

**6/H-24 (viii) (Syllabus-2020)**

**2 0 2 3**

( May/June )

**PHYSICS**

( Honours )

**( Atomic Physics—II, Molecular Spectroscopy,  
Nuclear Physics—II, Astrophysics )**

[ PHY-06 (T-B) ]

*Marks : 56*

*Time : 3 hours*

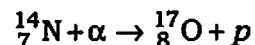
*The figures in the margin indicate full marks  
for the questions*

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

- 1. (a)** A spectral line of wavelength  $6000 \text{ \AA}$  shows a separation of  $0.2 \text{ \AA}$  between the component lines in a normal Zeeman pattern when subjected to a magnetic field of flux density  $1.2 \text{ Wb/m}^2$ . Calculate the value of  $e/m$  for the electron.

4

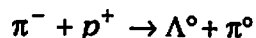
- (b) Calculate the  $Q$ -value of the following nuclear reaction :



where  $m_p = 1.0078 \text{ u}$ ,  $m_\alpha = 4.0026 \text{ u}$ ,  
 $m_N = 14.0031 \text{ u}$ ,  $m_O = 16.9994 \text{ u}$  and  
 $1 \text{ u} = 931 \text{ MeV}$ .

2

- (c) Consider the following strong interaction :



Is it an allowed or a forbidden reaction?  
 Justify your answer by using suitable  
 conservation laws.

2

2. (a) Explain the salient features of the vector atom model. Briefly explain the experiment which provides evidence in support of this model. 2+3=5
- (b) What are quantum numbers? Give the physical interpretation of the quantum numbers involved in completely defining a quantum state of the atom. 5
- (c) Calculate the values of  $L$  and  $J$  for the states (i)  ${}^1S_0$  and (ii)  ${}^2D_{3/2}$ . 2
3. (a) Describe the main features of the alkali spectrum. What is the effect of spin-orbit interaction on this type of spectrum? 2+1=3

- (b) Briefly explain  $L$ - $S$  and  $J$ - $J$  coupling for a two-electron atomic system. Find all the possible spectral terms for calcium ( $Z=20$ ) using  $L$ - $S$  coupling in the  $sp$  configuration. 4+2=6
- (c) State and prove Larmor's theorem and write down the expression for Larmor's frequency. 2+1=3
4. (a) What are the three types of molecular spectra? Mention the region of electromagnetic spectrum in which they belong. 1½+1=2½
- (b) Consider a vibrating diatomic molecule as a harmonic oscillator. Obtain the expression for the allowed or quantized energy levels for this molecule. Explain why molecules like  $\text{HCl}$  show vibrational-rotational spectra whereas molecules like  $\text{H}_2$  do not. 4½+2=6½
- (c) With the help of a schematic diagram, discuss the Frank-Condon principle in electronic band spectra. 3
5. (a) Give a brief and qualitative quantum mechanical explanation of the Raman effect. 4

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- (b) A Raman line is observed at  $4768.5 \text{ \AA}$  when the substance was excited by a  $4358.3 \text{ \AA}$  radiation. Calculate the vibrational frequency in  $\text{cm}^{-1}$  that causes this Raman line. 2
- (c) Describe the principle of working of atomic emission spectroscopy and atomic absorption spectroscopy. 3+3=6
6. (a) What is meant by binding energy of a nucleus? Deduce an expression for the binding energy of a nucleus. 1+2=3
- (b) Give three main evidences that support the nuclear shell model of nuclei. 3
- (c) Describe the Fermi's theory of  $\beta$ -decay. 6
7. (a) Distinguish between nuclear fission and nuclear fusion. Explain the energy released in the two processes from the binding energy curve. 2+2=4
- (b) Discuss the carbon-nitrogen cycle for the production of stellar energy. 4
- (c) Briefly explain the four different types of fundamental interactions by mentioning their strengths and ranges. 4

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8. (a) Describe how muons and pions were discovered in cosmic-ray showers. How was the mass of muons established? 2+2=4
- (b) What are resonance particles? How are they produced? 1+1=2
- (c) Give a brief outline of the three different types of the end products of stellar evolution. 4
- (d) What are Cepheid variables? What are their two main classes? 1+1=2

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