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M.Sc. 3rd Semester Examination, 2024

PHYSICS

PAPER – PHS-302.1 & 302.2

Full Marks : 50

Time : 2 hours

Answer all questions

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 Physics)

GROUP – A

Answer any two of the following questions : 2×2

- 1. The wavelength of mercury green light is 546.1 nm. Calculate the frequency in Hz and the wave number in cm^{-1} and m^{-1} .**

(Turn Over)

2. What is hot band and why it is so called ?
3. In a He-Ne laser transition from level gives a laser emission of $\lambda = 632.8$ nm. If the 2P level has energy 15.2×10^{-19} J, calculate the pumping energy required, assuming no loss.
4. Find an expression of the maximum value of the vibrational quantum number close to the dissociation limit in an electronic transition.

GROUP – B

Answer any two of the following questions : 4 × 2

5. The bond length of HF molecule is 0.0927 nm. What is its moment of inertia ? What is the value of rotational constant in joules and cm^{-1} . Find the wavenumbers of the first four transitions. [$M_{\text{H}} = 1.673 \times 10^{-27}$ kg; $M_{\text{F}} = 31.55 \times 10^{-27}$ kg] 1 + 2 + 1
6. The fundamental and first overtone transitions of CO are centred at 2143.3 cm^{-1} and 4260.0

cm^{-1} . Calculate the equilibrium oscillation frequency, the anharmonicity constant and force constant of the molecule.

$$[\mu_{\text{CO}} = 11.38365 \times 10^{-27} \text{ kg}]$$

7. The energy-gap between two levels corresponds to 20000 cm^{-1} . Find the ratio of population of the two states in thermal equilibrium at room temperature (300 K). Give an example of three level laser. 3 + 1
8. A molecule has undergone an electronic transition into an excited state. Indicate different processes by which its excess energy may be lost.

GROUP – C

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

9. The first line in the rotational spectrum of carbon monoxide has a frequency of 3.8424 cm^{-1} . Calculate the rotational constant, moment

of inertia, C-O bond length, angular velocity, angular momentum and number of revolution per second in the $J = 3$ state. And also find the wave number of the transition $J = 5$ to $J = 6$ state. [$\mu_{CO} = 11.38365 \times 10^{-27}$ kg]

1 + 1 + 1 + 2 + 1 + 2

10. What is a three-level laser system? Derive the rate equations for each energy level and determine the expression for population inversion in the system. Additionally, obtain the expression for its threshold power.

1 + 3 + 2 + 2

PHS-302.2

(Nuclear Physics-I)

GROUP - A

Answer any two of the following questions : 2×2

11. For ^{177}Hf ($Z = 72$), the quadrupole moment $Q = +3.0$ b. Calculate the ratio of the semi-major and semi-minor axes of this prolate nucleus.

(5)

12. In the decay of ^{242}Cm ($Z = 96$) to ^{238}Pu ($Z = 94$) the maximum α energy is 6.11 MeV (mass of ^{238}Pu is 238.049555 u). Find the mass of ^{242}Cm .

13. Write the difficulties arise in interpreting the continuous of β -spectrum.

14. Calculate the energy of γ -rays emitted in the β decay of $^{28}_{13}\text{Al}$. Given, $E_{\text{max}} = 2.86$ MeV.

GROUP – B

Answer any two of the following questions : 4×2

15. Using semi empirical mass formula derive an expression for the number of protons Z for which the isobar with a fixed A is stable (does not beta-decay). Find this Z for $A = 125$. Neglect the mass difference between neutron and proton.

16. Describe briefly the Gamow's tunneling mechanism for alpha-particles emission from a nucleus.

17. (i) A nucleus having spin-parity 1^- decays by emitting α -particles of energies 4.687 and 4.650 MeV to a nucleus having ground state spin parity of 0^+ . Emission of γ -rays of energies 266 and 305 keV is also observed. From this information construct the decay scheme.

(ii) Find the multipole character of γ -radiation emitted in the transition : $3/2^- \rightarrow 3/2^+$.

2 + 2

18. The end-point energy of the β -spectrum of ^{14}C is 0.155 MeV. What is the recoil energy of the product nucleus ? If 0.015 MeV be the K.E. of the emitted β -particle in a direction normal to that of motion of the recoil nucleus, show that the momenta of β , ν and recoil nucleus involved in the process are respectively around 0.14 MeV/c, 0.125 MeV/c and 0.063 MeV/c.

GROUP – C

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

19. (i) Discuss the Rabi's method for determination of magnetic moment of nuclei.

(ii) What do you mean by the Mosbauer effect ? 6 + 2

20. (i) Write down briefly the working principle of momentum filter of a double focussing mass-spectrometer.

(ii) A free neutron decays into a proton by emitting a β^- particle of maximum K.E. 0.782 MeV. If the rest masses of electron and neutrino are respectively $0.0005486 u$ and $1.008665 u$, find the masses of proton and hydrogen-atom.

(8)

(iii) Gold-156 ($Z = 79$) can decay by β^+ , β^- and electron capture. Find the Q values for these decays.

2 + 3 + 3

[Internal Assessment — 10 Marks]
