2022
PHYSICS
[HONOURS]
Paper : IX

Full Marks : 80 Time : 4 Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP–A

1. Answer any **seven** from the following: 1×7=7

   a) Define the dynamic resistance of a diode.

   b) Write down the quark composition of Σ^+.

   c) Explain the term 'mass defect' of a nucleus.

   d) How does a crystal differ from a lattice?

   e) State De-Morgan's theorem.

   f) What is the maximum number of possible Bravais lattices?

   g) Define the gas multiplication factor in connection with proportional counter.

   h) Define potential energy barrier at the surface of a metal.

   i) Define loop gain of a feedback amplifier.

2. Answer any **six** from the following: 2×6=12

   a) Define load line and Q point of a transistor amplifier.

   b) What is the effect of temperature on the position of the Fermi level of a semiconductor?

   c) What is meant by the 'range' of an α-particle? How is the 'straggling' of the range of α-particles explained?

   d) What is nuclear fission? Give an example.

   e) Give two evidences in favour of the shell model of the nucleus.

   f) What are the failures of Drude free electron theory?

   g) Define a NOT gate and write its truth table.

   h) Explain ‘Early effect’ in connection with the CB characteristics of a bipolar junction transistor.

GROUP–B

Answer any **three** from the following: 7×3=21

3. a) Deduce an expression for the growth of a radioactive substance formed by the disintegration of a parent substance.

b) Distinguish between secular and transient equilibrium. 3+(2+2)

4. a) What do you mean by biasing of a transistor? Draw a self-bias circuit.

b) Explain qualitatively from the stability point of view why the self-bias circuit is an improvement over the fixed-bias circuit.

c) An n-p-n transistor with $\beta = 49$ is used in common-emitter amplifier mode with $V_{CC} = 10V$ and $R_L = 2\ k\Omega$. If a $100\ k\Omega$ resistor is connected between the collector and the base of the transistor, calculate the quiescent collector current. (Assume V_{BE}=0) (1+2)+2+2

5. a) Define the terms: average life and half life period as applied to radioactive changes. Derive the relation between them.

b) A particular type of nucleus with decay constant λ, is being produced artificially using accelerator at a steady rate of P nuclei per second. Show that the number of nuclei present t sec after the production starts, is

$$N(t) = \frac{P}{\lambda}\left(1 - e^{-\lambda t}\right).$$ (1+1+2)+3

6. a) What is packing efficiency? What are its values for sc, bcc and fcc structure?

b) Describe the scheme to determine the Miller indices of a plane. Show that the parallel planes have the same Miller indices.

c) A plane makes intercepts 1, 2 and 3A on the crystallographic axes of an orthorhombic crystal with a:b:c=3:2:1. Determine the Miller indices of this plane. (1+2)+(2+1)+1

7. a) Draw the block diagram of a negative feedback amplifier.

b) Derive an expression for the voltage gain of an amplifier of gain A when subjected to negative feedback with a feedback fraction β.

c) Show that application of negative feedback to an RC coupled amplifier increases its bandwidth. 2+3+2

GROUP–C

Answer any **four** from the following: 10×4=40

8. a) Explain the electrical dipole and quadrupole moment of the nuclei. What are the shapes of nuclei for the zero, positive and negative electric quadrupole moment?

b) If the nuclear radius of ^{27}Al is 3.6F, find out the nuclear radius of ^{64}Cu.

c) Determine the activity of 1 gm sample of ^{90}Sr whose half-life against β decay is 28 years.

d) A cyclotron having segments of radius 0.4m is adjusted for accelerating hydrogen nuclei. The polarity is reversed 3×10^{7} times per second. Find the energy of the particles in the issuing beam. Mass of proton=1.67×10^{-27} kg.

(2+2)+2+2+2

9. a) How does a free electron gas differ from an ordinary gas?

b) Obtain expressions for the Fermi energy for a free electron gas in one dimension. How does the Fermi energy of a metal depend on temperature?

c) The atomic radius of sodium is 1.86 A. Circulate the Fermi energy of sodium at absolute zero. 1+(3+2)+4

10. a) What are the characteristics of an ideal OP AMP? What are the ranges of values for the voltage gain, input impedance and output impedance of a practical IC OP AMP?

b) Draw the OP AMP circuit of a voltage to current converter. Explain its operation.

c) Draw the basic inverting amplifier with an input resistance R_I and a feedback resistance R_f. Assuming the OP AMP to be ideal, calculate the voltage gain of the inverting amplifier.

(2+2)+(1+2)+(1+2)

11. a) Explain Geiger-Nuttal law relating to the range of α-particles in alpha ray disintegrations and the half value periods.

b) Some nuclei emit α-particles of more than a single energy. Explain why.

c) Explain 'straggling' of the range of alpha particle.

d) Explain how the neutrino hypothesis solves the apparent breakdown of conservation of momentum and energy.

e) What is the nature of energy spectrum of neutrino in case of (i) β-decay and (ii) electron capture?

f) Calculate the energy of γ-rays emitted in β-decay of $^{28}_{13}Al$ (Given: the end point energy is 2.81 MeV, M $\left(^{28}_{13}Al\right)$ = 27.9819 u, M$\left(^{28}_{14}Si\right)$ = 27.9769 u. 2+2+1+2+2+1

12. a) Define packing fraction of nuclei. How is it related to the binding energy of nucleus?

b) The masses of the hydrogen atom and neutron are 1.008142 u and 1.008982 u respectively. Calculate the packing fraction and the binding energy per nucleon of $^{64}_{29}Cu$ nucleus of mass 63.9298 u.

c) What are the basic similarities between a liquid drop and an atomic nucleus?

d) Using liquid drop model obtain an expression for the mass difference of two mirror nuclei of odd A and with N and Z differing by one unit. Estimate the Coulomb coefficient a_c of the semi empirical mass formula by using the following data: Masses of $^{15}_{7}N$, $^{15}_{7}O$, $^{1}_{1}H$ and neutron are 15.000108 u, 15.00307u, 1.008142 u, 1.008982 u respectively.

(1+1)+2+1+(3+2)

13. a) Draw the circuit diagram of a two stage RC coupled amplifier.

b) Explain qualitatively the nature of the frequency response characteristic of this amplifier.

c) Define lower and upper half power frequencies and bandwidth.

d) The mid frequency gain of an RC coupled amplifier is 100. If the lower and upper half power frequencies of the amplifier are 50Hz and 200kHz, respectively, find the frequencies at which the gain is reduced to 80. 2+3+2+3

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