2017

PHYSICS

(Major)

Paper : 5.2

(Atomic Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option : 1×7=7

(a) The electron of H-atom is excited to the n-th orbit. Then the total number of emission lines in the spectrum will be

(i) $\frac{1}{2}n(n-1)$

(ii) $\frac{1}{2}n(n+1)$

(iii) $n(n-1)$

(iv) $n(n+1)$

(b) According to vector atom model, the angular momentum (l) of an electron is conserved and quantized. Quantum mechanics therefore predicts that

(i) its magnitude is $l\hbar$

(ii) its magnitude is $\sqrt{l(l+1)}\,\hbar$

(iii) its orientation with magnetic field is $\cos^{-1}\left[\frac{m}{\sqrt{l(l+1)}}\right]$

(iv) its orientation with magnetic field is $\cos^{-1}\left[\frac{l}{l\sqrt{l+1}}\right]$

(c) Zeeman shift of wavelength $d\lambda$ is

(i) $d\lambda = \pm\frac{Be}{4\pi m}$

(ii) $d\lambda = \pm\frac{Be\lambda}{4\pi mc}$

(iii) $d\lambda = \pm\frac{Be\lambda^2}{4\pi mc}$

(iv) $d\lambda = \pm\frac{Be\lambda^2}{4\pi mc^2}$

(d) The maximum frequency of X-rays produced by electrons accelerated by a potential difference of V volts is

(i) $\frac{hc}{eV}$

(ii) $\frac{eV}{h}$

(iii) $\frac{h}{eV}$

(iv) eV

(e) Rutherford's α-particle scattering experiment gave experimental information about

(i) the charge of the α-particle

(ii) the size of the atom

(iii) the size of the nucleus

(iv) None of the above

(f) Frequency of Raman lines depend upon the

(i) frequency of incident light

(ii) scattering substance

(iii) intensity of incident light

(iv) strength of magnetic field

(g) Which quantum number takes $(2l+1)$ different values?

(i) Orbital quantum number

(ii) Magnetic orbital quantum number

(iii) Spin quantum number

(iv) Magnetic spin quantum number

2. Answer any *four* of the following : 2×4=8

(a) What velocity will an electron acquire in moving through a potential difference of 1 volt? Assume the values of the charge and mass of the electron.

(b) Calculate what will be the approximate quantum number n for an electron in an orbit of radius 0·1 nm.

(c) An X-ray tube operated at 40 kV emits a continuous X-ray spectrum with a short wavelength $\lambda_m = 0 \cdot 310$ Å. Calculate the Planck's constant. ($e = 1 \cdot 6 \times 10^{-19}$ coulomb and $c = 3 \times 10^8$ m/sec).

(d) The energy of a hydrogen atom in its ground state is $-13 \cdot 6$ eV. What is the energy corresponding to the first excited state?

(e) A beam of electrons travelling with a velocity of $1 \cdot 58 \times 10^7$ m/s is bent into a circle of radius 2 cm by a magnetic field of flux density $4 \cdot 5 \times 10^{-3}$ wb/m^2. Compute the value of the specific charge of the electron.

(f) Find the critical voltage that must be applied to an X-ray tube to excite the K-series of copper. Given that the K-absorption limit is 1·380 Å.

3. Answer *(a)* and any *two* from *(b)*, *(c)* and *(d)* : 5×3=15

(a) What do you understand by fine structure of the spectral lines? Name three contributory factors for the width of spectral lines.

(b) Show that the radii of stable orbits in a hydrogen like atom are proportional to n^2/z where n is the principal quantum number and z is the atomic number.

(c) Define and illustrate the following by taking the case of H-atom :

(i) Resonance potential

(ii) Excitation potential

(iii) Ionization potential

(d) Write any *one* explanatory note on the following :

(i) Franck-Hertz experiment

(ii) Ritz's combination principle

(iii) X-ray spectra

4. Answer (a) and (b), and any *one* from (c) and (d) : 10×3=30

(a) In a Bainbridge mass spectrograph, show that the radius r of the ion-path is linearly proportional to the ion mass M for the same ionic charge q. Mention three very important parameters on the Bainbridge spectrometer.

Singly ionised atoms of ^{20}Ne pass into the deflection chamber of a Bainbridge mass spectrograph with a velocity 10^5 m/s. They are deflected by a magnetic field of 0·07 tesla. What are the radii of their path? Where would ^{22}Ne ion fall if they possessed the same velocity initially? 4+2+4=10

Or

State the fundamental postulates of Bohr on which he based his theory of the spectrum of atomic hydrogen. What

interpretation do you give to the negative sign of the energy value? Explain the physical significance of the series limit.

A hydrogen atom is in the ground state. What is the quantum number to which it will be excited absorbing a photon of energy 12·75 eV? 3+2+2+3=10

(b) What is Mosley's law? Derive Mosley's law on the basis of Bohr's theory and discuss its importance.

What is the minimum wavelength of X-rays emitted by X-ray tube operating at 50 kV? 2+5+3=10

Or

Explain the meaning of different quantum numbers which specify the state of an electron in an atom. State Pauli's exclusion principle. Show that at any state of principal quantum number n, the maximum number of electrons which can be accommodated is $2n^2$.

Write down the electronic configuration of Cu ($z = 29$). 3+2+2+3=10

(c) Write any *two* explanatory notes of the following : 5×2=10

(i) Compton effect

(ii) *L-S* and *J-J* coupling

(iii) Bohr magneton

(iv) Sommerfeld's correction of Bohr's atom model

(d) Draw a neat diagram of the experimental arrange of Stern and Gerlach. What effect the magnetic field would have produced had it been uniform? Show how two traces are produced by the atomic beam. 3+1+2+4=10

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