PG/IIIS/PHS/302.1 & 302.2/23

M. Sc. 3rd Semester Examination, 2023

PHYSICS

PAPER – PHS-302.1 & 302.2

Full Marks : 50

Time : 2 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

PAPER – PHS-302.1

(*Molecular Spectroscopy and LASER Spectroscopy*)

Full Marks : 20

Answer any **two** of the following questions : 2×2

1. Convert 39.73×10^{-23} J to cm^{-1}.

2. For a diatomic molecule AB, the energy for the rotational transition from J=0 to J=1 is 3.9 cm^{-1}. Find the energy for the rotational transition from J=3 to J=4.

3. What is the advantage of four four-level laser systems over three three-level laser systems?

4. Explain why the intensity of vibrational lines in progressions differ.

Answer any **two** of the following questions : 4×2

5. HCl has a B value of 10.593 cm^{-1} and a centrifugal distortion constant D of 5.3×10^{-4} cm^{-1}. Estimate the vibrational frequency and force constant of the molecule. The observed vibrational frequency is 2991 cm^{-1}, explain the cause of any discrepancy if arises.

6. Calculate the amplitude of vibration in the v = 0 level of the molecule CO which has a force constant of 1870 N/m. ($M_C = 19.93 \times 10^{-27}$ kg; $M_O = 26.56 \times 10^{-27}$ kg).

7. The observed rotational spectrum of HF shows the J=0 to J=1 absorption at 41.11cm^{-1}, the spacing between adjacent absorption is 40.08 cm^{-1} around J=5 to J=6 transition and only 37.81cm^{-1} around J=10 to J=11 transition. Calculate B values and I values from the three given data. What explanation can you give for this variation?

8. Explain the rotational fine structure of electronic-vibration transitions and hence show the origin of band origin and band head.

Answer any **one** of the following questions : 8 ×

9. (*a*) The HCl molecule gives the vibrational absorption line of wavelength 3.465×10^{-6} m. Calculate the force constant of the H-cl

bond ($M_H = 1.673 \times 10^{-27}$ kg; $M_{Cl} = 58.06 \times 10^{-27}$ kg).

(*b*) What is the average period of rotation of the HCl molecule if it is in the J=1 state? The moment of inertia of HCl is 2.64×10^{-47} kg m^2. 4 + 4

10. (*a*) Obtain the equation of population inversion in a four-level laser system.

(*b*) The average spacing between successive rotational lines of carbon monoxide molecule is 3.8626 cm^{-1}. Determine the transition that gives the most intense spectral line at temperature 300K. 5 + 3

PAPER – PHS-302.2

(*Nuclear Physics I*)

Full Marks : 20

GROUP–A

Answer any **two** of the following questions : 2×2

1. An α–particle of energy 4 MeV traverses in Al of relative stopping power 1700, calculate the thickness of Al that is equivalent in stopping power to 1 *m* air. 2

2. Why the magnetic moment due to electron is not account in Rabi's method? 2

3. Chlorine-33 decays by positron emission with a maximum energy of 4.3 MeV. Calculate the radius of the nucleus from this. 2

4. What are the differences between atomic and nuclear resonance fluorescences ? 2

GROUP–B

Answer any **two** of the following questions : 4×2

5. (*a*) Show that the ratio of the average beta energy to the end-point energy of a weak β–emitter (K.E. To $<<$ $m_e c^2$) is 1/3. *Symbols have their usual meanings.*

(*b*) Calculate the average energy carried away by neutrinos in the β–decay process which has an end-point energy 18.1 keV. 3 + 1

6. Bismuth-212 (Z = 83) nuclide decays with half-life of 60.5 *min* by emitting 5 groups of α-particles with energies 6.08 *MeV*, 6.04 *MeV*, 5.76 *MeV*, 5.62 *MeV* and 5.60 *MeV*. Calculate the α–decay energies. Sketch its level scheme of decay. 4

7. (*a*) Two types of β–decay are given below:

$$^{7}_{4}Be \rightarrow {}^{7}_{3}Li + e^{+}$$
$$^{7}_{4}Be + e^{-} \rightarrow {}^{7}_{3}Li$$

Justify whether both decays are possible? Given, the atomic mass difference between $^{7}_{4}Be$ and $^{7}_{3}Li$ is 0.846 *MeV*.

(*b*) A nucleus with mass number 238 undergoes *alpha* emission. Find ratio of the energy shared between alpha particle and daughter nucleus. 2 + 2

8. (*a*) In a mass spectrometer, a single positive charged ion is accelerated through a potential difference 1 *kV*. It then travels through a uniform magnetic field for which B = 1*k Gauss* and is detected into a circular path of radius 18.2*cm*. Calculate the mass of the ion in unit of '*u*'.

(*b*) Why the Fermi-Kurie plot deviates sometime from the straight line at the lower energy?

GROUP–C

Answer any **one** of the following questions : 8×1

9. (*a*) How magnetic moment of nuclei is determined experimentally?

(*b*) What energy must be imparted to an α–particle to force it into the $_{92}U^{235}$ nucleus? Given $r_0 = 1.2\ fm$.

(*c*) The comparative half-life is small in allowed *beta* decay and large in forbidden *beta* decay. Explain it. 4+2+2

10. (*a*) What is Hindrance factor for α–decay?

(*b*) What are the expected types of *y*-ray transitions between the following states of odd A nuclei:

$g_{9/2} \rightarrow p_{1/2}$, $f_{5/2} \rightarrow p_{3/2}$, $h_{11/2} \rightarrow d_{5/2}$ & $h_{11/2} \rightarrow d_{3/2}$

(*c*) With energy level diagram show the isomeric transition schemes of $_{35}Br^{80}$ for *y*-rays, β–particles and *k*-captures. 1+4+3

[Internal Assessment – 10 Marks]