $E_{2,1,1} - E_{1,1,1}$? Also identify whether the energy is continuous or discrete?

a. 6.35, 1eV, continuous energy
b. 3.65, 1.12eV, discrete energy
c. 6.35, 1eV, discrete energy
d. 3.65, 1.12eV, continuous energy

Q20. Single electron transistors work on the principle of

a. Kronig penny model
b. Bloch's Theorem
c. Moore's law
d. Coulomb Blockade effect

Q21. GMR in spin-based devices stands for ____ .

a. Giant Magneto resistance effect
b. Geometric Mean resistance effect
c. Greenwich Mean resistance effect
d. Gentle magneto resistance effect

Q22. Electron transition occurring within a particular energy band (either conduction or valence band) due to low energies is known as _____ .

a. Excitonic Transition
b. Interband Transition
c. Intersubband Transition
d. None of the above

Q23. Which of these are three common methods of Self Assembly Technique?

a. Lattice Mismatch, Annealing, Etching
b. Wet Chemical Methods, Molecular Self Assembly, Lattice Mismatch
c. Molecular Self Assembly, Atomic Self Assembly, Annealing
d. Etching, Annealing, Wet Chemical Methods

Q24. The energy bands in the higher Brillouin zone can be translated to the first Brillouin zone by the shifts of n2Pi/a. This results in:

a. Extended Zone Scheme
b. Repeated Zone Scheme
c. Reciprocal Zone Scheme
d. Reduced Zone Scheme

Q25. Reflection probability of an electron wave is

a. Inverse of the tunneling probability
b. The modulus squared of the ratio of the reflected to incident wavefunctions
c. The modulus squared of the ratio of the incident to reflected wavefunctions
d. Both (a) and (c)

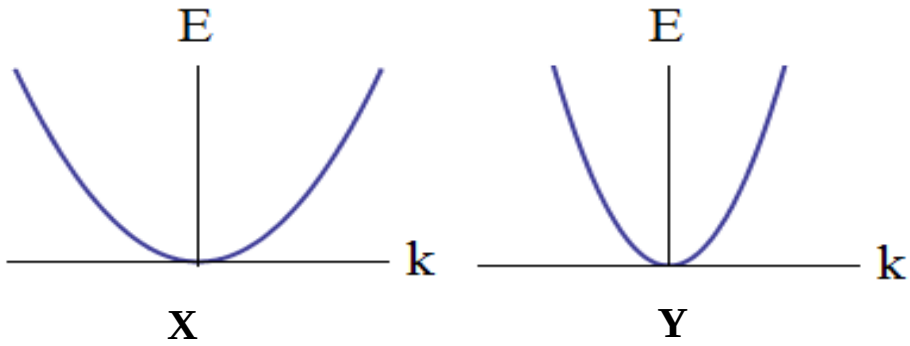
Q26. Density of States versus energy plot for an effectively two dimensional electron system (Quantum well) is

a. Exponentially Increasing
b. Exponentially Decreasing
c. Parabolic
d. Staircase

Q27. According to Quantum theory for a single tunnel junction, If T represents transmission probability, R represents reflection probability, E is energy of incident electron and Vo is barrier potential, choose correct option:

a. If $E < Vo$, $T \neq 1$, $R \neq 1$
b. If $E < Vo$, $T \neq 0$, $R \neq 1$
c. If $E < Vo$, $T \neq 0$, $R = 0$
d. If $E < Vo$, $T = 1$, $R = 0$

Q28. From the given E-K diagrams identify which particle (X or Y) has higher Effective mass?

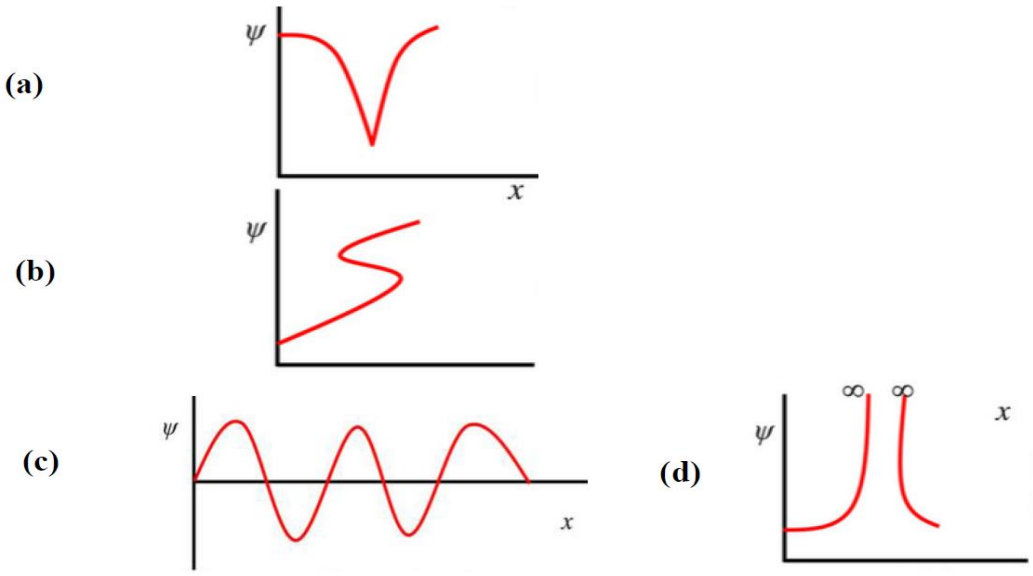


Answer : _____.

Q29. According to the Heisenberg uncertainty Principle, one cannot precisely measure:

a. Position and momentum of a particle in different directions
b. Position and momentum of two different particles in same direction
c. Energy and time of a particle in same direction
d. Energy and momentum of a particle in same direction

Q30. Which of the following are valid wavefunctions according to Born Interprettion?



SECTION B [20]

Q1. a) Explain atleast two differences between a fermion and a boson. Also, give two examples of each. [2]

b) Compute : $[\hat{P}, \hat{H}]$. Does this pair commutate or not? What does the result signify? [2]

Q2. a. Find out the expectation value of momentum for wave function : [2]

$$\Psi(x) = x \sin(n\pi x)$$

b. Define any two: [3]

a. Modulation Doping
b. Density of States
c. Degenerate energies

Q3. Derive the normalised wave function, energy and density of states (with DOS vs. energy plot) of quantum wire. [6]

Q4. i) Write Short notes on any two: [3]

a. Nano imprint Fabrication Technique
b. Quantum Conductance
c. Spin Transport

ii) If a molecule having mass 2.3×10^{-26} Kg is confined to a region 200nm in length, what is the minimum uncertainty in the molecule's velocity? [2]