2018

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 of any *seven* of the following : 1×7=7

(a) An electron revolves about a proton in second excited state. The angular momentum of the electron is

(i) $\frac{h}{2\pi}$

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

(iii) $\frac{3h}{2\pi}$

(iv) 0

(b) Lines of Balmer series are obtained from the hydrogen atom, when electron jumps from some higher orbit to

(i) fourth orbit

(ii) third orbit

(iii) second orbit

(iv) None of the above

(c) The formation of electronic spectrum is due to

(i) change in electronic energy

(ii) change in vibrational energy

(iii) change in rotational energy

(iv) change in all (i), (ii) and (iii)

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

(i) $\frac{eV}{\upsilon c}$ (ii) $\frac{eV}{hc}$

(iii) $\frac{hc}{eV}$ (iv) $\frac{h}{\upsilon}$

(e) The minimum number of electrons in a sub-shell with orbital angular momentum quantum number l is

(i) $2(2l+1)$ (ii) $(2l-1)$

(iii) $2(2l-1)$ (iv) $(2l+1)$

(Continued)

(f) Stern-Gerlach experiment confirms

(i) electron spin and associated magnetic moment

(ii) orbital motion of the electron and associated moment

(iii) specific charge (e / m) of the electron

(iv) spin-orbit interaction of the electron

(g) If ν_{K_α} and ν_{L_α} be the frequencies of K_α and L_α characteristic X-ray lines, then

(i) $\nu_{K_\alpha} = \nu_{L_\alpha}$ (ii) $\nu_{K_\alpha} < \nu_{L_\alpha}$

(iii) $\nu_{K_\alpha} > \nu_{L_\alpha}$ (iv) $\nu_{K_\alpha} = \frac{1}{\nu_{L_\alpha}}$

(h) The shape of the electron orbit is determined by the quantum number

(i) n (ii) l

(iii) j (iv) mj

(i) The splitting of spectral lines with components in strong electric field is known as

(i) normal Zeeman effect

(ii) anomalous Zeeman effect

(iii) Paschen-Back effect

(iv) Stark effect

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

(a) A charged oil drop is suspended in an uniform electric field of 3×10^4 V/m so that it neither rises nor falls. If the mass of the drop is $9 \cdot 75 \times 10^{-15}$ kg, find the charge on the drop.

(b) Find the precessional frequency of an electron orbit when placed in a magnetic field of 6 tesla. ($e = 1 \cdot 6 \times 10^{-19}$ C, $m = 9 \cdot 1 \times 10^{-28}$ kg)

(c) Electron moves at right angles to magnetic field of 150×10^{-14} tesla with a velocity of 6×10^6 m/s. Find the radius of circular path. ($e/m = 1 \cdot 7 \times 10^{11}$ C/kg)

(d) What is Lande g-factor? What is the value of g-factor of an atom with a single electron in $d_{3/2}$ state.

(e) If the PD between the anode and the cathode is 25 kV, what is the cut-off wavelength and the cut-off frequency of the emitted X-rays? ($c = 3 \times 10^8$ m/s, $h = 6 \cdot 6 \times 10^{-34}$ J-s)

(f) Using vector atom model, determine the possible values of the total angular momentum of an f-electron ($l = 3$).

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

(a) Mention the important feature of Rutherford's scattering of α-particles by gold foil which supported the nuclear model of the atom against Thomson model.

(b) A 2 keV electron enters a magnetic field of 5×10^{-4} Wb/m^2. If the radius of the electron path is 0·303 m, find the (e/m) of the electron.

(c) A beam of X-rays of wavelength 0·842 Å is incident on a crystal at a glancing angle of 8·6°, when the first-order Bragg's reflection occur. Calculate the glancing angle of the third-order reflection.

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

(i) Pauli's exclusion principle

(ii) Alkali spectra

(iii) Vector atom model

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

(a) If the positive charge of the gold atom is supposed to be spreaded uniformly over a spherical surface of diameter 1 Å, show that the α-particle of energy greater than a certain value E will not be reflected back. Calculate the value of E. $\left(\frac{1}{4\pi\varepsilon_0} = 9\times10^9\right)$ 5+5=10

Or

What is Compton effect? Derive an expression for the change in wavelength of a photon when it is scattered by an electron. Justify the importance of its theory. 2+5+3=10

(b) *(i)* Describe and explain *L-S* coupling. Under what condition does it hold?

(ii) Under what condition *L-S* coupling breaks down and what kind of new coupling takes place?

(iii) Describe *J-J* coupling. Illustrate *L-S* and *J-J* coupling with the help of vector diagram. 3+3+4=10

Or

Using the physical constants given below, calculate the following for hydrogen atom : 2+3+3+2=10

(i) Velocity of an electron in the ground state

(ii) Radius of Bohr orbit in the ground state

(iii) Time taken by the electron to transverse first orbit

(iv) Rydberg constant

$C = 1 \cdot 6 \times 10^{-19}$ C, $m = 9 \cdot 1 \times 10^{-31}$ kg

$h = 6 \cdot 6 \times 10^{-34}$ J-s, $c = 3 \times 10^{8}$ m/s

$\varepsilon_0 = 8 \cdot 86 \times 10^{-12}$ $C^2 / N - m^2$

(c) *(i)* Enumerate briefly the theory of Raman effect.

(ii) Why are the Stokes lines brighter than the anti-Stokes lines?

(iii) Compare Raman spectra with infrared spectra. 4+3+3=10

(d) What is Zeeman effect? Draw a neat diagram to illustrate the Zeeman splitting of D_1 and D_2 lines of sodium. What is the difference between normal and anomalous Zeeman effect? Write the Zeeman shift in terms of wavelength and e/m in terms of Zeeman shift. 2+3+3+2=10

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