ZLX-T-GPY

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.

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.*

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.

Constants which may be needed :

Kepler's constant	=	$3{\cdot}986004418 \times 10^{5}\ km^{3}\ s^{-2}$
Mean radius of Earth	=	6378 km
Mass of electron (m_e)	=	$9{\cdot}11 \times 10^{-31}$ kg
Charge of electron (e)	=	$1{\cdot}602 \times 10^{-19}$ C
Planck's constant (h)	=	$6{\cdot}62 \times 10^{-34}$ J-sec
Boltzmann's constant (k)	=	$1{\cdot}38 \times 10^{-23}$ J/K

SECTION A

Q1. (a) (i) Define the American Petroleum Institute (API) unit of gamma radiation, by considering the master calibration of gamma ray tool.

(ii) Given the bed resolution to be 1 ft and time constant to be 2 s, estimate the logging speed (ft/hr) of a radiation/radioactivity logging tool. *5*

(b) (i) State the reason for not applying elevation correction usually to total magnetic intensity (TMI) data.

(ii) State the basic premise of radiocarbon dating method. *5*

(c) State the basic heat flow equation with appropriate units for its entities. *5*

(d) Name any three non-explosive offshore seismic sources and two seismic receivers. *5*

(e) Can we digitize all signals properly ? State your answer with brief justification. *5*

(f) We have a signal with frequencies ranging between 18 kHz and 24 kHz. If we sample this signal such that there would be two replicas of the signal (between −18 kHz and +18 kHz), what should be the sampling frequency(ies) ? *5*

(g) What do you understand by scale of a map ? Out of two maps of the same area having scales (i) 1 : 2,50,000, and (ii) 1 : 25,000, which one will be useful for your detailed mapping ? Justify your answer. *5*

(h) What is meant by the term 'FCC' in Remote Sensing ? Why does vegetation always appear red in FCC ? *5*

Q2. (a) Briefly discuss the airborne phase component electromagnetic system with the help of a schematic block diagram. *8+2=10*

(b) (i) State the Fourier differentiation theorem. *1*

(ii) Prove the Fourier differentiation theorem. *5*

(iii) Give the physical consequence and application of this theorem. *4*

(c) (i) What do you understand by 'Atmospheric Window' ? *3*

(ii) What is meant by BAND in Remote Sensing ? Discuss briefly the different types of BANDs used by the sensors of Indian and United States' Remote Sensing satellites. *2+5=7*

Q3. (a) Briefly discuss the physical principles of an air gun and the need for air gun arrays in offshore seismic investigations. *7+3=10*

(b) (i) Explain the geological field condition or situation, where directional noise is required to be reduced by aerial geophone array. *3*

(ii) Also draw and label two standard geophone aerial arrays used for reducing such directional noises. *4*

(iii) Suppose you need to have a signal-to-noise ratio factor of 3, then for reducing random noise, how many geophones are required in a group ? *3*

(c) (i) Define Geographic Information System (GIS). Name the different components of GIS. *3+2=5*

(ii) What is 'Geostationary Satellite' ? Mention three important uses of geostationary satellites. Give an example of an Indian Geostationary Satellite. *3+1+1=5*

Q4. (a) Provide the mathematical expressions of 2-D analytic signal supported by physical significance in the following cases :

(i) Magnetic anomaly interpretation *5*

(ii) Seismic data analysis *5*

(b) (i) State the reason(s) for applying IGRF correction to offshore total magnetic intensity (TMI) data. *5*

(ii) Suppose a time sequence is defined as

$$f_k = \begin{cases} 1 & 0 \le k < 10 \\ 0 & 10 \le k < 100 \end{cases}.$$

Determine its Amplitude spectrum. *5*

(c) (i) What are the different types of remote sensing sensors ? Discuss briefly, the different types of sensors used by Indian Remote Sensing satellites. Also give their resolutions. *2+2+1=5*

(ii) What is a Multispectral Scanner used in Remote Sensing ? Describe in brief the operational procedure of a multispectral scanner. *2+3=5*

Q5. (a) (i) In which environment are radioactive elements formed ? *3*

(ii) Write a short note on position location methods for offshore geophysical surveys. *7*

(b) Enumerate the procedure of Auto Regressive (AR) modelling for any random process with a supporting seismic example. *10*

(c) (i) Provide the formula for shale fraction estimation on the basis of a GR log reading against a formation by using the entire GR log data. *4*

(ii) Discuss briefly the Electromagnetic (EM) energy and its interactions with terrain features. *6*

SECTION B

Q6. (a) What is Meissner effect ? Show that the perfect diamagnetism and zero resistivity are the two independent properties of the superconducting state. *2+3=5*

(b) Show that for a normal optical source with temperature about 10^3 K and wavelength 6000 Å, the emission is predominantly due to spontaneous transitions. *5*

(c) What do you understand by Q-switching the laser cavity ? How is it achieved using an acousto-optical device ? *5*

(d) Explain how voltage amplification is obtained in a transistor common base amplifier although the current gain is less than unity. *5*

(e) Give the logic symbols, Boolean expressions and the truth tables of a two-input NOR and a two-input NAND gate. *5*

(f) What do you mean by radar cross-section of targets ? Explain the various parameters affecting the radar cross-section of a target. *2+3=5*

(g) Two copper conducting wires are separated by an insulating oxide layer (CuO). Modelling the oxide layer as a square barrier of height 10 eV, estimate the transmission coefficient for penetration by 7 eV electrons, if the layer thickness is 1 nm. *5*

(h) Prove that

$$[L_z, p^2] = 0$$

where L_z is the operator corresponding to z-component of the angular momentum, and p is the operator corresponding to the linear momentum. *5*

Q7. (a) What is Bragg's law of diffraction ? Why can it not be used in the case of visible light ?

In a powder diffraction experiment using CuK_α radiation of wavelength 1·54 Å, the first five lines are observed from a monoatomic cubic crystal when the angle 2θ is 38·0, 44·2, 64·4, 77·2 and 81·4 degrees. Determine the crystal structure and the lattice parameter. *2+1+7=10*

(b) What is the position of the Fermi level in an intrinsic semiconductor ? How does its position change when (i) donors, and (ii) acceptors are added to the semiconductor ? How does the Fermi level vary, if the temperature is raised ? *2+3+3+2=10*

(c) Describe the construction and working of a ruby laser, and show how population inversion is achieved here. *10*

Q8. (a) Define the acceptance angle and the numerical aperture of an optical fibre. How are they related to the refractive indices of the core and the cladding ?

Explain how light is guided by an optical fibre. *2+2+3+3=10*

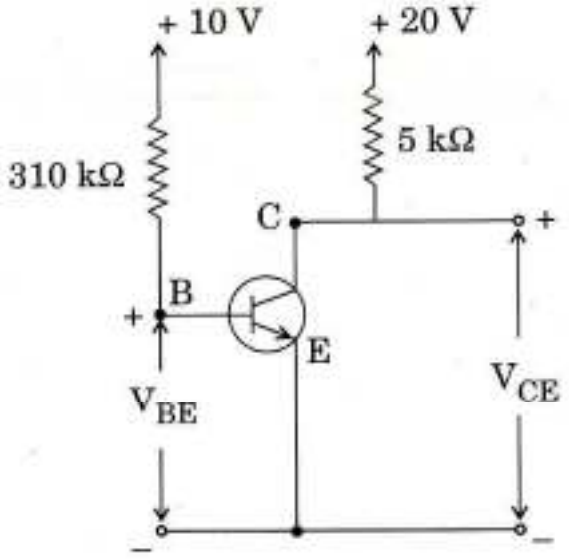
(b) Explain the principle of operation of the Light Emitting Diode (LED). Why is silicon not used as an LED material ? *7+3=10*

(c) Obtain the eigen function with the help of Schrödinger's wave equation, for a particle of mass m enclosed in a box of length L, and represent the first three eigen functions graphically. Also prove that the energy eigen values of the particle are discrete. *7+3=10*

Q9. (a) Explain the static characteristics of an n-channel Junction Field Effect Transistor (JFET). What are saturation voltage and saturation current, and how do they vary when the reverse gate-bias increases ? Why is a forward bias not applied to the gate of a JFET ? *4+4+2=10*

(b) When a voltage $V_1 = + 40\ \mu V$ is applied to the non-inverting input terminal and a voltage $V_2 = - 40\ \mu V$ is applied to the inverting terminal of an operational amplifier, an output voltage $V_o = 100$ mV is obtained. But when $V_1 = V_2 = + 40\ \mu V$, one obtains $V_o = 0{\cdot}4$ mV. Calculate the voltage gains for the difference and the common-mode signals, and the common-mode rejection ratio. *5*

(c) A transistor is operating in the common emitter mode, shown in the figure. Calculate V_{CE} if current gain, $\beta = 125$, assuming $V_{BE} = 0{\cdot}6$ V. *5*



(d) Explain Kepler's laws of planetary motion. Illustrate their relevance to an artificial satellite orbiting the Earth. What do you understand by geosynchronous and geostationary orbit ? *3+3+4=10*

Q10. (a) Distinguish between the characteristic features of diamagnetism, paramagnetism and ferromagnetism. Give an example of each type of material. Comment on the temperature variation of susceptibility for each type of material. *6+4=10*

(b) Determine the interplanar spacing between two parallel planes with Miller indices (h k *l*) in a cubic crystal of side 'a'.

Which is the most densely packed structure amongst the various cubic structures ? Determine the packing fraction of this structure. *5+1+4=10*

(c) Establish both, the time-independent and time-dependent Schrödinger wave equations for a non-relativistic particle. *10*