M.Sc. PHYSICS
THIRD SEMESTER
ELEMENTS OF MODERN PHYSICS (MDC)
MPH-306

Duration: 3 Hrs. **Marks: 70**

PART : A (OBJECTIVE) = 20
PART : B (DESCRIPTIVE) = 50

[PART-B : Descriptive]

Duration: 2 Hrs. 40 Mins. **Marks: 50**

[Answer question no. One (1) & any four (4) from the rest]

1. What are the postulates of special theory of relativity? (2+5+3=10)
   Derive the Lorentz transformation equation based on invariance of speed of light in free space.
   How fast would a rocket have to go relative to an observer for its length to be contracted to 99% of its length at rest?

2. Derive the time independent Schrödinger wave equation for a particle. (5+3+2=10)
   Give physical interpretation of wave function ψ associated with a particle.
   Using operator representation of the x-component of a particle, prove that $(x\hat{p}_x - \hat{p}_x x)\psi = i\hbar\psi$, ($\psi$ is an arbitrary function).

3. Prove that zero resistivity and Meissner effect in a superconductor are mutually consistent. (5+5=10)
   Explain the type-I and type-II superconductors using Meissner effect. Show graphically how their magnetization varies with applied magnetic field.

4. Define nuclear fission and fusion. (2+8=10)
   Discuss the construction and working principle of a nuclear power reactor.

5. What is population inversion, define with figures? In context of lasers; deduce the Einstein coefficients. (5+5=10)

6. What is band theory? How the band structures of conductor and semiconductors are different from each other? Show with figure and their proper notation. (2+8=10)

7. What is X-ray diffraction by a crystal? Deduce the expression of Bragg's law. (2+8=10)

8. Define with figure (a) crystal lattice, (b) unit cell, (c) basis, (d) lattice constant, (e) lattice translational vector. (5×2=10)

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[PART-A : Objective]

Choose the correct answer from the following: **1×20=20**

1. According to Newtonian mechanics, space:
   a. is absolute b. is relative
   c. depends on time d. none of these

2. According to special theory of relativity, velocity of light in free space is:
   a. 0
   b. ∞
   c. constant
   d. none of these

3. For velocity $v \ll c$, Lorentz transformation reduces to _____ transformation.
   a. Newtonian b. Fourier
   c. Galilean d. Hamiltonian

4. Superconductor follows:
   a. Perfect magnetism
   b. Perfect diamagnetism
   c. Perfect ferromagnetism
   d. Perfect anti-ferromagnetism

5. "Ultraviolet catastrophe" resulted in:
   a. Wein's radiation theory
   b. Plank's quantum theory
   c. Rayleigh-Jeans Law
   d. Photoelectric effect

6. The de Broglie wavelength for matter wave is given by:
   a. $\lambda = \infty$
   b. $\lambda = \frac{h}{2\pi}$
   c. $\lambda = \frac{h}{mv}$
   d. $\lambda = \frac{mv}{h}$

7. Normalization condition for a wave function ψ is:
   a. $\int_{-\infty}^{\infty} \psi\psi^* d\tau = 0$
   b. $\int_{-\infty}^{\infty} \psi\psi^* d\tau = 1$
   c. $\int_{-\infty}^{\infty} \psi\psi^* d\tau = \hbar$
   d. $\int_{-\infty}^{\infty} \psi\psi^* d\tau = E$

8. In nuclear chain reaction the number of neutrons goes on multiplying almost in _____ during fission.
   a. arithmetic progression
   b. geometric progression
   c. harmonic progression
   d. none of these

9. Binding energy curve per nucleon attains a maximum for the nucleus of:
   a. $_{92}U^{238}$
   b. $_{14}Si^{28}$
   c. $_{4}Be^{7}$
   d. $_{26}Fe^{56}$

10. Select the correct number of neutrons in the following fission reaction
    $_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236*} \rightarrow {}_{54}Xe^{141} + {}_{38}Sr^{94} +$ _____ + Q.
    a. $4\ {}_{0}n^{1}$
    b. $3\ {}_{0}n^{1}$
    c. $2\ {}_{0}n^{1}$
    d. ${}_{0}n^{1}$

11. According to band theory of solids, with decrease in distance between atoms, the energy difference between each allowed state:
    a. Increases.
    b. Decreases.
    c. Depends on the material.
    d. None of the above.

12. Fermi energy is the:
    a. Lowest allowed energy level at 0°k.
    b. Highest allowed energy level at 0°k.
    c. Lowest occupied energy level at 0°k.
    d. Highest occupied energy level at 0°k.

13. In a p-type semiconductor holes and electrons are:
    a. Always equal.
    b. Sometime equal.
    c. Holes are more than electrons.
    d. Electrons are more than holes.

14. Laser is the result of:
    a. Spontaneous emission
    b. Diffused emission
    c. Stimulated emission
    d. None of the above

15. In a laser resonator there must be:
    a. A pair of lenses.
    b. A pair of facing mirrors.
    c. A pair of a facing mirror and one lens.
    d. No lens no mirrors.

16. In a FCC crystal the total number of atoms per unit cell is:
    a. 1 b. 2 c. 3 d. 4

17. The bonding that holds together the two strands of DNA is:
    a. Ionic
    b. Covalent
    c. Metallic
    d. Hydrogen

18. An exciton is:
    a. A strongly bound electron and ion pair.
    b. A weakly bound electron ion pair.
    c. A weakly bound electron hole pair.
    d. A strongly bound electron hole pair.

19. In an extrinsic n-type semiconductor the fermi level_____ in the energy band diagram.
    a. Remain in the same position.
    b. Moves downwards.
    c. Moves upwards.
    d. Moves left.

20. With increase in temperature the electrical conductivity of intrinsic semi-conductor:
    a. Decreases.
    b. Increases.
    c. Remain same.
    d. First increase and then decreases.

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UNIVERSITY OF SCIENCE & TECHNOLOGY, MEGHALAYA

[PART (A) : OBJECTIVE]

Duration : 20 Minutes

Serial no. of the main Answer sheet

Course : .....

Semester : ..... **Roll No :** .....

Enrollment No : ..... **Course code :** .....

Course Title : .....

Session : 2017-18 **Date :** .....

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Instructions / Guidelines

- The paper contains twenty (20) / ten (10) questions.
- Students shall tick (✓) the correct answer.
- No marks shall be given for overwrite / erasing.
- Students have to submit the Objective Part (Part-A) to the invigilator just after completion of the allotted time from the starting of examination.

Full Marks	Marks Obtained
20	

Scrutinizer's Signature *Examiner's Signature* *Invigilator's Signature*