GEO-PHYSICS

PAPER—II

Time Allowed : Three Hours | Maximum Marks : 200

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions

There are TEN questions divided under TWO Sections.

Candidate has to attempt SIX questions in all.

Question Nos. **1** and **6** are compulsory.

Out of the remaining EIGHT questions, FOUR questions are to be attempted choosing TWO from each Section.

The number of marks carried by a question/part is indicated against it.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the QCA Booklet must be clearly struck off.

Neat sketches may be drawn to illustrate answers, wherever required.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary, and indicate the same clearly.

Answers must be written in ENGLISH only.

Physical Constants

Electron rest mass, m_e	$= 9 \cdot 109 \times 10^{-31}$ kg
Proton rest mass, m_p	$= 1 \cdot 672 \times 10^{-27}$ kg
Neutron rest mass, m_n	$= 1 \cdot 675 \times 10^{-27}$ kg
Atomic mass unit ($C^{12} = 12$), a.m.u.	$= 1 \cdot 661 \times 10^{-27}$ kg
Bohr magneton, μ_B	$= 9 \cdot 27 \times 10^{-24}$ J/tesla
Nuclear magneton, μ_N	$= 5 \cdot 05 \times 10^{-27}$ J/tesla
Boltzmann constant, k_B	$= 1 \cdot 381 \times 10^{-23}$ J/K
Speed of light in vacuum, c	$= 2 \cdot 998 \times 10^{8}$ m/s
Electron charge, $\lvert e \rvert$	$= 1 \cdot 602 \times 10^{-19}$ C
Planck's constant, h	$= 6 \cdot 626 \times 10^{-34}$ J s
Avogadro's number, N_A	$= 6 \cdot 023 \times 10^{23}$ /mole

$1 \text{ eV} = 1 \cdot 602 \times 10^{-19}$ J

Mass of $C^{14} = 14 \cdot 003242$ a.m.u.

Mass of $N^{14} = 14 \cdot 003074$ a.m.u.

$m_\pi = 139 \cdot 6$ MeV/c^2

$m_\mu = 105 \cdot 7$ MeV/c^2

SECTION—A

1. (a) What is 'Hammer Chart' and how is it useful in gravity data processing? Explain the answer using appropriate diagram. 8

(b) What are various factors on which the amplitude of seismic wave depends when it travels through a medium? Quantify the change in amplitude using appropriate mathematical expression and define various terms. 8

(c) Find the 'coefficient of anisotropy' of geoelectrical section consists of alternating series of horizontal beds with a total thickness of 100 m, the individual beds being isotropic, one meter thick each and with resistivities alternating 50 Ω m and 200 Ω m. 8

(d) A plane electromagnetic wave is travelling vertically downward in the earth in the z-direction. The wave has angular frequency ω and time dependance $e^{i\omega t}$.

At this location, the electric field can be written as $\overline{E} = \begin{bmatrix} E_x \\ 0 \\ 0 \end{bmatrix}$ and magnetic field

as $\overline{B} = \begin{bmatrix} 0 \\ B_y \\ 0 \end{bmatrix}$. Show that Maxwell's equation reduces to single differential

equation for E_x as

$$\frac{\partial^2 E_x}{\partial z^2} = i\omega\mu\sigma E_x - \omega^2 \mu \varepsilon E_x$$

Indicate the type of electric current that is represented by each term on the right-hand side of the above equation. 8

(e) How are the porosities estimated from density log and neutron log biased in the presence of gas-bearing zone? How can gas-bearing zone be delineated from the combination of density and neutron porosity logs? Explain the answer with the help of neat diagram. 8

2. (a) Draw and explain the gravity and magnetic anomaly curves over a semi-infinite horizontal sheet-type structure using labelled diagram. 15

(b) What are various factors responsible for generating magnetic field measured at any point on the surface of the earth? How will you remove various components to deduce the magnetic anomaly produced by subsurface mineralized structure? 15

3. (a) Draw the seismic refraction path between source and detector for a horizontal 3-layer model. The velocities in 3 layers are V_1, V_2, V_3 ($V_1 < V_2 < V_3$) and thicknesses of top two layers are h_1 and h_2. The distance between source and detector is x. Find the travel time expression from source to detector for a wave refracted critically from the top of the third layer. Write the general refraction travel time expression for n-layer case. 15

(b) A P-wave is incident at an angle 30° from vertical at the interface of horizontal two-layer medium and partitioned into reflected P- and S-waves and refracted P- and S-waves. The velocities of P- and S-waves are 4000 m/sec and 2500 m/sec, respectively in the first medium; and 5500 m/sec and 3500 m/sec in the second medium. Find the angle of reflected and refracted P- and S-waves from vertical. 15

4. (a) The following well log data are obtained from analysis of recorded log. Calculate formation water saturation for this data set using saturation index $n = 2$:

$$\begin{aligned} R_t &= 5 \cdot 0 \ \Omega\,\text{m} \\ R_w &= 0 \cdot 05 \ \Omega\,\text{m} \\ \phi &= 18\% \\ m &= 2 \cdot 0 \\ a &= 0 \cdot 81 \end{aligned}$$

All symbols have their usual meanings. 15

(b) What do you understand by spontaneous potential log? How can it be used to determine formation water resistivity? 15

5. (a) What do you understand by the term 'in-phase and quadrature response function' used in frequency domain electromagnetic method? Obtain expression for in-phase and quadrature response in three-loop representation used to explain EM induction in the earth. Discuss response behaviour with varying depth of conducting body. 15

(b) Explain induced polarization in terms of membrane and electrode polarizations. Define the terms 'chargeability' and 'metal factor'. 15

SECTION—B

6. (a) How do you determine the structure of a material from Raman and Infrared spectroscopy? 8

(b) Mention the principle of tunneling electron microscope (TEM). How do you determine the particle size of the material? 8

(c) Discuss Weiss theory of ferromagnetism based on magnetic domains. 8

(d) How did Gell-Mann form a triangular pattern for three types of flavors of quarks? 8

(e) State the postulates of special theory of relativity and write its importance. 8

7. *(a)* For $J=0$ to $J=1$ absorption line in CO occurs at a frequency of $1 \cdot 153 \times 10^{11}$ cycles/sec. Calculate the moment of inertia and internuclear separation of CO. 10

(b) Compute the possible terms and energy levels for a configuration with three optically active electrons $2p$, $3p$, $4d$. 10

(c) Establish the Einstein coefficients and their relation in laser. 10

8. *(a)* Explain quark confinement and the formation of baryons and mesons with quarks. 10

(b) Write the working principle of Geiger-Müller counter for the detection of nuclear charged particles. How can the quenching effect be overcome? 10

(c) A pion at rest decays into a muon plus neutrino. What is the speed of the muon? 10

9. *(a)* Establish Maxwell equations in free space and demonstrate symmetry in Maxwell equations. 10

(b) Two electric dipoles lying on the x-axis and oriented along the z-axis oscillate exactly out of phase. Their x-coordinates are separated by $\lambda/2$. Calculate the Poynting vector at the large distances. 10

(c) Write the dispersion relations in plasma. 10

10. *(a)* Show how London's equations lead to the Meissner effect and flux penetration through thin film of superconductors. 10

(b) Show that $x^2 + y^2 + z^2 = c^2 t^2$ remains invariant under Lorentz transformation. 10

(c) Write the principle of Mössbauer spectroscopy and mention its applications. 10

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