2023

(May/June)

PHYSICS

(Honours)

(Atomic and Molecular Spectroscopy, Nuclear Physics)

[PHY-08 (T)]

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer Question No. **1** and *any* **four** from the rest

1. *(a)* Calculate the Lande g-factor for the level $^3P_1$. 3

(b) The moment of inertia of the CO molecule is $1{\cdot}46\times10^{-46}$ kg-m^2. Calculate the energy (in eV) and the angular velocity in the lowest rotational energy level of the CO molecule. (Given $h = 6{\cdot}63\times10^{-34}$ J-s; 1 eV = $1{\cdot}60\times10^{-19}$ J) 3

(c) Calculate the binding energy of He^4 in MeV. Given : Mass of neutron $M_n = 1{\cdot}0087$ a.m.u.; Mass of proton $M_p = 1{\cdot}0073$ a.m.u.; Mass of Helium $M_{He} = 4{\cdot}0026$ a.m.u. 3

(d) Complete the reactions for the events written as follows : 1×3=3

(i) $P^- + P^+ \rightarrow \pi^\circ + \pi^- + \ldots + \pi^+ + \pi^-$

(ii) $\pi^+ \rightarrow \ldots + \nu_\mu$

(iii) $\mu^+ \rightarrow e^+ + \ldots + \bar{\nu}_\mu$

2. (a) What is Zeeman effect? Distinguish between normal and anomalous Zeeman effect. Give the quantum mechanical theory of anomalous Zeeman effect for one-electron system. 1+2+4=7

(b) What are L-S and J-J coupling schemes? 2+2=4

3. (a) Discuss the pure rotational spectra of a heteronuclear diatomic molecule as a rigid rotator and show that pure rotation spectrum of such a molecule consists of a series of equally-spaced lines separated by a constant wave number difference of 2B. 5+2=7

(b) Explain the R-branch and the P-branch in vibrational-rotational spectra. 4

4. (a) What is Raman effect? Discuss its quantum mechanical explanation and hence obtain the expression for the Raman shifts. Write down the selection rule for Raman allowed transitions. 2+4+2=8

(b) What are Stokes and anti-Stokes lines? Explain why Stokes lines are more intense than anti-Stokes lines. 1+2=3

5. (a) Discuss the basic properties of a nucleus. 4

(b) Briefly discuss the shell model of a nucleus. 4

(c) What is artificial transmutation? Give examples. 2+1=3

6. (a) Discuss the Bohr-Wheeler theory of nuclear fission and hence obtain the condition of spontaneous fission. 8

(b) Derive the four-factor formula for nuclear fission. 3

7. (a) Discuss Fermi's theory of beta decay. 6

(b) What are elementary particles? Classify elementary particles on the basis of mass. ½+½=1

(c) Discuss the four fundamental interactions in nature. 4

8. Write short notes on any *two* of the following : 5½×2=11

(a) Stern-Gerlach experiment

(b) Frank-Condon principle

(c) X-ray fluorescence (XRF)

(d) Gamow's theory of α-decay

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