GEO-PHYSICS

Paper III

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.

Questions No. **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. These shall be drawn in the space provided for answering the question itself.

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 Question-cum-Answer Booklet must be clearly struck off.

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

Constants which may be needed :

Kepler's constant	$= 3{\cdot}986004418\times10^{5}\ km^3\ s^{-2}$
Mean radius of the Earth	= 6378 km
Mass of electron (m_e)	$= 9{\cdot}11\times10^{-31}$ kg
Charge of electron (e)	$= 1{\cdot}602\times10^{-19}$ C
Plank's constant (h)	$= 6{\cdot}62\times10^{-34}$ Js
Boltzmann's constant (k)	$= 1{\cdot}38\times10^{-23}$ J/K
Permittivity of free space (ε_0)	$= 8{\cdot}854\times10^{-12}\ Fm^{-1}$

SECTION 'A'

1.(a) Describe the principle of radioactive decay. Draw schematically the decay of parent nuclides and growth of daughter nuclides. What is the relationship between half-life and decay constant. 4+1

1.(b) State radioactive equilibrium. Describe the equations representing α emission, β emission and K capture. 5

1.(c) What is the predominant noise that appears in marine seismic records and how to reduce it. 5

1.(d) Schematically draw the nature of waveforms of airgun and swept-frequency seismic sources. 5

1.(e) A continuous time signal $x(t)$ is obtained at the output of an ideal low-pass filter with cutoff frequency $\omega_c = 2\times10^3\ \pi$ rad/sec. If the impulse train sampling is performed on signal $x(t)$, with sampling periods of (i) 2×10^{-4} sec and (ii) 2×10^{-3} sec then which sampling period will recover the signal from its sampled version using an appropriate low-pass filter. 5

1.(f) Define discrete even and odd signals with graphical illustrations. 5

1.(g) Write about the hazards associated in coastal aquifers when excess water is drawn. 5

1.(h) What is the significance of thermal sensors in Remote Sensing ? 5

2.(a) (i) Describe the basic principle of INPUT method in airborne electromagnetic (EM) survey.

(ii) Assuming the transmitter coil is excited by half-sine waves of alternatively opposite polarity, schematically plot the primary magnetic field (H_p), and voltage induced in the receiver coil due to the influence of (i) H_p only, and (ii) both primary and secondary fields (H_p+H_s).

(iii) Mention possible sources of noise in airborne EM survey. How do you remove the noise resulting from secondary magnetic field of aircraft. 3+5+2

2.(b) Define gravitational field in terms of scalar potential. Define Laplace and Poisson's equations highlighting major difference between them. 10

2.(c) (i) Briefly write about the confined and unconfined aquifers and write special features to establish unconfined aquifers. 5

(ii) Briefly write about Reflectance and Emmittance of Solar Radiation. 5

3.(a) Compute DFT of the sequence $x[n] = \{1, 0, 0, 1\}$. 10

3.(b) Define regional and residual gravity anomalies. Define any two methods of their separation. 10

3.(c) Briefly write about the advantages and disadvantages of Remote Sensing Applications. 10

4.(a) Draw schematically the ray paths of multiple reflections in a seismic experiment at sea. 10

4.(b) Explain the linearity property of z-transform and find the z-transform of the sequence

$$x(n) = 3\left(-\tfrac{1}{3}\right)^n u(n) - 3(2)^n u(-n-1).$$ 10

4.(c) Assuming heat conduction mechanism of heat transfer in fluids in 1–D, describe the equation with its solution that explains how temperature of an ocean floor changes with time. 10

5.(a) Briefly describe how Porosity, Permeability, Specific yield and Specific retention are useful to assess the aquifer and explain their characters. 10

5.(b) (i) What are the advantages of using three-component geophones over the hydrophones in marine seismics. 5

(ii) Define forward and inverse problems in gravity interpretation. Define maximum-depth rule in depth estimation from gravity anomalies. 5

5.(c) Determine whether the given system is Linear Time Invariant (LTI) system or not.

$$y(n) = x(n+1) - x(n-1)$$ 10

SECTION 'B'

6.(a) Lead is a face centered cubic with an atomic radius of 1·764 Å. Find the spacing of (i) 200 planes and (ii) 220 planes. 5

6.(b) For an N-channel JFET, $I_{DSS} = 8{\cdot}7$ mA $V_P = -3$V, $V_{GS} = 1$ V. Find the values of (i) I_D (ii) g_{mo} (iii) g_m. 5

6.(c) Describe the principle of Ruby laser. How is population inversion obtained in Ruby laser ? 5

6.(d) Calculate the numerical aperture and acceptance angle of an optical fibre with a core index of 1·54 and a cladding index of 1·50. 5

6.(e) Prove the following Boolean identities :

(i) $A + \overline{A}B + AB = A + B$

(ii) $A\overline{B} + \overline{A}B + AB + \overline{A}\,\overline{B} = 1$ 5

6.(f) State Kepler's laws of planetary motion. Briefly outline how these laws are useful in describing the orbit of a satellite. 5

6.(g) Write Heisenberg's uncertainty relation for any two pairs of canonically conjugate variables.

If the uncertainty in the time during which an electron remains in the excited state is 10^{-6} second, what is the least uncertainty in the energy of the electron in the excited state. 2+3

6.(h) The wave functions of the particle in a one dimensional box is given by

$\Psi_n(x) = A \sin\dfrac{n\pi x}{L}$, where L is the length of the box. Find the value of the normalised constant A and write the normalised wave functions. 5

7.(a) In a diagnostic X-ray procedure $6{\cdot}50 \times 10^{10}$ photons are absorbed by a tissue of mass 0·60 kg. The X-ray wavelength is 0·020 nm

(i) What is the total energy absorbed by the tissue ?

(ii) What is its equivalent in rem. ? 5+5

7.(b) (i) What do you mean by logic gates ?

(ii) Explain about universal gates. 10

7.(c) (i) Take three differential operators $\frac{d}{dx}$, $\frac{d^2}{dx^2}$ and $\frac{d^3}{dx^3}$. The function $(\sin 2x)$ is an eigenfunction of which operator ? And what is its eigenvalue ? 5

(ii) For the Pouli spin matrices σ_x, σ_y and σ_z, show that $[\sigma_x, \sigma_y] = 2i\sigma_z$ 5

8.(a) The light output of a typical laser is 10·6 μm. What is the difference between the energy levels of the excited states and Metastable state ? What will be the energy of the photon emitted ? What is the frequency associated with the photon ? If two moles of photons are emitted per second, what is the power of the laser output ? 10

8.(b) With block diagram show the important components of radar and explain the principle of each component. Mention few uses and applications of radar. 10

8.(c) Obtain energy values of a one-dimensional harmonic oscillator of mass m oscillating with a frequency ω with the help of the WKB approximation. 10

9.(a) Derive an expression for the effective mass of an electron. 10

9.(b) (i) Bring out the difference between temporal and spatial coherence. 4

(ii) Laser line widths as low as 20 Hz is obtained. Calculate the coherence length and frequency stability of the laser. (Assume $\lambda = 6328$ Å). 6

9.(c) Formulate Klein-Gordon equation in the form of de-Alembertion operator. Find its plane wave solution $\Psi(\vec{r}, t) = \exp[i(\vec{k} \cdot \vec{r} - \omega t)]$. What are negative energy states ? 7+3

10.(a) Calculate the lattice specific heat capacity of an array of N identical atoms on the basis of Debye approximation. 10

10.(b) (i) What do you mean by mode-locking technique in laser ? Make a comparison between non-mode locked and mode locked laser outputs. 5

(ii) What do you mean by Q-switching technique in laser. Briefly mention different methods of Q-switching. 5

10.(c) (i) Discuss the forces that keep the satellite in the orbit. Mention the orbital elements commonly used in satellite communication. 5

(ii) Earth rotates once per sidereal day of 23 h 56 min 4·09 sec. Find the radius of the geostationary earth orbit.
(Take Kepler's constant $(\mu) = 3{\cdot}986004418 \times 10^5$ km^3/s^2). 5
