Ex:B.SC/PHY/32/H13/GR-A/79/2019

FINAL B.Sc. EXAMINATION, 2019

(3rd Year, 2nd Semester)

PHYSICS (HONOURS)

Paper : HO-13

Time : Two hours Full Marks : 50

Use separate answer-script for each group.

GROUP - A

Answer any ***five*** questions. 5x2=10

1. Is it possible to have a nuclear reaction which is neither endoergic nor exoergic in nature ? If yes, represent it symbolically.

2. What is enriched Uranium ? What is its importance ?

3. How neutron can be detected ?

4. In beta energy spectrum, sometimes sharp spikes are observed at certain energy values–Explain.

5. What are the main constituents of primary and secondary cosmic rays ?

6. Which process is responsible for generation of energy in sun ? Give an example of such a process.

7. Nuclear density is independent of nuclear size–Explain.

Answer any ***three*** questions. 3x5=15

8. What is an Alpha particle ? Show that an Alpha particle with energy less than the corresponding coulomb barrier height can come out of the nucleus. 1+4

9. What is meant by "cross-section" of a nuclear reaction. Calculate the threshold energy of the reaction $^{14}N(n,\alpha)^{11}B$. Relevant masses are :
   $M(^{14}N) = 14.007550$ amu
   $M(n) = 1.008983$ amu
   $M(\alpha) = 4.003879$ amu
   $M(^{11}B) = 11.012811$ amu 2+3

10. Write the relevant nuclear reaction which helped Chadwick to discover neutron. How did he estimated the mass of a neutron ? 1+4

11. Show that in a Betatron the magnetic field at the orbit position is half of the average magnetic field existing over the whole orbit area.
    In a 70MeV betatron, the radius of the stable orbit is 28cm. Find he value of the magnetic field at this orbit for the given energy. 3+2

(c) Define order parameter in the context of ferromagnetic to paramagnetic phase transition. What magnetic property a material must have so as to exhibit electron spin resonance ? 1+1

16. (a) In the Kronig-Penny model, behavior of energy is governned by the equation

$$\frac{mV_0 b}{\hbar^2 \alpha}\sin\alpha a + \cos\alpha a = \cos ka$$

where V_0 and b is the height and width of the potential barrier. The period of the potential is $a+b$. $\alpha = \sqrt{\frac{2mE}{\hbar^2}}$. Other symbols have their usual meaning. How do we arrive the concept of band structure of the solid. Under what condition, energy bands look very similar to that of particle in a constant potential box. 2+2

(b) Show that total number of possible wavefunctions in any energy band equal to the twice the number of unit cells. 5

(c) When does semiconductor behave like an insulator and why ? 1

—— X ——

12. What is gas amplification factor ? Draw a graph of gas amplification factor against applied voltage. Different type of detectors may be developed utilizing its different portions – explain. 1+1.5+2.5

GROUP - B (25 marks)

Answer ***q.no. 13*** and any ***two*** from the rest. 1x5=5

13. (a) What is the lattice constant for FCC crystal having atomic radius 1.476 $\mathring{A}$?
    (b) The interplanar spacing of (220) planes of a FCC structure is 1.75 $\mathring{A}$. Calculate the lattice constant.
    (c) Arrange descending order of the energy band gaps of copper, diamond and silicon.
    (d) In a ferromagnetic material, find the internal field when the applied field is 12 units, molecular field constant is 0.1 units and the magnetization is 74 units.
    (e) Why does single crystal exhibit aniosotropy in the physical properties of crystal ?

14. (a) Consider X-ray scattering from a material. Show that scattered amplitude is the Fourier transform of electron density of the material. 4
    (b) Crystal is defined as the convolution of lattice ($\rho_{lattice}$(r)) with the local electron density (basis) ρ_{basis}(r). Express $\vec{r}$ in terms of three primitive lattice

vectors $\vec{a}, \vec{b}\ and\ \vec{c}$ and hence define $\rho_{lattice}$(r). Write down the fourier transform of $\rho_{lattice}$(r). 1+1+1

(c) Starting from the local electron density of an unit cell, obtain expressions for atomic form factor and structure factor of the basis. 3

14. (a) What do you mean by Ewald construction ? Starting from the scattering amplitude, obtain the general diffraction condition. 2+3
    (b) The primittive translation vectors of the hexagonal space lattice are given by

$$\vec{a}_1 = \frac{\sqrt{3}\,a}{2}\hat{x} + \frac{a}{2}\hat{y}$$

$$\vec{a}_2 = -\frac{\sqrt{3}\,a}{2}\hat{x} + \frac{a}{2}\hat{y}$$

$$\vec{a}_3 = c\hat{z}$$

Calculate the primitive translation vectors in the reciprocal lattice. Is there any specific relation of the reciprocal lattice with its own lattice ? 4+1

15. (a) What is Wiedemann-Franz law. Why does this law show excellent agreement with oversimlified classical Drude model ? 1+2
    (b) Show that Hall coefficient (R_H) is inversely proportional to the carrier concentration. Hence comment on temperature dependence of R_H. 4+1