Junior Research Fellowship in Geology, 2014

The candidates for Junior Research Fellowship in Geology will have to take two tests: Test GEA (forenoon session) and Test GEB (afternoon session).

Syllabus (GEA)

Part - 1

Algebra: Properties of real numbers. Geometry of complex variables. DeMoiver's theorem. Algebra of matrices. Rank & inverse of a matrix. Determinants. Solution of linear equations. Orthogonal & unitiary 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. Heat conduction equations.

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

Part - II

Geomathematics and Geostatistics: Analysis of orientation and time-series data, 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.

Applications of elementary probability theory, Measures of central tendency, Dispersion, Binomial-Poisson-Normal distributions, Student's T test, ANOVA models, Snedecor's F test, Correlation & regression.

Indian Statistical Institute

Junior Research Fellowship in Geology, Entrance Examination

Sample Question

BOOKLET No. TEST CODE: **GEA**

Forenoon Time: 2 hours

Part I - ten questions	10 X 4 = 40
Part II - six questions	6 X 10 = 60
Total	**100**

Give your answers in the answer booklet only.

Write your Name, Registration Number, Test Centre, Test Code and the Number of this booklet in the appropriate places on the answer sheet.

STAPLE/ATTACH QUESTION BOOKLET WITH THE ANSWER BOOKLET. ALL ROUGH WORK MUST BE DONE ON THE QUESTION BOOKLET AND / OR ON THE ANSWER BOOKLET. YOU ARE NOT ALLOWED TO USE CALCULATOR.

WAIT FOR THE SIGNAL TO START WRITING

Part-I

Select the right answer from the given alternatives for each of the following questions.

(*10×4=40 Marks*)

1. The equation to the common chord of the two circles: $x^2 + y^2 - 6x - 10y + 9 = 0$ and $x^2 + y^2 - 4x + 6y - 12 = 0$ is

a) $2x + 16y - 21 = 0$

b) $16x + 2y - 21 = 0$

c) $8x + y - 10 = 0$

d) $x + 8y - 10 = 0$

2. If $y = \sqrt{\sin x + \sqrt{\sin x + \sqrt{\sin x + \sqrt{etc}}}}$ to $\propto$, then $\frac{dy}{dx}$ is

a) $\frac{\cos x}{2y-1}$

b) $\frac{\sin x}{2y-1}$

c) $\frac{\cos x}{1-2y}$

d) $\frac{\sin x}{1-2y}$

3. If $f(x) = 1 + x$, $x < 0$

$= x$, $0 < x < 1$

$= 2 - x$, $1 < x < 2$

$= 3x - x^2$, $x > 2$,

then $f(x)$ is

a) continuous at x = 2

b) discontinuous at x= 2

c) differentiable at x = 2

d) None of these

4. If $\tan y = \frac{2t}{1-t^2}$ and $\sin x = \frac{2t}{1+t^2}$, then $\frac{dy}{dx}$ is

a) 1

b) $\frac{2t-t^2}{1-2t^2}$

c) $\frac{2t}{1-t^2}$

d) $\frac{2t-1}{1-2t^2}$

5. $\lim_{x\to\propto} \frac{5x^{12}+7x^2+12}{14x^{16}+9x^2-3}$ is equal to

a) 0

b) 1

c) 2

d) 3

6. If $\alpha = \cos\frac{2r\pi}{n} + i\sin\frac{2r\pi}{n}$ and if r and p are prime to n, then the value of $1 + \alpha^p + \alpha^{2p} + \cdots + \alpha^{(n-1)p}$ is

a) 0

b) 1

c) -1

d) i

7. $\int_0^{\frac{\pi}{2}} \log \sin x dx$ is equal to

a) $\frac{\pi}{2} \log \frac{1}{2}$

b) $\frac{\pi}{4} \log 2$

c) $\frac{\pi}{8} \log \frac{1}{2}$

d) $\frac{\pi}{6} \log 2$

8. The maximum value of $\left(\frac{1}{x}\right)^x$ is

a) $e^{\frac{1}{e}}$

b) $\left(\frac{1}{e}\right)^e$

c) $(e^2)^{\frac{1}{e}}$

d) $\left(\frac{1}{e^2}\right)^e$

9. The values of α for which the equations with $a \neq b \neq c$ are consistent

$x + ay + a^2 z = a^4 + \alpha a^2$

$x + by + b^2 z = b^4 + \alpha b^2$

$x + cy + c^2 z = c^4 + \alpha c^2$

are when $a + b + c \neq 0$

a) $-(a^2 + b^2 + c^2 + ab + ac + bc)$, $1 - (a^2 + b^2)$

b) $a^2 + b^2 + c^2$, $1 - (a^2 + b^2 + ab)$

c) $+ac + bc$, $1 - (a^2 + b^2 + c^2)$

d) None of these

10. The eigen values and the corresponding eigen vectors of the matrix

$$\begin{bmatrix} 8 & -6 & 2 \\ -6 & 7 & -4 \\ 2 & -4 & 3 \end{bmatrix}$$

are

a) 0, $[1 \quad 2 \quad 2]'$; 3, $[2 \quad 1 \quad -2]'$; 15, $[2 \quad 2 \quad 1]'$

b) 2, $[1 \quad 2 \quad 0]'$; 2, $[-1 \quad 0 \quad 2]'$; 8, $[2 \quad -1 \quad 1]'$

c) 2, $[2 \quad 5 \quad -3]'$; 3, $[1 \quad 1 \quad -2]'$; 2, $[5 \quad 2 \quad -5]'$

d) None of these

Part-II

(*Six questions, ten marks each*)

11. Consider the reaction *aA + bB* ⇌ *cC + dD* at a given pressure P bar and temperature T ^{o}C.

a) If the reaction attains equilibrium (at a given P – T) then show that the equilibrium constant (K_{eq}) of this reaction will be $K_{eq} = \frac{[C]^c \cdot [D]^d}{[A]^a \cdot [B]^b}$

b) What will be the dimension of K_{eq}.

c) If the stoichiometric coefficients of the reaction *aA + bB* ⇌ *cC + dD* is such that *a=b=c=d*=1 and the initial amounts of both the reactants A and B are 0.1 M, then show that the amounts x M of each products C and D at equilibrium will be $[x] = [0.1] \cdot \frac{\sqrt{K_{eq}}}{(1+\sqrt{K_{eq}})}$

[2+1+7]

12. Which of the following statements is accurate about the chart of morphological data given below? The "1" in the box means the trait is present and the "0" indicates that the trait is absent.

	Jaws	Lungs	Amniotic Membrane	Hair	No tail	Bipedal
Lamprey	0	0	0	0	0	0
Shark	1	0	0	0	0	0
Salamander	1	1	0	0	0	0
Lizard	1	1	1	0	0	0
Tiger	1	1	1	1	0	0

Gorilla	1	1	1	1	1	0
Human	1	1	1	1	1	1

A) a) All organisms in this chart share all of the derived characteristics.

b) Only the gorilla and humans share all of the derived characteristics.

c) The lamprey is the only outgroup since it shares none of the derived characteristics.

d) The salamander and the tiger are outgroups because they only share two of the derived characteristics (jaws and lungs).

e) The shark is an outgroup since it only has one of the derived characteristics (jaws)

B) Draw a cladogram based on the above matrix.

[5+5]

13. Grain size in a sediment sample is given by 500 ± 50 μm (mean value± 1 standard deviation). In Normal distribution, 68.2 % of the measurements of the variable lies within ± 1 standard deviation of the mean. If the grain size in the sediment sample is expected to follow Normal distribution calculate:

a) the probability of getting of grains smaller than 450 μm;

b) the probability of getting grains larger than 550 μm, in the sample.

c) Is the probability of getting grains smaller than 100 μm zero?

d) Is the probability of getting grains larger than 1mm non-zero?

[3+3+2+2]

14. a) Two boreholes, named A and B, dug 100m apart on an E-W traverse encounter a coal seam at depths of 100m (A) and 200m (B) respectively. If the coal seam is uniformly dipping between these two bore holes then which of the following is a correct statement regarding slope (θ) of the coal seam.

i) $\theta \leq 45^\circ$

ii) $\theta = 45^\circ$

iii) $\theta \geq 45^\circ$.

Justify your answer.

b) The same seam is encountered at a depth of 100m in a third borehole (C) dug 100m west of A. A geologist interprets the observation in terms of a fault passing between A and C. Calculate the vertical separation of the coal seam across the fault.

c) In order to get the true dip of the coal seam which of the following alternative locations for a third borehole to be dug is correct? Assume that there is no fault or fold between A and B.

i) mid-point on the line AB;

ii) 50m north or south of line AB.

Give reasons for your answer.

[5+2+3]

15. The table below lists the major element oxide values for five basalt samples taken from an area.

a) Calculate the mean SiO_2, TiO_2 and MgO values.

b) Is there any correlation between SiO_2 and TiO_2 values?

c) By calculating the correlation coefficient between SiO_2 and MgO values, one notices a moderate correlation ($R^2 = 0.436$). Is it a positive correlation or negative correlation?

d) If the linear regression equation is given by $y = -0.334\,x + 21.83$, where $x = SiO_2$ and y = MgO, then show that mean MgO value can be predicted from the mean SiO_2 value.

Sample no.	GDR19D-1	GDR27	GDR28D	GDR31	GDR33

Major elements (wt%)					
SiO_2	51.84	47.82	49.58	48.28	48.31
TiO_2	2.484	2.292	1.981	3.717	0.944
Al_2O_3	13.17	14.21	14.15	13.84	18.37
Fe_2O_3	3.58	2.96	3.87	4.91	1.7
FeO	10.9	11.2	10.9	12.3	7.86
MnO	0.215	0.211	0.216	0.229	0.134
MgO	4.35	5.87	5.61	4.72	6.35
CaO	9.26	10.74	9.24	7.93	10.46
Na_2O	1.56	2.34	2.83	2.72	3.2
K_2O	0.67	0.44	0.46	0.3	0.22
P_2O_5	0.27	0.09	0.27	0.07	0.27
LOI	0.86	0.38	0.46	0.38	0.64
Total	99.16	98.55	99.57	99.40	98.46

[3+2+2+3]

16. What will be the sphericity of a clastic grain having two dimensional shape of

a) a rectangle with sides two mm and four mm long

b) a rhombus with sides 2mm long and having a largest internal angle of 120°? Given: cosine of 30° ≈ 0.87

[5+5]