

Total number of printed pages-4

3 (Sem-5/CBCS) PHY HE4

2021

(Held in 2022)

PHYSICS

(Honours Elective)

Paper : PHY-HE-5046

(Physics of Device and Instruments)

Full Marks : 60

Time : Three hours

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

1. Answer the following questions : $1 \times 7 = 7$
- (a) Write the full form of MOSFET.
- (b) Capacitor is a
- (i) high-pass filter
 - (ii) low-pass filter
 - (iii) both high and low-pass filters

Contd.

- (c) What does the USB stand for?
- (d) What is the difference between an astable multivibrator and a monostable multivibrator?
- (i) The astable is free running
 - (ii) The astable needs to be clocked
 - (iii) The monostable is free running
- (e) What happens when the modulation index is greater than 1?
- (f) Mention *two* advantages of CMOS technology.
- (g) At critical frequency at which the response drop from the pass band is
- (i) -20 dB
 - (ii) -3 dB
 - (iii) 20 dB

2. Answer the following questions briefly :
 $2 \times 4 = 8$

- (a) Give *two* differences between MOSFET and JFET.
- (b) Explain active and passive filter. Give an example of each.
- (c) What is RS232 communication?

- (c) What does the USB stand for?
- (d) What is the difference between an astable multivibrator and a monostable multivibrator?
- (i) The astable is free running
 - (ii) The astable needs to be clocked
 - (iii) The monostable is free running
- (e) What happens when the modulation index is greater than 1?
- (f) Mention *two* advantages of CMOS technology.
- (g) At critical frequency at which the response drop from the pass band is
- (i) -20 dB
 - (ii) -3 dB
 - (iii) 20 dB

2. Answer the following questions briefly : $2 \times 4 = 8$

- (a) Give *two* differences between MOSFET and JFET.
- (b) Explain active and passive filter. Give an example of each.
- (c) What is RS232 communication?

(d) Calculate the carrier frequency of an AM wave when its highest frequency component is 850 Hz and the bandwidth of the signal is 50 Hz .

3. Answer **any three** of the following questions : $5 \times 3 = 15$

(a) Give the circuit diagram and explain the working of a dc power supply using bridge rectifier and L-section filter.

(b) Explain the I-V characteristic of UJT. Explain its use as a relaxation oscillator.

(c) Give a short note on short circuit protection.

(d) What do you mean by USB standard? Give details of the USB 2.0.

(e) What is a tunnel diode? Explain its V-I characteristics.

4. Answer **any three** of the following questions :

(a) What is a sequential logic circuit? Draw the circuit diagram of a monostable multivibrator and explain its operation.

$2 + (2 + 6) = 10$

(b) Define low-pass filter and high-pass filter. Write the differences between them. 5+5=10

(c) With a neat sketch, describe the construction of an n -channel JFET. Explain the principle of operation. 5+5=10

Or

Explain with neat sketch the structure and working of p -channel enhancement type MOSFET. 10

(d) What is an IC circuit? What are the basic steps of IC fabrication? Explain etching and masking in case of IC fabrication. 5+5=10

(e) Discuss the working of an exclusive-OR phase detector. Give the schematic diagram of PLL and explain its working. 5+5=10

(f) What is amplitude modulation? Show that the amplitude modulation wave consists of a carrier and two sidebands. 3+7=10

Or

Draw the circuit of a CE amplitude modulation and derive the expression for its output. 10

Total number of printed pages-7

3 (Sem-5/CBCS) PHY HE 5

2021

(Held in 2022)

PHYSICS

(Honours Elective)

Paper : PHY-HE-5056

(Nuclear and Particle Physics)

Full Marks : 80

Time : Three hours

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

1. Give short answers to the following questions : 1×10=10

(a) The radius of ${}^{64}_{29}\text{Cu}$ nucleus is measured to be 4.8×10^{-13} cm. What would be the radius of ${}^{27}_{12}\text{Mg}$?

(b) Why does neutron number exceed proton number in heavy and intermediate nuclei ?

Contd.

- (c) How is the deviation of the charge distribution of a nucleus from spherical symmetry measured ?
- (d) What is the parity of the function $\psi(x) = \cos(\pi x/a)$?
- (e) What is the relation between the range of alpha particle and decay constant of the emitting nucleus ?
- (f) Will there be any difference between the energy spectra of electrons and positrons in β -decay ?
- (g) Can a photon of energy 1 MeV undergo pair production ?
- (h) The maximum energy of deuterons coming out of a cyclotron is 20 MeV. What will be the maximum energy of protons that can be obtained from this accelerator ?
- (i) What property distinguishes neutrino from anti-neutrino ?
- (j) What are the structures of neutron and proton in terms of quarks ?

2. Briefly answer the following questions :

2×5=10

- (a) What is the distance of closest approach of an α -particle of energy 5 MeV when it is scattered by an angle 180° by a fixed uranium nucleus ?

[Given $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$,
 $e = 1.6 \times 10^{-19} \text{ C}$]

- (b) A nucleus emits an α particle followed by two β particles. Show that the final nucleus is an isotope of the original nucleus.
- (c) Show that the mean momentum of a nucleon in a nucleus with mass number A varies as $A^{-1/3}$.
- (d) What is straggling of range ?
- (e) Show that pion decay, muon decay and pair production conserve the lepton number.

3. Answer **any four** of the following :

5×4=20

- (a) What are mass defect and packing fraction ? The mass of deuteron is 2.014103 amu. If the masses of proton and neutron are respectively 1.007825 amu and 1.008663 amu, find the mass defect and packing fraction of deuteron.

- (b) How can it be shown that nuclear forces are of short range ?
- (c) What is alpha disintegration energy ? Calculate the kinetic energy of alpha particle in the following decay :



[Given, $M(\text{Pu}^{239}) = 239.052158$ amu,

$M(\text{U}^{235}) = 235.043925$ amu,

$M(\text{He}^4) = 4.002603$ amu]

- (d) Show that the frequency of revolution of the ion in a cyclotron is independent of its speed and the radius of the path. Can electron be accelerated in a cyclotron ?
- (e) How can neutron be detected ?
- (f) What are 'strange' particles ? How are the strangeness quantum number, the baryon number and the third component of isotopic spin related to the charge of the elementary particle ?

4. Answer the following questions : $10 \times 4 = 40$

- (a) (i) What are the characteristics of nuclear force ?
- (ii) Explain meson field theory put forward by Yukawa to explain nuclear force. 5+5=10

Or

- (i) Write the semiempirical mass formula.
- (ii) Explain the significance of various terms. 2+8=10
- (b) (i) How is the energy spectrum of alpha particles different from that of beta particles ?
- (ii) What difficulties are faced in explaining beta spectrum without neutrino hypothesis ?
- (iii) How does neutrino hypothesis help in solving beta spectrum ?
- (iv) A free neutron decays into a proton, an electron and an antineutrino. If $M(n) = 1.00898 u$, $M(p) = 1.00759 u$ and $M(e) = 0.00055 u$, find the kinetic energy (in MeV) shared by the electron and the antineutrino.
1+4+2+3=10

Or

- (i) Describe how γ -rays interact with matter.

(ii) How does the relative importance of each process depend on energy of gamma radiation ?

(iii) A beam of monoenergetic γ -rays is incident on an aluminum sheet of thickness 10 cm. The sheet reduces the intensity of the beam to 21% of the original. Calculate the linear and mass absorption coefficients, given density of aluminum is 2700 kg.m^{-3} .

$$5+2+3=10$$

(c) (i) What is the Q-value of a nuclear reaction ?

(ii) What are the conservation laws applicable to a nuclear reaction ?

(iii) Find an expression of threshold energy for the nuclear reaction.

(iv) Calculate the threshold energy for the nuclear reaction $^{14}\text{N}(n, \alpha)^{11}\text{B}$ in MeV. [Given

$$M(^{14}\text{N}) = 14.007550 u,$$

$$M(^{11}\text{B}) = 11.012811 u,$$

$$M(n) = 1.008987 u \text{ and}$$

$$M(\alpha) = 4.003879 u]$$

$$1+3+3+3=10$$

Or

- (i) What is meant by cross-section of a nuclear reaction ?
- (ii) What are differential cross-section and total cross-section ?
- (iii) What is the difference between compound nucleus reaction and direct reaction ? Give *one* example in each case. $4+3+3=10$
- (d) (i) Describe the construction and working principle of a linear accelerator.
- (ii) Electrons are accelerated to 30 GeV in the SLAC linear accelerator. Calculate the difference between the electron's speed and the speed of light. $7+3=10$

Or

Write short notes on **any two** of the following : $5 \times 2 = 10$

- (i) K-electron capture
- (ii) Cherenkov radiation
- (iii) Quark model
-