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PHYSICS

(Major)

Paper : 6.1

(Nuclear Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks
for the questions

1. Give short answers to the following
   questions : $1 \times 7 = 7$

   (a) How do neutrino and antineutrino differ
   from each other?

   (b) How is the radius of nucleus related to
   the mass number?

   (c) When $_3Li^7$ nucleus is bombarded by a
   proton, $_4Be^8$ nucleus is produced.
   What will be the emitted particle?

   (d) What limits the size of a stable nucleus?

(*Turn Over*)

(e) What nature of primary cosmic ray indicates that it consists mainly positively charged particles?

(f) Give the names of two detectors which are based on detection of free charge carriers.

(g) What nature of nucleons permits us to consider their collective behaviour in determining the properties of the nucleus?

2. Answer the following questions in brief : 2×4=8

(a) Binding energies of $_8O^{16}$ and $_{17}Cl^{35}$ are 127·35 MeV and 289·3 MeV respectively. Which of the two nuclei is more stable?

(b) Give two evidences to show the existence of shell structure within the nuclei.

(c) Explain why it is necessary to increase the lengths of the successive tubes of a linear accelerator to maintain resonance condition.

(d) What are mirror isobars? Give example.

(Continued)

3. Answer any *three* from the following questions :   5×3=15

(a) A cyclotron in which the flux density 0·7 weber m^{-2} is employed to accelerate proton. Calculate the frequency of the rf voltage. Given the mass of proton = $1·66 \times 10^{-27}$ kg. Give the reason why cyclotron cannot be used to accelerate electrons.   3+2=5

(b) Give an account with the help of the 'meson field theory' how Yukawa had come to a conclusion that exchanging particles producing exchanged force between protons and neutrons in the nucleus were not positive or negative electrons, but mesons positive or negative.   5

(c) How did Pauli become able to eliminate the problems related to continuous energy distribution, apparent failure to conserve linear and angular momenta, and conservation of statistics as well, in the beta decay process?   5

(d) What is meant by self-propagating fission reaction? How can fission process be explained with the help of liquid-drop model of nucleus?   2+3=5

(Turn Over)

(e) What are cosmic rays? Where do the primary cosmic rays originate and how do they acquire the enormous energies they posses? 1+2+2=5

4. Answer any *three* of the following questions : 10×3=30

(a) (i) How are alpha and beta particles absorbed in matter? 3

(ii) What is meant by range of alpha particles? Describe a method used to determine range of alpha particles. What is straggling of range? 1+5+1=7

(b) (i) Define Q-value of nuclear reaction, and explain its significance. Define nuclear reaction cross-section. 1+2+2=5

(ii) Using semi-empirical mass formula, estimate Q-value of nuclear fission reaction. 5

(c) (i) Mention two effects by which the quantitative detection of gamma ray is possible. 1

(ii) "Interaction of gamma rays with matter is different from that of charged particles such as alpha and beta particles." Explain. 3

(iii) What are the processes by which a gamma ray of 0·85 MeV will lose energy in passing through matter? 2

(iv) How can you explain gamma rays as a source of information about nuclear energy levels? How can you relate internal conversion with gamma ray emission? 4

(d) Write short notes on any *two* of the following topics : 5×2=10

(i) Ionization chamber

(ii) Linear accelerator

(iii) Geiger-Nuttall law

(iv) Thermonuclear reaction

(v) Extensive air shower

(e) (i) Calculate the fission rate for U^{235} required to produce 2 watt, and the amount of energy that is released in the complete fissioning of half kilogram of U^{235}. Explain why U^{235} is fissionable and U^{238} is not. 3+2=5

(ii) A linear accelerator for the acceleration of protons to 45·3 MeV is designed so that, between any pair of accelerating gaps, the protons spend one complete radio-frequency cycle inside a drift tube. The radio frequency used is 200 Mc/sec. Calculate the length of final drift tube and kinetic energy initially present in the injected proton. Given the length of first drift tube is 5·35 cm.   5

Or

(f) (i) Calculate the neutron separation energy of nuclei $_{20}Ca^{41}$ and $_{13}Al^{27}$.

Given—

$$m(_{20}Ca^{40}) = 39 \cdot 962591 \, u$$

$$m(_{20}Ca^{41}) = 40 \cdot 962278 \, u$$

$$m(_{13}Al^{26}) = 25 \cdot 986895 \, u$$

$$m(_{13}Al^{27}) = 26 \cdot 981541 \, u$$

$$m(\text{neutron}) = 1 \cdot 008665 \, u$$ 3

(ii) Obtain the maximum kinetic energy of beta particle and the radiation frequencies of gamma decay in the decay scheme shown below :
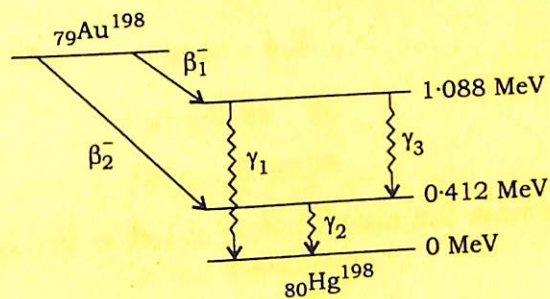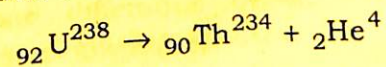

Given—

$$m(_{79}Au^{198}) = 197 \cdot 968233 \, u$$

$$m(_{80}Hg^{198}) = 197 \cdot 966760 \, u$$ 5

(iii) Explain how the neutron to proton ratio changes in the following reaction :   2

$$_{92}U^{238} \rightarrow {_{90}Th^{234}} + {_2He^4}$$

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PHYSICS

(Major)

Paper : 6.3

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Modern Optics)

(Marks : 40)

1. Answer the following questions : $1 \times 4 = 4$

   (a) What is a non-linear medium?

   (b) Write one difference between prism spectra and grating spectra.

   (c) What type of pumping process is used in case of ruby laser?

   (d) What is monomode fiber?

2. Answer the following questions : $2 \times 3 = 6$

   (a) Optical pumping is not generally used in gases to produce laser. Explain why.

(Turn Over)

(b) Write the advantages of optical fiber over conventional copper cable in communication system.

(c) Why second harmonic generation cannot occur in liquids or gases?

3. Explain the working principle of Babinet compensator.

Or

Describe how Rochon prism is used to separate the plane polarized O-rays and E-rays.

4. What is stimulated emission of radiation? Obtain a relation between rate of spontaneous emission and rate of stimulated emission. Show that for visible light of frequency 5×10^{14} Hz at temperature $T = 10^3$ K stimulated emission is negligible compared to spontaneous emission. 2+6+2=10

Or

Write two differences between photography and holography. Explain mathematically the construction and reconstruction of hologram.

2+8=10

5. Describe the construction and working of Ramsden eyepiece. The focal length of field lens and eye-lens of a Ramsden eyepiece is 12 cm and they are separated by a distance 8 cm. If the final image is formed at infinity, find the position of the cross wire. 3+4+3=10

Or

Show graphically the refractive index distributions for step index and graded index fiber. What is intermodal dispersion? Show that after travelling a distance L through a step-index fiber, light rays spread in space by a length

$$\nabla L = L\left(\frac{n_1}{n_2} - 1\right)$$

where n_1 and n_2 are refractive indices of core and cladding regions. 2+2+6=10

5

6. Write short note on (any *one*) :

(a) Second harmonic generation

(b) Optical fiber communication system

GROUP—B

(**Electromagnetic Theory**)

(*Marks : 20*)

7. Answer the following questions : 1×3=3

(a) What is the unit of E/B, where E and B are the amplitudes of electric and magnetic fields?

(b) "A space varying electric field can produce a magnetic field." Correct the sentence.

(c) What is the basic difference between conduction current and displacement current?

8. Define Poynting vector. What is its unit? 1+1=

9. Show that electromagnetic waves are transverse in nature with the electric and magnetic field vectors at right angle to the direction of propagation.

Or

What is meant by polarization of electromagnetic wave? Derive the wave equation for a circularly polarized light. 2+3=5

10. Answer *either (a)* and *(b)* or *(c)* and *(d)* :

(a) Derive the laws of reflection and refraction of electromagnetic wave by considering a plane electromagnetic wave incident on an interface of two dielectric media. 5

(b) Obtain the expression for the energy density of electromagnetic field. 5

(c) Write down the conditions under the light of electromagnetic theory for which a medium would be conducting medium or dielectric medium or quasi-conducting medium. 3

(d) Deduce Fresnel's law of reflection and refraction from electromagnetic theory of light with electric field vector perpendicular to the plane of incidence. 7

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PHYSICS

(Major)

Paper : 6.4

Full Marks : 60

Time : 3 hours

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

rite the answers to the two Groups in separate books

GROUP—A

(**Statistical Mechanics**)

(*Marks* : 30)

1. Answer the following questions :   1×4=4

   (a) Give the statistical definition of entropy.

   (b) What is Fermi energy?

   (c) State Liouville's theorem.

   (d) What do you mean by 'bosons' and 'fermions'?

2. Answer the following questions :   2×3=6

   (a) How do you define the most probable macrostate? What is its importance in statistical physics?

(Turn Over)

(b) Name the statistics which is obeyed by photoelectrons and photons.

(c) What is phase space and how can it be related to elementary cell?

3. Answer the following questions : 5×2=1

(a) Assuming M-B distribution of molecular velocity, show that the most probable velocity is given by

$$v_{mp} = \sqrt{\frac{2kT}{m}}$$

(b) Compare the distribution laws according to M-B, B-E and F-D statistics. Under what conditions do B-E and F-D statistics yield classical result?

4. Answer any *one* of the following : 10

(a) What are fermions? Write down the postulate of F-D statistics. Derive an expression for the probability distribution of particles governed by F-D statistics. 1+2+7=10

(b) What is B-E condensation? Explain B-E condensation applying B-E statistics. Define gas degeneracy. 1+8+1=10

Or

(c) (i) Starting from

$$g(p)\,dp = \frac{V}{n^3} \iiint dp_x\,dp_y\,dp_z$$

find the number of phase space cells lying in the momentum interval p and $p+dp$, and energy interval u and $u+du$. 5

(ii) Using Maxwell's velocity distribution law, obtain the energy distribution law for the kinetic energy u. 5

GROUP—B

(Computer Applications)

(Marks : 30)

1. State True or False : 1×3=3

(a) Arithmetic operators are associative from left to right.

(b) Keywords can be used as identifiers.

(c) Loops cannot be nested.

2. Write FORTRAN-95 or C or C++ statements to perform the following tasks : 2+2=4

(a) To increment each element of an array by 5

(b) To find the result of

$$2+4+6+\cdots 20 \text{ terms}$$

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

$5 \times 3 = 15$

(a) Write a program in either FORTRAN-95 or C or C++ to find real roots of the equation $x^3 - 27 = 0$.

(b) Write a program in either FORTRAN-95 or C or C++ to arrange a list in ascending order.

(c) Write a program in either FORTRAN-95 or C or C++ to find the smallest of five numbers.

(d) A rocket is launched from the ground. Its acceleration is registered during the first 80 seconds and is given in the table below. Write a program to find velocity of the rocket at $t = 80$ sec using Simpson's 1/3rd rule :

t (sec)	0	10	20	30	40	50	60	70	80
f (cm/sec^2)	30	31·6	33·34	35·47	37·75	40·33	43·25	46·69	50·67

(e) Give a brief description of data types available in the programming language of your choice.

4. Write a program in either FORTRAN-95 or C or C++ to fit a straight line to a given set of data points using least square method.   8

Or

Write a program to find the roots of a system of linear equations.

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