B.Sc. Semester-V Examination, 2022-23
PHYSICS [Honours]

Course ID : 52417   **Course Code : SH/PHS/504/DSE-2**

Course Title :   **Astronomy and Astrophysics**
OR
Nuclear and Particle Physics

Time : 2 Hours   Full Marks : 40

The figures in the right-hand margin indicate marks.
Candidates are required to give their answers in their own words as far as practicable.

(Astronomy and Astrophysics)
UNIT–I

1. Answer any **five** of the following: 2×5=10

    a)   Define parsec. How is it related to astronomical unit?

    b)   What are the advantages that are derived by astronomers by using telescopes?

    c)   How do you classify the stars according to their temperature range?

    d)   A massive star has a much shorter lifespan than the sun– Explain it.

    e)   What do you mean by X-ray astronomy?

    f)   What are extra solar planets?

    g)   What is corona?

    h)   Give two arguments for the existence of dark matter.

UNIT–II

2. Answer any **four** of the following: 5×4=20

    a)   Discuss about the existence of dark matter from galaxy rotation curve.

    b)   Explain the internal structure of the sun.

    c)   Write the similarities and dissimilarities between asteroids and comets in detail.

    d)   Draw a sketch of the Earth's atmospheric layers, indicating the major constituents and their interaction with electromagnetic radiation of different wavelengths.

    e)   What is Hubble's Law? Explain its utility.

    f)   State the virial theorem in astrophysics. How it can be used to determine the temperature of the interior of a star?

UNIT–III

3. Answer any **one** of the following: 10×1=10

    a)   Define luminosity of a star. Derive the relationship between the luminosity and the absolute magnitude of a star. Explain the cause of a nova outburst. Draw the Hertzsprung-Russell diagram of our Milky-way galaxy and show the position of different stars with proper axis titles.

                                                    1+3+3+3=10

b) Compare the structure, velocity, metallicity and age of stars in open cluster and globular cluster. What is white dwarf? How does it form? Define Schwarzschild radius of an object. Why this is also called the event horizon?   4+1+2+1+2=10

(Nuclear and Particle Physics)

UNIT–I

1. Answer any **five** of the following questions:

$$2\times5=10$$

a) With example, give definitions of compound and direct nuclear reaction.

b) Give two experimental evidences of magic numbers.

c) What are the mirror nuclei? Give two examples.

d) Is it possible to get high energy electron from a Cyclotron? Explain.

e) How does one can explain the continuous nature of β-spectrum?

f) What is pair production? Give an example of pair production.

g) A neutron star is an astrophysical object with a density similar to the one of a nucleus. Knowing that its typical mass is of the order of one solar mass ($M_0=2\times10^{30}$ kg), calculate its radius.

h) Over what distance in free space will the intensity of a 5 eV neutron beam be reduced by a factor of one-half? ($T_{1/2}=12.8$ min).

UNIT–II

2. Answer any **four** of the following questions:

$$5 \times 4 = 20$$

a) Write a brief note on different types of interactions by which the elementary particles can undergo. Give example of each interaction. What are the intrinsic properties of each interaction? $3+1+1$

b) What is meant by range of alpha particle? How does the range depend upon the energy of the particles? The half-life of a radioactive nucleus is 2.5 days. What percentage of the original substance will have disintegrated in 7.5 days?

$$1+2+2$$

c) What is Q-value of nuclear reaction? How can it be determined experimentally? $1+4$

d) Using the semi-empirical mass formula establish whether the nucleus $^{64}_{29}\text{Cu}$ can have $\bar{\beta}$ decay (into $^{64}_{30}\text{Zn}$) and/or β+decay (into $^{64}_{28}\text{Ni}$). Calculate also the maximum energies of the emitted β-particles. [M_p=938.272 MeV/c^2, M_n=939.565 MeV/c^2, m_e=0.511 MeV/c^2] $3+2$

e) Explain the working principle of synchrotron. What are the specific uses of synchrotron that are not met by cyclotron? What is the dead time of the detector? $3+1+1$

f) A particular radioactive nuclei undergoes two successive transformations. Derive an expression for the activity of the last generation of nuclei as a function of time. Write two major differences between secular and transient equilibrium. $3+2$

UNIT–III

3. Answer any **one** of the following questions:

$$10 \times 1 = 10$$

a) What is nuclear reaction cross-section and how is it measured experimentally? Name various types of nuclear reactions. What is a half-thickness of a material? A 0.01 mm thick $^{7}_{3}\text{Li}$ target is bombarded with the α beam of flux of 10^3 particles/cm^2-s. As a result, 10^8 neutrons/s are produced. Calculate the cross-section for this reaction. Given: density of lithium=500 kg/m^3. $(1+2)+2+1+4=10$

b) What were the problems in explaining the beta-spectrum? How did Pauli solve them? Provide a thought experiment to establish that a neutrino moves with velocity of light. $3+5+2$

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