2021

(July)

PHYSICS

(Elective/Honours)

(Atomic, Nuclear and Solid-state Physics)

[PHY 04 (T)]

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer Question No. **1** and *any* **four** from the rest

1. Answer any *four* of the following questions : 3×4=12

(a) Ground state energy of hydrogen atom is –13·6 eV. Calculate the energy and frequency of the spectral line emitted when the electron jumps from n 3 to n 2 orbits.

(b) Monochromatic X-ray of wavelength 0·124 Å, undergoes Compton scattering from a carbon block. Calculate the wavelength of the ray scattered through 60°.

(c) A carbon specimen found in a cave contains $\frac{1}{8}$ as much C^{14} as in an equal amount of carbon in living matter. Calculate the approximate age of the specimen. Half-life of $C^{\ 4}$ is 5568 years.

(d) Calculate the Q-value in MeV of the reaction $Al^{27}(d,\ \ )Mg^{25}$. Given, masses of Al^{27}, Mg^{25},   and d are 26·9901 amu, 24·9936 amu, 4·0039 amu and 2·0147 amu, respectively.

(e) Calculate the interplanar spacing for (3 2 1) planes in a simple cubic lattice with lattice constant $4{\cdot}2\times10^{\ 10}$ m.

(f) In a crystal, a lattice plane cut intercepts of 2a, 3b and 6c along the crystallographic axes where a, b and c are primitive vectors of the unit cell. Determine the Miller indices of the given plane.

2. *(a)* Distinguish between excitation and ionization potential. 2

(b) What is a mass spectrograph? Describe the construction and working principle of Thomson mass spectrograph. Mention two of its important limitations. 2+3+3+1=9

3. *(a)* State the basic postulates of Bohr's atom model. Name the different spectral series of hydrogen atom and explain their origin on the basis of Bohr's atom model with a suitable diagram. 2+5=7

(b) State Pauli's exclusion principle. Use this principle to show that the maximum number of electron that can be accommodated in an orbit is $2n^2$ where n is the principal quantum number. 1+3=4

4. *(a)* What is mean life of a radioactive element? Establish a relation between mean life and decay constant. 1+3=4

(b) Briefly describe three processes through which -ray interacts with matter. 3

(c) Describe how neutron was discovered. Write four basic properties of neutron. 2+2=4

5. *(a)* Explain the construction and working principle of a linear accelerator. Find an expression for the kinetic energy acquired by the ion. What are the limitations of linear accelerator? 2+3+2+1=8

(b) What is the function of a moderator in nuclear reactor? Name two substances that can be used as moderator. 2+1=3

6. *(a)* Explain the *Q*-value of a nuclear reaction in terms of rest mass energy of the elements. What are exothermic and endothermic reactions? 2+2=4

(b) What are primary and secondary cosmic rays? 3

(c) Establish Duane-Hunt law. 2

(d) What is the phenomenon of superconductivity? 2

7. *(a)* What is packing fraction of a lattice? Calculate the packing fraction of an fcc lattice. 1+3=4

(b) For a simple cubic lattice, show that $d_{100} : d_{110} : d_{111} \quad 1 : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$, where d is the interplanar spacing. 3

(c) Derive Bragg's law in X-ray diffraction. Will visible light produce diffraction pattern in solid? Explain. 3+1=4

8. *(a)* What are diamagnetic, paramagnetic and ferromagnetic substances? Give two examples of each. 2+2+2=6

(b) Define persistent current. 2

(c) What are type-I and type-II superconductors? 3

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