भू-विज्ञान परीक्षा
GEOLOGIST EXAM-2018

YLO–B–GPHY

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.
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.
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.
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 ($C^{12} \equiv 12$), 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, $\|e\|$	$= 1{\cdot}602 \times 10^{-19}$ 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.
$m_\pi = 139{\cdot}6\ \text{MeV}/c^2$
$m_\mu = 105{\cdot}7\ \text{MeV}/c^2$

SECTION—A

1. *(a)* Define skin depth associated with the penetration of an electromagnetic wave in the Earth. Determine the resistivity of the medium, if an electromagnetic wave of frequency 40 Hz penetrates into the Earth up to a depth of 1006 m. (Consider $\mu = 4\pi \times 10^{-7}$ H/m) 8

(b) Define elevation correction in gravity prospecting. Determine the elevation correction factor assuming the slab density $\rho = 2 \cdot 65$ gm/cc. 8

(c) Show that the Laplace's equation for potential V holds good in an isotropic homogeneous medium when a current of constant frequency (DC) or a very low frequency AC flows in it. 8

(d) Write down the Wyllie's time-average equation. Compute the porosity in a sandstone reservoir using the above equation considering the following observations : 8

(i) An interval transit time in the sandstone reservoir was measured as 90 μs/ft.

(ii) The acoustic velocity of the rock matrix was 18000 ft/s.

(iii) Fluid transit time was 189 μs/ft.

(e) Define multiples. Distinguish between short-path and long-path multiples with the help of a schematic diagram for the case of horizontal beds. 8

2. *(a)* Explain the static shift phenomenon affecting the magnetotelluric (MT) apparent resistivity data and discuss its effect on MT impedance phase. Define the subsurface dimensionality as a function of MT impedance tensor. 15

(b) Derive the expressions for potential and electric fields due to a current dipole placed over a homogeneous ground at a distance r from the measuring point. 15

3. *(a)* Explain the concept of 'zero-length spring'. Discuss the principle of operation of astatic type of gravimeter. 15

(b) Draw a neat sketch explaining the elements of the Earth's magnetic field. Express the magnetic potential V at any point on the surface of the Earth in spherical coordinate system, signifying its internal and external origins. 15

4. *(a)* Show the positions of different detectors used in neutron logging tool with respect to a neutron source, making suitable diagrams. Also show the energy range for neutron-thermal neutron log and neutron-epithermal neutron log on the drawing itself. 15

(b) From the given well log data, estimate the formation water resistivity and water saturation : 15

Formation temperature = 150 °F
SSP = –32 mV
R_{mf} = 1·2 ohm-m at formation temperature
R_t = 3·5 ohm-m
Formation factor, $F = 2$
The ratio R_{mfe}/R_{we} = 0·25
Multiplying factor for R_{mfe} = 0·85
Multiplying factor for R_w = 1·72

5. (a) Describe the methodology for common midpoint (CMP) or roll-along shooting in seismic reflection survey with a suitable diagram. 15

(b) Derive the expression for estimation of depth of a horizontal reflector using the intercept time and crossover distance methods in seismic refraction with a suitable diagram. 15

SECTION—B

6. (a) Obtain a relation between spontaneous emission and stimulated emission coefficients in lasers. 8

(b) A neutron breaks into a proton and an electron. Calculate the energy produced in this reaction in MeV : 8

Mass of an electron = 9×10^{-31} kg
Mass of neutron = $1\cdot675\times10^{-27}$ kg
Mass of proton = $1\cdot6725\times10^{-27}$ kg
Speed of light = $2\cdot998\times10^{8}$ m/s

(c) What do you mean by Poisson's equation? Convert this into Laplace's equation. 8

(d) A diatomic molecule can be considered to be made of two masses m_1 and m_2 separated by a fixed distance r. Deduce a formula for the distance of the centre of masses C from mass m_1. Also show that the moment of inertia about an axis through C and perpendicular to r is μr^2, where $\mu = m_1 m_2 / (m_1 + m_2)$. 8

(e) A soap film of refractive index $\frac{4}{3}$ and of thickness $1\cdot5\times10^{-4}$ cm is illuminated by white light incident at an angle of 45°. The light reflected by it is examined by spectroscope in which is found a dark band corresponding to a wavelength of 5×10^{-5} cm. Calculate the order of interference band. 8

7. *(a)* Briefly describe an X-ray spectrometer used in the study of crystal structure. 15

(b) Write the principles of Mössbauer spectroscopy and discuss the effect of magnetic field. 15

8. *(a)* Calculate *(i)* the fission rate of U^{235} for producing a power of one watt and *(ii)* the energy released in the complete fissioning of 1 kg of U^{235}. Assume that 200 MeV is released per fission of the uranium nucleus. 15

(b) Find the specific heat at constant pressure of helium. If $C_V = 3129$ J/kg/K, one gram molecule of the gas occupies 22·42 litres at NTP. Given, density of mercury = 13600 kg/m^3. 15

9. *(a)* State Biot-Savart law and using that deduce an expression for the magnetic field induction B due to a long current-carrying straight wire. 15

(b) What do you mean by scalar and vector potentials? Obtain gauge transformations. 15

10. *(a)* Compute the mass m and speed v of an electron having kinetic energy 1·5 MeV. Given, rest mass of an electron $m_0 = 9 \cdot 1 \times 10^{-31}$ kgm, velocity of light in vacuum $c = 3 \times 10^8$ m/s. 15

(b) Obtain the derivation of Lagrange's equations from Hamiltonian principle. 15

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