PG/IIIS/PHS/302.1&302.2/22

M.Sc. 3rd Semester Examination, 2022

PHYSICS

(Molecular Spectroscopy and LASER Spectroscopy/ Nuclear Physics)

PAPER – PHS-302.1 & 302.2

Full Marks : 40

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

PHS–302.1

(Molecular Spectroscopy and LASER Spectroscopy)

A. Answer any *two* of the following : 2×2

1. What is the vibrational frequency corresponding to a thermal energy of kT at 298K ?

2. The fundamental vibrational frequency of HCl is 2989 cm^{-1}. Find the force constant of HCl bond. ($\mu_{HCl} = 1.6379 \times 10^{-27}$ kg)

3. What do you mean by Q-switching in a laser radiation ?

4. What is Fortrat Parabola ?

B. Answer any *two* of the following : 4×2

5. What do you mean by Q-factor of a laser resonator ? Derive the expression of Q-factor of a laser resonator. 1 + 3

6. What is the average period of rotation of HCl molecule if it is in the $J = 1$ state. The inter-nuclear distance of HCl is 0.1274 nm ($M_H = 1.673 \times 10^{-27}$ kg; $M_{Cl} = 58.06 \times 10^{-27}$ kg). 4

7. The fundamental and first overtone transitions of CO are centered at 2143 cm^{-1} and 4260 cm^{-1}. Calculate the equilibrium oscillation frequency, the anharmonicity constant and force constant of the molecule. ($M_C = 19.93 \times 10^{-27}$ kg; $M_O = 26.56 \times 10^{-27}$ kg). 4

8. What is meant by vibrational coarse structure ? Explain why the intensity of vibrational-electronic spectra in a progression vary ? 4

C. Answer any *one* question from the following : 8×1

9. (*i*) A microwave spectrometer capable of operating only between 60 and 90 cm^{-1} was used to observe the rotational spectrum of HI. Absorptions were measured at 64.275, 77.130 and 89.985 cm^{-1}. Find B, I and r, also determine the J values between which transition occurs for the first line listed above ($M_H = 1.673 \times 10^{-27}$ kg; $M_I = 210.7 \times 10^{-27}$ kg).

(*ii*) The fundamental band for HCl is centered at 2886 cm^{-1}. Assuming that the internuclear distance is 0.1276 nm, calculate the wave number of the first two lines of each of the P and R branches of HCl ($M_H = 1.673 \times 10^{-27}$ kg; $M_{Cl} = 58.06 \times 10^{-27}$ kg). $4 + 4$

10. What is a three level laser system ? Obtain the expression of population inversion equation of a three level laser system. Also find the expression of threshold power required in a three level laser for lasing action. 2 + 4 + 2

PHS–302.2

(*Nuclear Physics*-I)

D. Answer any *two* questions : 2×2

11. What information does one get about a nucleus from the knowledge of the sign of electric quadrupole moment ? 2

12. How can you conclude from the semi-empirical mass formula that a heavy nuclide of mass number >150 is energetically unstable against α-decay ? 2

13. Discuss the selection rules for Fermi and Gamow-Teller transitions in case of β-decay. 2

14. Calculate the energy of γ-rays emitted in the β-decay of Al^{28}. Given, $E_{max} = 2.86$ MeV. 2

E. Answer any *two* questions : 4×2

15. (*i*) Write the basic principle of the Rabi's method for determination of magnetic moment of nuclei.

(*ii*) Find out the maximum energy shift that can be observed for a nuclear body whose quadrupole moment is Q. $2 + 2$

16. (*i*) Show that the Gamow factor can be written as $e^{-\pi kb}$, where k is the wave number and b is the collision diameter.

(*ii*) What do you mean by the recoil free resonance emission of γ-rays. $3 + 1$

17. (*i*) A proton is circling in the horizontal X-Y plane of a spherical nucleus having equal values of Z and N. What will be the sign of the quadrupole moment of the nucleus ?

(*ii*) Some isobaric nuclear families are represented by one mass parabola while some *others are represented* by two mass parabolas-Explain. $2 + 2$

18. Two stable isotopes of silver ^{107}Ag and ^{109}Ag are to be separated using electromagnetic means. The singly charged ions are first accelerated through an electrostatic potential of 10kV and then deflected in a uniform magnetic field through a semi-circular path of radius 1m. (*a*) What is the intensity of the magnetic field required ? (*b*) Assuming the entrance and exit slits are of the same size and the entrance slit is imaged perfectly on the exit slit, calculate the maximum slit width for which the two isotopes will be completely separated. 4

F. Answer any *one* question : 8×1

19. (*i*) Verify the possibility for electron-neutrino emissions to have $l \neq 0$.

(*ii*) Discuss about the nuclear resonance absorption and fluorescence. $2 + 6$

20. (*i*) What are the expected types of γ-ray transitions between the following states

$$\frac{3^+}{2} \rightarrow \frac{1^-}{2}\,;\ \frac{1^+}{2} \rightarrow \frac{1^+}{2}$$

(*ii*) What phenomena of α-decay provides a complete evidence of the existence of discrete energy levels in a nucleus ? Explain this phenomenon with example.

(*iii*) Why coulomb correction is necessary in Fermi's theory of beta decay ?

$2 + (1 + 3) + 2$
