Serial No. 4624 A–GSE–P–HQB

GEO-PHYSICS

Paper—II

Time Allowed : Three Hours *Maximum Marks : 200*

INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions divided under **TWO** Sections.*

*Candidate has to attempt **SIX** questions in all.*

*Question no. **1** and **5** are compulsory.*

*Out of the remaining **SIX** 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.

All parts and sub-parts of a question are to be attempted together in the answer book.

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 answer book must be clearly struck off.

*Answers must be written in **ENGLISH** only.*

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.

Physical Constants

Electron rest mass $m_e = 9.109 \times 10^{-31}$ kg

Proton rest mass $m_p = 1.672 \times 10^{-27}$ kg

Neutron rest mass $m_n = 1.675 \times 10^{-27}$ kg

Atomic mass unit ($C^{12} \equiv 12$) a.m.u. $= 1.661 \times 10^{-27}$ kg

Bohr magneton $\mu_B = 9.27 \times 10^{-24}$ J/tesla

Nuclear magneton $\mu_N = 5.05 \times 10^{-27}$ J/tesla

Boltzmann constant $k_B = 1.381 \times 10^{-23}$ J/°K

Speed of light in vacuum $c = 2.998 \times 10^{8}$ m/s

Electron charge $| e | = 1.602 \times 10^{-19}$ C

Planck's constant $h = 6.626 \times 10^{-34}$ J-s

Avogadro's number $N_A = 6.023 \times 10^{23}$/mole

1 eV $= 1.602 \times 10^{-19}$ J

Mass of $C^{14} = 14.003242$ a.m.u.

Mass of $N^{14} = 14.003074$ a.m.u.

SECTION—A

1. (a) What is Free-air correction in gravity prospecting ? Why this correction is neglected in magnetic prospecting ? 8

   (b) Differentiate between normal and formation pressures in Reservoir Geophysics. If the formation fluids at 2800 m depth are at a pressure of 400 kg/cm^2, then calculate the overpressure.

Assume formation fluids are saline in nature with a density of 1.09 gm/cc. 8

(c) Describe CDP stacking in seismic prospecting with a neat sketch. Explain why it is done. 8

(d) Explain why the measured resistivities in parallel and perpendicular directions of geological strata are different. A heterogeneous rock sample has 1.24 as coefficient of electrical anisotropy. If the resistivity measured in perpendicular direction of this strata is 500 Ωm, then what will be the resistivity parallel to strata ? 8

(e) Define Königsberger ratio. How it is useful in deciding the rocks of an area are totally dominated by remanance or induced magnetization ? 8

2. (a) Define Eötvös correction. Also explain the role of ship's heading and velocity in evaluating this correction. Also calculate the Eötvös correction, when a ship at a latitude of 30°, is heading West with a speed of 10 knots. 10

(b) Explain the basic principle used in time-average equation to determine sonic porosity. What correction is required to the sonic porosity in a gas bearing zone ? 10

(c) A dip angle electromagnetic survey is carried out along a profile 1 km long. Two thin vertical conductors of 10 Ωm resistivity each are located at the same depth of 50 m. Also the two conductors are located at 400 m and 600 m along the profile. The resistivity of host medium is 1000 Ωm and frequency of measurement is 1000 Hz. Then draw the dip angle profile and give the logical explanation for drawing such anomaly. 10

3. (a) A series of geophones (marked as 1 to 100) are placed on the Earth surface at 100 m interval over a horizontal two layered earth with velocity V_1 = 2000 m/s and V_2 = 3000 m/s. The thickness of the first layer is 500 m. If the first geophone is placed near the shot point, then find the :

(i) nearest geophone from shot point where refracted wave reaches before the reflected wave.

(ii) nearest geophone from shot point where refracted wave reaches before the direct wave.

10+10

(b) Explain the theory of origin of Self-Potential in which subsurface anomalous structure acts like a dry cell. Draw the self-potential anomaly due to this theory and explain the limitations of this theory. 10

4. (a) Distinguish between production and injection wells. Also explain identification of zones of injection and production with the help of a flow meter tool. 10

(b) Differentiate between a conventional magnetic survey and a magnetic gradient survey. What are the advantages of magnetic gradient survey ? 10

(c) Describe Slingram EM profiling over a 2-D dipping sheet like body along with its field setup. Mention the parameters measured and precautions needed during the survey. Also draw the response curves. 10

SECTION—B

5. Answer **all** of the following : 8×5=40

(a) In a Raman scattering experiment, a laser beam is scattered by diatomic molecules. Obtain an expression for the Raman shifted frequency in terms of moment of inertia of each molecule.

(b) Discuss decay of ${}_6C^{14}$ to ${}_7N^{14}$ by β-emission and calculate how much energy is released in this process.

(c) Primitive translation vectors of an fcc lattice are

$$\vec{a}_1 = \frac{a}{2}(\hat{i}+\hat{j}),\ \vec{a}_2 = \frac{a}{2}(\hat{j}+\hat{k}),\ \vec{a}_3 = \frac{a}{2}(\hat{k}+\hat{i}),$$

where a is the lattice constant and $\hat{i}, \hat{j}$ and $\hat{k}$ are unit vectors along the coordinate axes. Find the reciprocal lattice to the fcc lattice.

(d) Discuss physical significance of the displacement current considering a parallel-plate capacitor in a circuit.

(e) Derive, for a system with many degrees of freedom, the condition for a quantity (q, p, t) to be an integral of motion if the Poisson bracket [f, H] vanishes.

6. (a) What is Franck-Condon principle ? Discuss the intensity distribution in the vibrational electronic spectra of a diatomic molecule on the basis of this principle. 15

(b) Use the energy-time uncertainty principle to estimate the rest mass of a π-meson, whose exchange leads to nucleon-nucleon interaction, in terms of range R of the nuclear force. If $R \cong 2F$, estimate m_π in units of m_e. (Take $v_\pi = c$) 10

(c) Explain why population inversion is not possible in a two-level laser system. 5

7. (a) Solve the equation of motion to find out the nature of trajectory for a charged particle moving in the plane $Z = 0$ and placed in a uniform magnetic field $\vec{B} = B\hat{Z}$. Also, calculate the rate of change for the work done by the field. 15

(b) Using the second London equation, $\nabla^2\vec{B} = \vec{B}/\lambda_L^2$, where $\vec{B}$ is the magnetic flux density and λ_L is the London penetration depth, explain how Meissner effect is accounted for in superconductors. 10

(c) An infinitely long straight wire has a uniform linear charge density. Derive an expression for the electric field at a perpendicular distance 'd' from the wire. 5

8. (a) Consider a rigid body rotating about an axis passing through a fixed point in the body with an angular velocity $\vec{\omega}$ and angular momentum $\vec{J}$. Show that the kinetic energy T of the rotating body is given by

$$T = \frac{1}{2}\vec{\omega}\cdot\vec{J}\,.$$ 15

(b) A vector potential is given by

$$\vec{A} = K[\,ct - |\,x\,|\,]^2\,\hat{z} \text{ for } |\,x\,| < ct \text{ and}$$

$\vec{A} = 0$ for $|\,x\,| > ct$ with K as a constant.

Calculate the corresponding magnetic field and give its schematic plot as a function of x. 10

(c) Find the horizontal component of the Coriolis force acting on a body of mass 1.5 kg moving northward with a horizontal velocity of 100 m/s at 30°N latitude on the earth. 5