2021
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) Write down the quark composition of neutron.

   b) What will be the maximum efficiency (theoretical) of a half-wave rectifier?

   c) Define loop gain of a feedback amplifier.

   d) Define the term 'cut-in voltage' for a p-n junction diode.

   e) State Norton's theorem.

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

   g) Define mobility of a charge carrier.

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

   i) Explain 'artificial radioactivity' with suitable example.

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

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

   b) Draw the energy level diagram of an n-type semiconductor and label it.

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

   d) Why is it that only α-particles are emitted by radioactive nuclei, while protons and neutrons are not?

   e) Explain 'Early effect' in connection with the CB characteristics of a bipolar junction transistor.

   f) How do you classify amplifiers as audio and radio frequency amplifiers?

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

   h) Find the binary equivalent of 19.

GROUP-B

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

3. 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

4. a) The conductivity of metals decreases while that of semiconductors increases with rise in temperature - Explain.

   b) Obtain an expression for the conductivity of doped semiconductors.

   c) Determine the number density of donor atoms which have to be added to an intrinsic Ge semiconductor to produce an n type semiconductor of conductivity 5mho/cm. Given that the mobility of electrons in the n type semiconductor is 3850cm^2/volt sec. 2+3+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) 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

7. a) Draw a neat diagram of a cathode ray tube and explain its working.

   b) Derive an expression for the electrostatic deflection sensitivity of cathode ray tube. 3+4

GROUP-C

Answer any **four** from the following: $10 \times 4 = 40$

8. 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)

9. a) How many possible quarks are there? Give the charge and quantum number associated with each quark.

   b) What are the conservation laws and invariance principles used in elementary particle physics?

   c) Σ^0 hyperon (of rest mass energy 1192MeV) decays at rest into $\wedge^0$ hyperon (of rest mass energy 1116MeV) and photon i.e. $\Sigma^0 \rightarrow \wedge^0 + \gamma$. Calculate the energy of the photon released.

   d) Which interactions are allowed from the following?

      i) $\pi^- + p \rightarrow \Sigma^- + K^+$

      ii) $n + p \rightarrow \wedge^0 + \Sigma^0$ (1+2)+3+3+1

10. 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

11. 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

12. a) Draw the block diagram of 8085 microprocessor and explain it.

b) What are the various registers in 8085?

c) Name the various flag bits available in 8085 microprocessor. (3+3)+2+2

13. a) Draw the circuit of an I.C. positive TTL NAND gate and describe its operation.

b) Prove that the following Booleans represent an EXCLUSIVE OR:

i) $(A+B)(\bar{A}+\bar{B})$

ii) $\overline{AB+\bar{A}\bar{B}}$

c) Explain the function of a full adder. How many half adders are required to implement it? Draw a logic diagram for full adder. (2+1)+2+(2+1+2)

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