

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 :

1. Convert $39.73 \times 10^{-23} \text{ J}$ to cm^{-1} .

2 × 2

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 $5.3 \times 10^{-4} \text{ cm}^{-1}$. 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 41.11 cm^{-1} , the spacing between adjacent absorption is 40.08 cm^{-1} around $J=5$ to $J=6$ transition and only 37.81 cm^{-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 : 8×1

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 m². 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 :

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
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

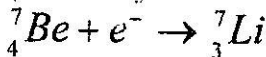
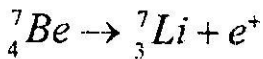
Answer any **two** of the following questions :

5. (a) Show that the ratio of the average beta energy to the end-point energy of a weak β -emitter (K.E. To $\ll m_e c^2$) is 1/3. Symbols have their usual meanings. 4 × 2

- (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:



Justify whether both decays are possible?

Given, the atomic mass difference between

${}^7_4\text{Be}$ and ${}^7_3\text{Li}$ 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 $B = 1\text{ kGauss}$ 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 :

9. (a) How magnetic moment of nuclei is determined experimentally? 8×1
- (b) What energy must be imparted to an α -particle to force it into the ${}_{92}\text{U}^{235}$ nucleus? Given $r_0 = 1.2\text{ fm}$.
- (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 γ -ray transitions between the following states of odd A nuclei:

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

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

[Internal Assessment – 10 Marks]
