2024

(CBCS)

(4th Semester)

PHYSICS

FOURTH PAPER

(Atomic, Nuclear Physics and Solid-State Physics)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. Which of the following represents the four quantum numbers for an electron present in $4f$ orbital?

   (a) $n = 4,\ l = 3,\ m = +1,\ s = +\frac{1}{2}$ ( )

   (b) $n = 3,\ l = 2,\ m = -2,\ s = +\frac{1}{2}$ ( )

   (c) $n = 4,\ l = 4,\ m = -4,\ s = -\frac{1}{2}$ ( )

   (d) $n = 4,\ l = 3,\ m = -4,\ s = -\frac{1}{2}$ ( )

2. What is the charge on X-rays?

(a) Positive ( )

(b) Negative ( )

(c) Both positive and negative ( )

(d) No charge ( )

3. The half-life of a radioactive substance is 10 years and its initial mass is 10 g. The remaining amount after 20 years is

(a) 7·5 g ( )

(b) 5 g ( )

(c) 2·5 g ( )

(d) 1·25 g ( )

4. Which type of radiation is the least penetrating?

(a) Alpha ( )

(b) Beta ( )

(c) Gamma ( )

(d) Neutron ( )

5. The coordination number of FCC crystal is

(a) 4 ( )

(b) 8 ( )

(c) 12 ( )

(d) 16 ( )

6. Which of the following symmetry elements is found in all objects?

(a) An inversion centre ( )

(b) Identity ( )

(c) A group of rotational symmetry ( )

(d) Mirror planes ( )

7. In X-ray diffraction, Bragg's law is used to determine

(a) the intensity of diffraction peaks ( )

(b) the lattice parameters of the crystal ( )

(c) the orientation of the crystal lattice ( )

(d) the wavelength of the incident X-rays ( )

8. In a crystal, covalent molecules are held together by

(a) dipole-dipole attraction ( )

(b) hydrogen bonds ( )

(c) van der Waals' attraction ( )

(d) electrostatic attraction ( )

9. What happens to the specific heat of a substance as its temperature increases?

(a) It increases ( )

(b) It decreases ( )

(c) It depends on the substance ( )

(d) It remains constant ( )

10. The mean free path of a moving gas molecules is directly proportional to the *k*th power of the diameter of a molecule. Here, the value of *k* is

(a) −1 ( )

(b) −2 ( )

(c) +1 ( )

(d) +2 ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. Distinguish between continuous X-ray radiation and characteristics X-ray radiation.

OR

2. Mention at least three properties of positive rays.

UNIT—II

3. Discuss radioactive carbon dating.

OR

4. Define nuclear fusion. Give one representative equation.

UNIT—III

5. What do you mean by primitive cell?

OR

6. Define the term 'packing fraction'. What is the packing fraction for simple cubic lattice?

UNIT—IV

7. Explain the concept of cohesive energy.

OR

8. Determine the Madelung constant for NaCl.

UNIT—V

9. Show that the ratio of thermal and electrical conductivities at a temperature is constant.

OR

10. Write a short note on Wiedemann-Franz ratio.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. Describe Bainbridge's mass spectrograph and explain how atomic masses are determined with it. Mention two uses of mass spectrograph. 4+4+2=10

OR

2. *(a)* On the basis of Bohr's atomic model, derive an expression for the total energy of an electron in the *n*th orbit of hydrogen atom. 6

(b) State and explain Compton effect with a suitable diagram. 4

UNIT—II

3. *(a)* Deduce the law of radioactive disintegration. Derive the expressions for mean-life and half-life of a radioactive substance. 4

(b) Calculate the binding energy per nucleon of helium nucleus. Given that—

mass of helium nucleus = 4·00276 a.m.u.;
mass of proton = 1·00728 a.m.u.;
mass of neutron = 1·00867 a.m.u.;
1 a.m.u. = 931·5 MeV. 3

(c) Explain the importance of nuclear binding energy in relation to stability of the nucleus. 3

OR

4. *(a)* Explain the terms 'chain reaction' and 'multiplication factor (k)'. What should be the value of k for sustained chain reaction? 1+3=4

   (b) Calculate the time required to disintegrate the sample of thorium by 10%. (Assume the half-life of thorium is $1 \cdot 4 \times 10^{10}$ years.) 3

   (c) Explain proton-proton cycle. 3

UNIT—III

5. *(a)* What are point groups and space groups? Give their numbers for two- and three-dimensional lattices. 2+2=4

   (b) Prove that five-fold rotation axis is not permissible with a crystalline lattice. 4

   (c) What do you mean by Miller indices and atomic packing factor? 2

OR

6. *(a)* Derive the expression for the interplanar spacing d for a set of Miller indices ($h\ k\ l$) planes of a cubic lattice. 4

   (b) Calculate the packing fraction of simple cubic, body-centred cubic and face-centred cubic structures. 6

UNIT—IV

7. *(a)* Establish a relation between crystal lattice and reciprocal lattice. 4

   (b) Deduce Bragg's law of X-ray diffraction. 4

   (c) Show that every reciprocal lattice vector is normal to the lattice plane of the crystal. 2

OR

8. *(a)* Derive Laue's condition for X-ray diffraction. 5

   (b) What is reciprocal lattice? Prove that the volume of the reciprocal lattice is inversely proportional to the volume of a unit cell of direct lattice. 1+4=5

UNIT—V

9. Obtain an expression for Einstein's theory of specific heat. Explain the failures of this theory. 8+2=10

OR

10. *(a)* Write the assumptions of Debye model of lattice specific heat. Obtain Debye T^3 law. 5

(b) Deduce the expression for electrical conductivity from free electron model. 3

(c) How does Debye model differ from Einstein model of specific heat of solids? 2

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Student's Copy

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