

4/EH-24 (iv) (Syllabus-2015)

2 0 1 7

(April)

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. (a) State the limitations of Aston's mass spectrograph. In a mass spectrometer, a singly charged positive ion is accelerated through a uniform magnetic field of 0.1 tesla and is deflected into a circular path 18.2 cm in radius. Find (i) the speed of the ion, (ii) the mass of the ion in kg and a.m.u., and (iii) the mass number of the ion.

1+3=4

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(Turn Over)

(2)

(3)

(b) Define the term 'half-life' of a radioactive material. A radioactive sample has its half-life equal to 60 days. Calculate (i) its decay constant, (ii) its average life and (iii) the time required for $\frac{2}{3}$ of the original number of atoms to disintegrate. $1+3=4$

(c) Explain what you understand by Miller indices of a lattice plane. In a crystal, a plane cuts intercepts $2a$, $3b$ and c along the crystallographic axes. Determine the Miller indices of the plane. $2+2=4$

2. (a) Describe Millikan's oil drop method for the determination of electronic charge. What corrections did Millikan apply to Stokes' formula and why? $3+1+1=5$

(b) State Pauli's exclusion principle and use it to show that at any state of principal quantum number n , the maximum number of electrons which can be accommodated, is $2n^2$. 3

(c) Calculate the ionization potential of (i) H-atom and (ii) He-atom in the ground state. $1\frac{1}{2}+1\frac{1}{2}=3$

3. (a) What is Compton effect? Obtain an expression for the Compton shift using non-relativistic mechanics only. $1+4=5$

(b) State Moseley's law. Show that this law can be deduced from the modified Bohr's theory of hydrogen spectra. $1+2=3$

(c) What is population inversion? Explain why laser action cannot occur without population inversion between atomic levels. $1+2=3$

4. (a) Describe with a neat sketch the principle of operation of a cyclotron. Explain what is meant by 'resonance condition' in a cyclotron. Derive an expression for the maximum energy produced in this machine. $3+1+2=6$

(b) Describe a GM-counter and explain its operation. What is meant by dead time of a GM-counter? $4+1=5$

5. (a) Distinguish between nuclear fission and nuclear fusion. Explain the energy released in these two processes from the graph showing the variation of binding energy per nucleon as a function of mass number. Why does ^{235}U and not ^{238}U nucleus undergo fission with thermal neutrons? $2+2+1=5$

(b) Define nuclear reactions. What are the quantities that are conserved in a nuclear reactions? Discuss the significance of Q-factor in this context. $1+1+2=4$

(Turn Over)

(4)

- (c) Calculate the binding energy in MeV of ${}^4\text{He}$ from the following data : 2
- Mass of ${}^4\text{He} = 4.003875$ a.m.u.
Mass of ${}^1\text{H} = 1.008145$ a.m.u.
Mass of neutron = 1.008986 a.m.u.
6. (a) What are cosmic rays? What is the effect of the earth's magnetic field on them? Discuss the nature of the hard and soft components of cosmic rays. 1+3+2=6
- (b) What are elementary particles? How are the elementary particles classified on the basis of their masses, interaction or statistics? 1+2=3
- (c) A μ^- meson decays into an electron e^- and a pair of neutrinos. Calculate the maximum available energy for the process and the average electron energy. 2
7. (a) Define coordination number. Write down the same for simple cubic, b.c.c. and f.c.c. lattices. Also prove that the distances between nearest neighbours are a , $\frac{a\sqrt{3}}{2}$ and $\frac{a}{\sqrt{2}}$ respectively. 1+2+2=5
- (b) What are reciprocal lattice vectors? Write down Laue's equations representing the conditions of X-ray diffraction by crystal and hence obtain Bragg's law. 1+1½+3½=6

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(Continued)

(5)

8. (a) Distinguish between dia-, para- and ferro-magnetic materials. 3
- (b) What are magnetic susceptibility and Meissner's effect? Calculate the penetration depth of lead at 5.2 K if the London penetration depth at 0 K is 37 nm. The critical temperature of lead is 7.193 K. 1+1+2=4
- (c) Define Fermi energy E_F . Explain the classification of solids into conductors, semiconductors and insulators on the basis of band theory. 1+3=4

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