

Syllabus and Sample Questions for JRF in Geology

2007

The candidates have to take two tests: Test **GM (Part -1:** objective and **Part -II:** short answer type/numerical problems) in the forenoon session and test **RG** (critical appreciation, short answer and objective type) in the afternoon session. For both tests Full Marks will be 100 and Time 2 Hours.

Syllabus

FORENOON SESSION

(GM Part -1)

***Algebra:** Properties of real numbers, Geometry of complex variables, DeMoivre's theorem, Algebra of matrices, Rank & inverse of a matrix, Determinants, Solution of linear equations, Orthogonal & unitary matrices, Eigenvalues & eigenvectors of a matrix*

***Calculus:** Sequence & series, Taylor series, Limit & continuity, Derivatives, Integration of functions of one variable, Definite integrals, Functions of several variables, Partial derivatives, Maxima & minima, Ordinary linear differential equations, Elementary linear partial differential equations..*

***Co-ordinate Geometry:** Straight line, Conic sections, Elementary 3-D co-ordinate geometry*

(GM Part II)

***Geomathematics and statistics:** Mohr's Circle of stress and strain, Geological Strain Analysis, Rheology of materials, Heat flow within the Earth, Flow through porous media, Thermodynamic Principles, Stereographic Projection of geological data, Paleovector determination.*

Elementary probability theory, Measures of central tendency, Dispersion, Binomial, Poisson, Normal distributions, Student's T test, ANOVA models, Snedecor's F test, Correlation & regression, Time series analysis.

Sample Questions

Forenoon session

GM

Part -I

(To be answered in separate answer script, not in the Question Paper)

1. If $x_n = \sqrt{n+1} - \sqrt{n}$, then $\lim_{n \rightarrow \infty} x_n$ is equal to
(a) ∞ (b) 1 (c) 0 (d) $\sqrt{2} - 1$
2. If a and b are any two positive unequal quantities and $b > a$, then which one of the following is correct
(a) $ma^{m-1}(b-a) > b^m - a^m$ (b) $ma^{m-1}(b-a) = b^m - a^m$ (c) $ma^{m-1}(b-a) < b^m - a^m$ (d)
none of these.
3. The real roots of $x^3 - 5x - 5 = 0$ lies in the interval
(a) (2,3) (b) (-7, 2) (c) (3, 7) (d) (-3, -2)
4. If M and N are two matrices, given by
 $M = \begin{bmatrix} i & 0 \\ 0 & -i \end{bmatrix}$, $N = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$, $i^2 = -1$, then which of the following is correct
(a) $M^2 = I$ (b) $N^2 = I$ (c) $MN = -NM$ (d) $MN = NM$
5. If 'O' and 'D' denote the order and degree of differential equation respectively, then $d^3y/dx^3 - 7 dy/dx - 6y = e^{2x}(1+x)$ is characterised by
(a) (O = 3, D = 3) (b) (O = 1, D = 3)
(c) (O = 2, D = 3) (d) (O = 3, D = 1)
6. The maximum value of the function $f(x) = (1/x)^x$ is
(a) e (b) e^e (c) $e^{1/e}$ (d) $1/e$
7. One of the radii of curvature of the curve $y^2 = \frac{x^2(a+x)}{a-x}$ is

- (a) $\sqrt{2a}$ (b) $-\sqrt{2a}$ (c) $2\sqrt{2a}$ (d) $a\sqrt{2}$

8. The value of the integral $\int_0^{\infty} e^{-x^2} \cos \alpha x dx$ is

- (a) $\frac{\sqrt{\pi}}{2} e^{-\frac{1}{4}\alpha^2}$ (b) $\sqrt{\pi} e^{-\frac{1}{2}\alpha^2}$ (c) $\frac{\sqrt{\pi}}{2} e^{-\frac{1}{4}\alpha^2}$ (d) $\frac{\pi}{2} e^{-\frac{1}{4}\alpha^2}$

9. The condition that the line $y = px + r$ is a tangent to the parabola $y^2 = 4ax$ is

- (a) $r = ap$ (b) $r = 2a/p$ (c) $r = -a/p$ (d) $r = a/p$

10. The value of Z satisfying $C^2 - Z^2C = Z^2I + I$ where $C = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$ is

- (a) 1, 2 (b) 1, -1 (c) 2, -2 (d) None of these

GM

Part II

Group A

1. Between the years 1951 and 1960, the aluminium production (in Tons) is given

1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1.13	1.24	1.62	1.75	1.90	2.02	2.01	1.86	2.31	2.34

Assuming a linear trend in the change in production through time, find the coefficients a ,

b in $Y = a + bx$.

2. For a rock analysis following results were obtained for 10 measurements:
 $\text{SiO}_2 = 56.23, 54.12, 56.10, 53.21, 50.15, 51.52, 50.19, 56.10, 49.72, 50.82$

Find the instrumental precision for SiO_2 .

3. Both the variables x_1 and x_2 have a large variance, but their covariance is small. Find the most appropriate inference, describing the relation between the two variables x_1 and x_2 .

- Arkoses normally contain more than 25% feldspar. Find the probability of encountering feldspar grains in a thin section of arkose.
- Symmetric extinction angle in plagioclase is related to the solid-solution composition. Under the microscope when these are measured, what type of scale of measurement should be relevant?

Group B

- Assuming a stoichiometrically balanced reaction $A + 3B \leftrightarrow 1.5 C + D$ and given the following standard state properties of the phases, which way will the reaction proceed at 500°C , 5 Kbar?

	H (Kj/mol)	S (J/mol/K)	V (J/b)
A	-6207.34	334.16	14.98
B	-910.70	41.46	2.27
C	-3091.10	66.17	3.13
D	-3970.79	214.15	10.87

- The cross-bedding dip directions (azimuths) measured on separate sets at a single locality, are as follows: 10, 250, 261, 265, 274, 281, 285, 290, 293, 297, 300, 301, 302, 303, 307, 311, 320, 326, 333, 352. Determine the vector mean and strength.
- The two-dimensional state of stress at a point P in the x_1x_2 -plane is given by:
 - stress normal to $x_1 = 5$ kPa
 - stress normal to $x_2 = 3$ kPa
 - shear stress = 2 kPa

Write the above data as a stress tensor (or matrix). Write the deviatoric stress matrix. What are the components of stress (in the x_1 - and x_2 - directions) acting on a surface inclined at an angle of 60 degrees to the x_1 -axis?

- Write the Darcy's equation and derive the definition of the coefficient of permeability.

5. Under equilibrium state, the variables temperature (T), pressure (P) and specific volume (V) are interrelated. Construct a partial differential equation to relate the change in specific volume with change in T and P. β and α_v are defined as follows

$$\beta = -1/v (\delta v/\delta p)_T \text{ and } \alpha_v = 1/v (\delta v/\delta T)_P$$

If the material is confined, i.e. its volume does not change, then shown that changes in temperature can lead to large changes in pressure. The values of β and α_v are of the order of 10^{-11}Pa^{-1} and $3 \times 10^{-5} \text{K}^{-1}$.

Syllabus

AFTERNOON SESSION

RG

1. **Structural Geology and Tectonics:** Concepts of stress and strain, plastic and viscous flow; theory of brittle fracture. Folding and faulting – their classification and mechanics. Superposed folds and their recognition. Classification and genesis of foliation, lineation and joints. Outlines of the structure of the Himalayas. Interpretation of geological maps.

Plate tectonics, mobile belts and seismic zones. Plume Tectonics
2. **Rock forming minerals and mineral optics:** General principles of mineral optics and modern methods of mineral identification.
3. **Petrology:** Phase equilibria studies of various silicate systems with reference to petrogenesis. Concept of magma. Magma generation in the mantle, various possible processes; magmatic differentiation and assimilation.
Petrogenetic study of important igneous or groups of igneous rocks – granites, pegmatites, alkaline rocks, andesite, basalt, ophiolites. Processes of generation of magmas in the crust and upper mantle – correlation with plate tectonics.
Controls of metamorphism, nature of metamorphic reactions, chemical equilibrium. Facies concept : Mineral assemblages and important reactions in different metamorphic facies. Relationship between metamorphism, ultrametamorphism, crustal anatexis and migmatites. Petrogenetic problems of Khondalites and Charnockites.
4. **Geochemistry:** Geochemical classification and distribution of elements in the earth. Law of ionic substitution, concept of solid solution and controlling factors. Radioactivity, Radioactive decay systems and their application in Geochronology.

5. ***Sedimentology***: Classification of sedimentary rocks. Transport of sediments by fluids. Depositional environments. Processes and characteristics of continental, mixed and marine sedimentation. Lithification and diagenesis of sediments. Textures and structures. Statistical analysis of grain size and shape. Palaeocurrents and basin analysis. Sedimentary facies and methods of their analysis.
6. ***Economic geology***: Principles of classification of mineral deposits. Processes of formation of economic mineral deposits. Hydrocarbon deposits and strategic minerals of India.
7. ***Palaeontology***
Evolution of life. Fossils, their nature, modes of preservation and uses. Migration, dispersal and extinction of animals and plants. Morphology, classification and evolution of important invertebrate and vertebrate fossil groups. Microfossils – techniques of their study and importance in geology. Fundamentals of palaeoecology. Important Gondwana flora and fauna of India.
8. ***Stratigraphy***: Principles of stratigraphy. Stratigraphic Units. Standard geological time scale. Elements of Sequence Stratigraphy. Principles of palaeogeographic reconstruction. Principles of stratigraphic correlation. Elements of Indian Stratigraphy. Important age and correlation problem in Indian stratigraphy.
9. ***Geophysics***: Earth's rotation, gravimetry, and Isostasy; Geomagnetism and rock magnetism; Earthquakes and Seismic exploration; Apparent Polar Wander Paths.
10. ***Elements of Remote Sensing***:

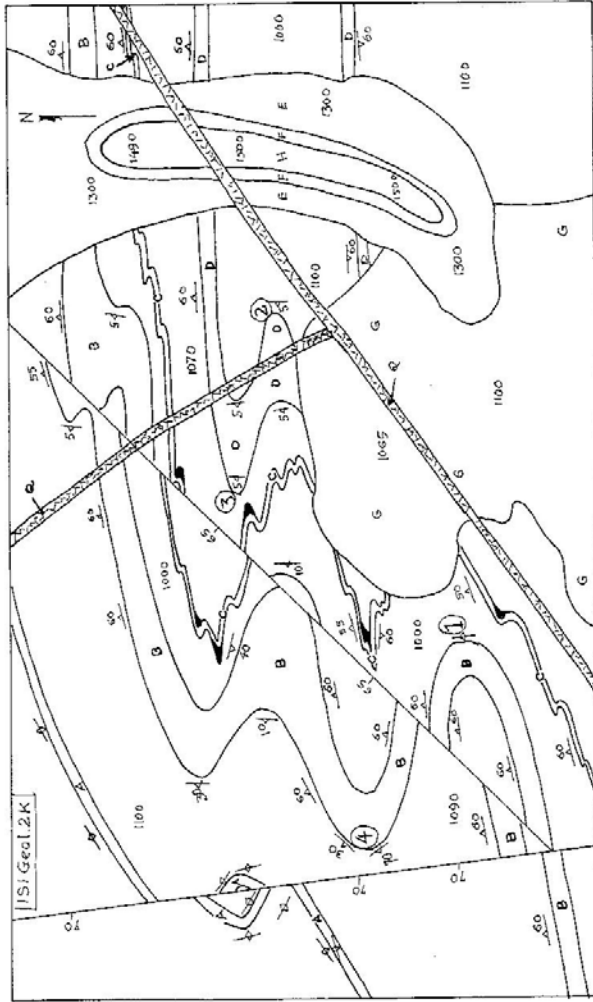
Sample Questions

Afternoon Session

RG

Group A

1. Work out the following from the geological map (ISI-GEOL-2K, Figure 1) given on page 1. Scale of the map is approximately 10 cm = 750m. Spot height in feet.
 - (a) Describe the relation between rock sequences A-B-C-D and E-F-H.
 - (b) Describe the relation between rock unit G and the other rock sequences in the area.
 - (c) Which rock unit is the youngest in the area and what is its mode of occurrence? Justify your answer.
 - (d) Is the NE trending fault a normal fault? Justify your answer.
 - (e) Comment on the nature of displacement on the NNW trending fault.
 - (f) Change in attitude of foliation shown in different parts of the mapped area indicates that the foliation is folded. Are all the folds shown on the map of comparable style? Cite orientations of fold axes and axial planes at locations 1 through 4 (circled spots) in support of your answer.



(Fig - 1)

Group B

Note : Write short answer to each of the following questions.

2. Describe briefly the history of differentiation of the earth.
3. "Granitic rocks have mineralogical compositions close to eutectics." – explain.
4. Give an account of the textural features suggestive of chemical equilibrium in metamorphic rocks.
5. Give an account of the climatic and tectonic significance of arkosic sandstones.
6. (a) Could *Archaeopteryx* fly? Justify your answer. (b) Why are fossil brachiopods mostly found with their valves closed?
7. How do you explain the origin of crustal stresses?

Group C

Questions 8-12 are multiple choice type. Select the correct answer for each and justify it.

8. The primitive crust of the earth was
 - (a) granitic
 - (b) basaltic
 - (c) komatiitic
 - (d) andesitic
9. The major source of heat in the primordial earth was
 - (a) decay of short-lived radioactive isotopes
 - (b) decay of long-lived radioactive isotopes
 - (c) impact of planetesimals
 - (d) all of the above
10. Bedforms with the crest trending roughly parallel to the net sediment transport direction are called
 - (a) linear dune
 - (b) longitudinal dune
 - (c) seif dune
 - (d) parabolic dune
11. Transgression is caused by
 - (a) rise in eustatic sea level
 - (b) rise in relative sea level
 - (c) increased rate of subsidence
 - (d) decreased rate of sedimentation
12. Boudins are products of
 - (a) homogeneous deformation
 - (b) inhomogeneous, brittle deformation
 - (c) inhomogeneous, ductile deformation
 - (d) none of the above.

Group D

Select the correct answer from the multiple choice. No justification is needed.

13. Temperature at the crust-mantle boundary is of the order of
 - (a) 600°C
 - (b) 900°C
 - (c) 1700°C
 - (d) 1300°C

14. Diphyodonty does not take place in
 - (a) incisors
 - (b) pre-molars
 - (c) molars
 - (d) canines

15. Epsilon cross-stratification is common in
 - (a) marine environment
 - (b) fluvial environment
 - (c) lacustrine environment
 - (d) aeolian environment

16. S- or Z-shaped inclusion trails in garnets indicate
 - (a) Syn-tectonic crystallization
 - (b) Pre-tectonic crystallization
 - (c) Post-tectonic crystallization
 - (d) None of the above

17. Under high P-T conditions Al is favoured in a SiO₄ tetrahedra linkage in the
 - (a) 4 co-ordinated position
 - (b) 6 co-ordinated position
 - (c) 8 co-ordinated position
 - (d) 10 co-ordinated position

18. *Barapasaurus tagorie*, a Jurassic dinosaur, was recovered from
 - (a) Jabalpur Formation
 - (b) Ariyalur Formation
 - (c) Kota Formation
 - (d) Bhuj Formation

19. Paratype is formally designated when
 - (a) used in the description of the species
 - (b) a new specimen is used due to the destruction of the type specimen
 - (c) it is not the part of the original type material
 - (d) several type specimens are used

20. Foreland basins are associated with
- (a) crustal extension
 - (b) strike slip faults
 - (c) thrust loading
 - (d) thermal contraction
21. Transform faults occur within
- (a) continental lithosphere
 - (b) oceanic lithosphere
 - (c) both continental and oceanic lithosphere
 - (d) none of the above
22. An area in isostatic equilibrium would show
- (a) no free air anomaly but may show Bouguer anomaly
 - (b) no free air and Bouguer anomaly
 - (c) free air anomaly but no Bouguer anomaly
 - (d) none of the above.