

Paper Specific Instructions

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, **A**, **B** and **C**. All sections are compulsory. Questions in each section are of different types.
2. **Section – A** contains a total of 30 **Multiple Choice Questions (MCQ)**. Each MCQ type question has four choices out of which only **one** choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.
3. **Section – B** contains a total of 10 **Multiple Select Questions (MSQ)**. Each MSQ type question is similar to MCQ but with a difference that there may be **one or more than one** choice(s) that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.
4. **Section – C** contains a total of 20 **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.
5. In all sections, questions not attempted will result in zero mark. In **Section – A** (MCQ), wrong answer will result in **NEGATIVE** marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In **Section – B** (MSQ), there is **NO NEGATIVE** and **NO PARTIAL** marking provisions. There is **NO NEGATIVE** marking in **Section – C** (NAT) as well.
6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are **NOT** allowed in the examination hall.
7. The Scribble Pad will be provided for rough work.

SECTION – A
MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q. 10 carry one mark each.

Q.1 Which of the following is associated with a divergent plate boundary?

- (A) Ridge (B) Trench (C) Island arc (D) Accretionary prism

Q.2 Shear waves do not travel through the

- (A) upper continental crust (B) upper mantle
(C) lower mantle (D) outer core

Q.3 Fossils of burrows and footprints are known as

- (A) pseudofossils (B) coprolites (C) body fossils (D) trace fossils

Q.4 Horst and graben structures are typically formed by

- (A) normal faulting (B) strike-slip faulting
(C) reverse faulting (D) thrust faulting

Q.5 *Dicroidium* is known from the

- (A) Pachmarhi Formation (B) Raniganj Formation
(C) Panchet Formation (D) Denwa Formation

Q.6 Permian is a/an

- (A) Eon (B) Era (C) Epoch (D) Period

Q.7 Polymorphic minerals have

- (A) different crystal forms and identical composition
(B) different crystal forms and different compositions
(C) identical crystal form and different compositions
(D) identical crystal form and identical composition

Q.8 Turbidites commonly form in

- (A) fluvial environment (B) deep marine environment
(C) tidal flat environment (D) beach environment

Q.9 Which of the following is the fundamental constituent of humic coal?

- (A) Mineral matter (B) Maceral (C) Lithotype (D) Kerogen

Q.10 Which of the following mineral assemblages characterizes blueschist facies metamorphism of a mafic rock?

- (A) Glaucophane + lawsonite (B) Hornblende + plagioclase ± epidote ± garnet
(C) Omphacite + garnet (D) Phengite + chlorite + garnet

Q. 11 – Q. 30 carry two marks each.

Q.11 Match the geomorphic features in Group I with corresponding environments in Group II.

Group I

- P. Eskers
Q. Natural levee
R. Chenier ridge
S. Plug dome

Group II

1. Beach
2. Volcanic
3. Glacial
4. Fluvial

- | | | | |
|-----|-----|-----|-----|
| (A) | (B) | (C) | (D) |
| P-3 | P-3 | P-2 | P-2 |
| Q-4 | Q-1 | Q-1 | Q-4 |
| R-1 | R-4 | R-4 | R-1 |
| S-2 | S-2 | S-3 | S-3 |

Q.12 Match the bivalves in Group I with their modes of life in Group II

Group I

- P. *Gryphaea*
Q. *Mya*
R. *Mytilus*
S. *Pecten*

Group II

1. Swimming
2. Unattached, free-lying
3. Burrowing
4. Sessile byssate

- | | | | |
|-----|-----|-----|-----|
| (A) | (B) | (C) | (D) |
| P-4 | P-4 | P-2 | P-2 |
| Q-1 | Q-3 | Q-3 | Q-1 |
| R-2 | R-2 | R-4 | R-4 |
| S-3 | S-1 | S-1 | S-3 |

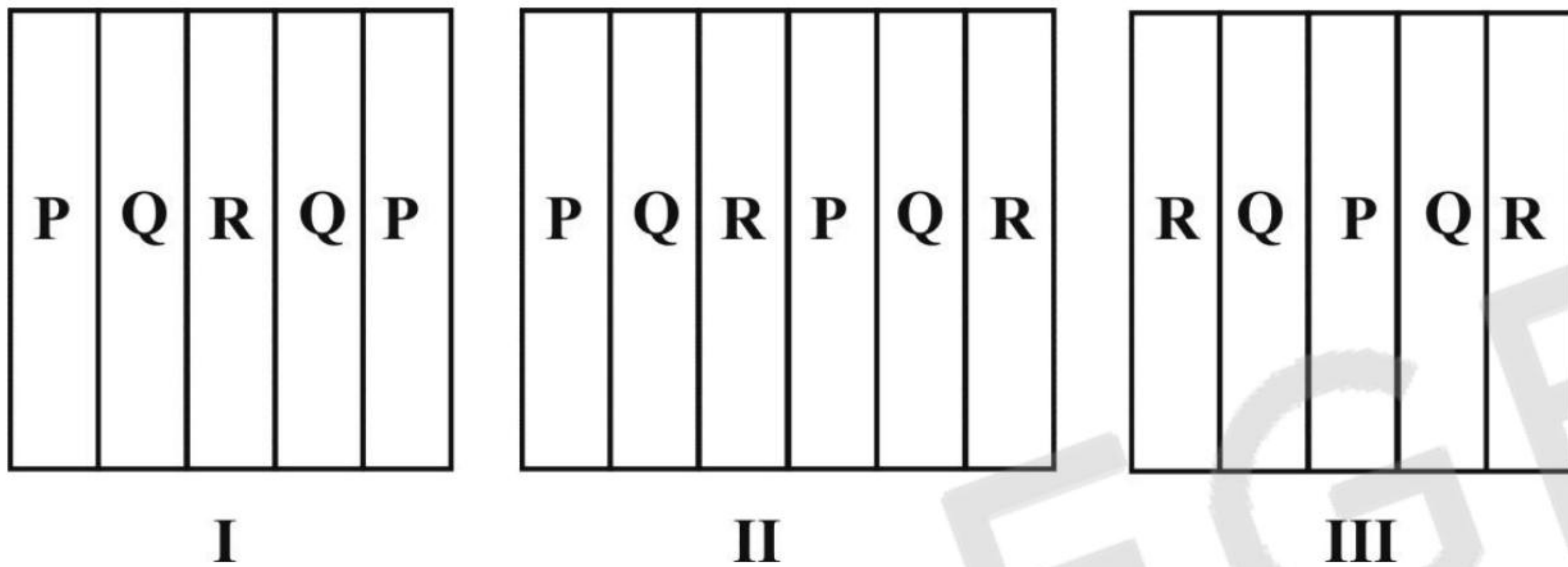
Q.13 Which of the following changes occurred during the evolution of Equidae?

- (A) Number of lateral digits or toes increases (B) Decrease in hypsodonty
(C) Lengthening of skull in front of the orbit (D) Limb ratios remained constant

Q.14 Which of the following rocks occurs typically in a ductile shear zone?

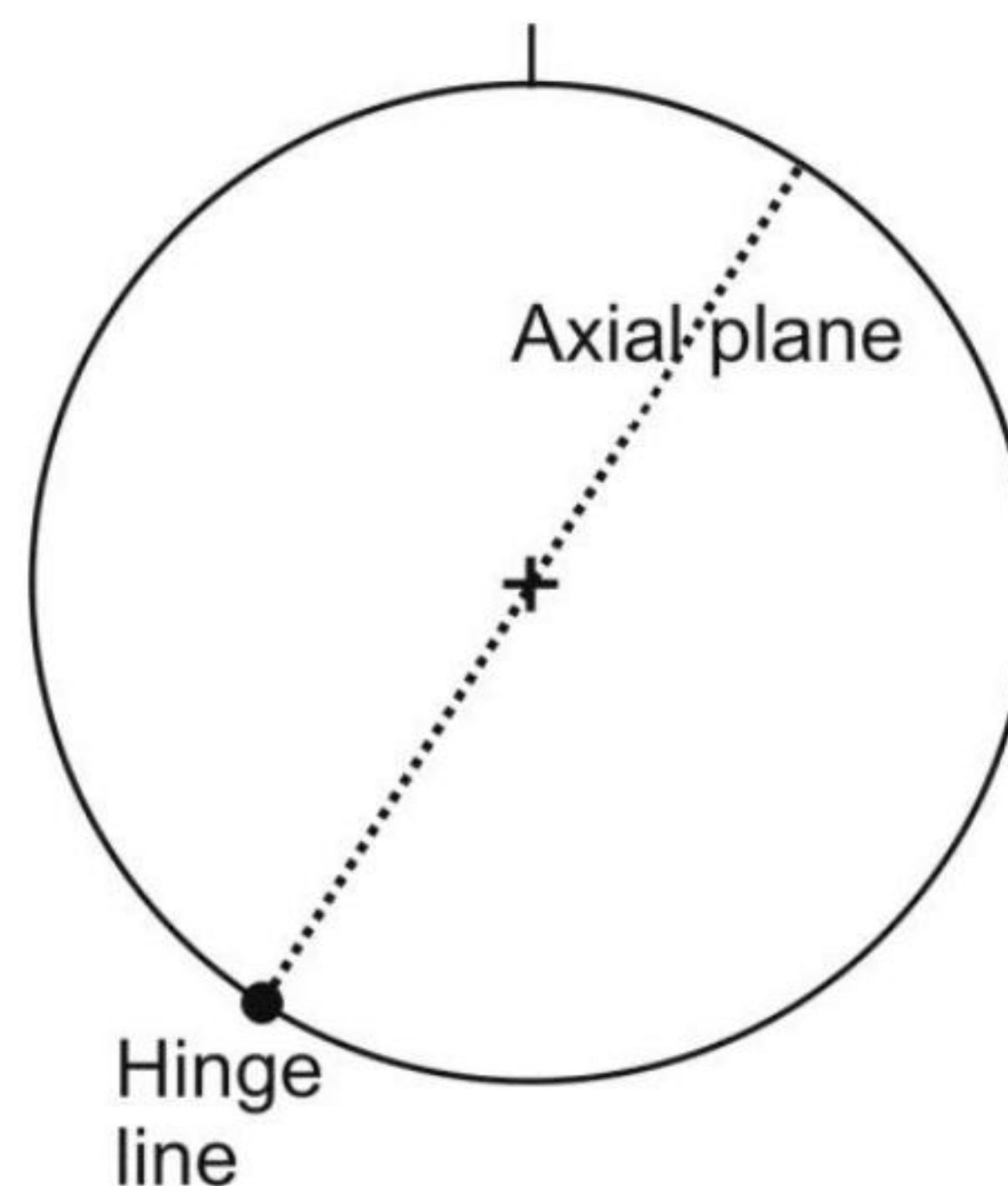
- (A) Gouge (B) Breccia (C) Pseudotachylite (D) Mylonite

Q.15 Figures I, II and III are the outcrop patterns of three inclined beds P, Q and R on a flat ground. P is the oldest and R is the youngest amongst these beds. Identify the correct option that explains repetition of beds in the figures.



- (A) I- anticline; II- syncline; III- fault
 (B) I- syncline; II-anticline; III- fault
 (C) I- fault; II- anticline; III- syncline
 (D) I- syncline; II- fault; III-anticline

Q.16 The figure shows stereographic projections of the axial plane and the hinge line of a fold. Which one of the following folds is represented in the figure?



- (A) Upright plunging (B) Upright non-plunging
 (C) Reclined (D) Recumbent

- Q.17 Figures X and Y show profile sections of folds traced by two cross-bedded sandstone beds. Which one of the following is the correct interpretation?



- (A) X- Antiformal anticline; Y- Antiformal syncline
 (B) X- Antiformal anticline; Y- Synformal syncline
 (C) X- Overtured antiform; Y- Overtured synform
 (D) X-Antiformal syncline; Y- Synformal anticline
- Q.18 On a geological map of a flat area, the plunge direction of an antiformal anticline is
- (A) towards the fold closure
 (B) away from the fold closure
 (C) towards the dip direction of the left limb
 (D) towards the dip direction of the right limb
- Q.19 Match the Precambrian lithounits in Group I with corresponding cratons in Group II.

Group I

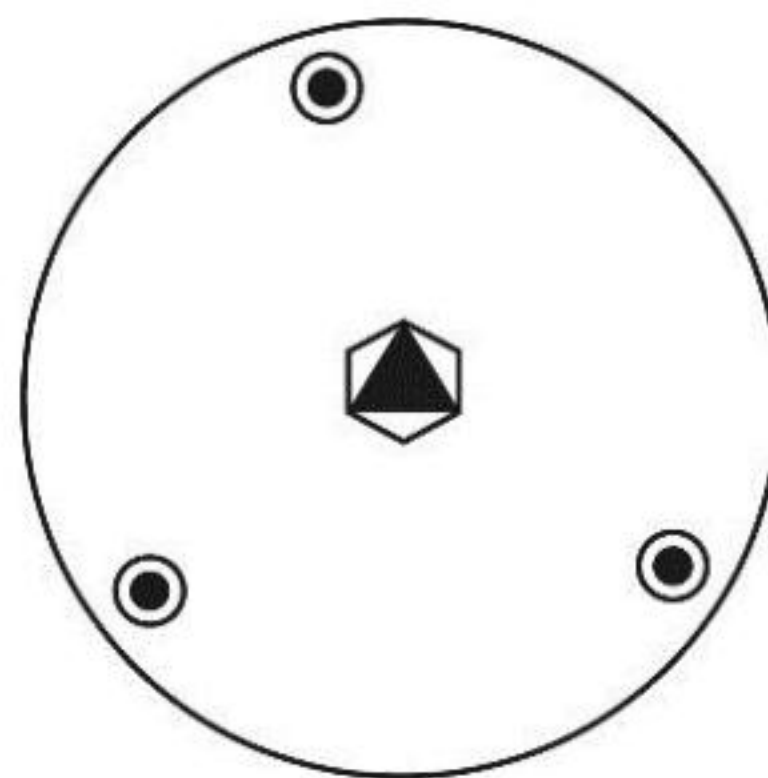
P. Kolhan Group
 Q. Debari Group
 R. Bababudan Group
 S. Sukma Group

Group II

1. Aravalli
 2. Bastar
 3. Singhbhum
 4. Dharwar

(A)	(B)	(C)	(D)
P-2	P-3	P-3	P-2
Q-4	Q-4	Q-1	Q-1
R-1	R-1	R-4	R-4
S-3	S-2	S-2	S-3

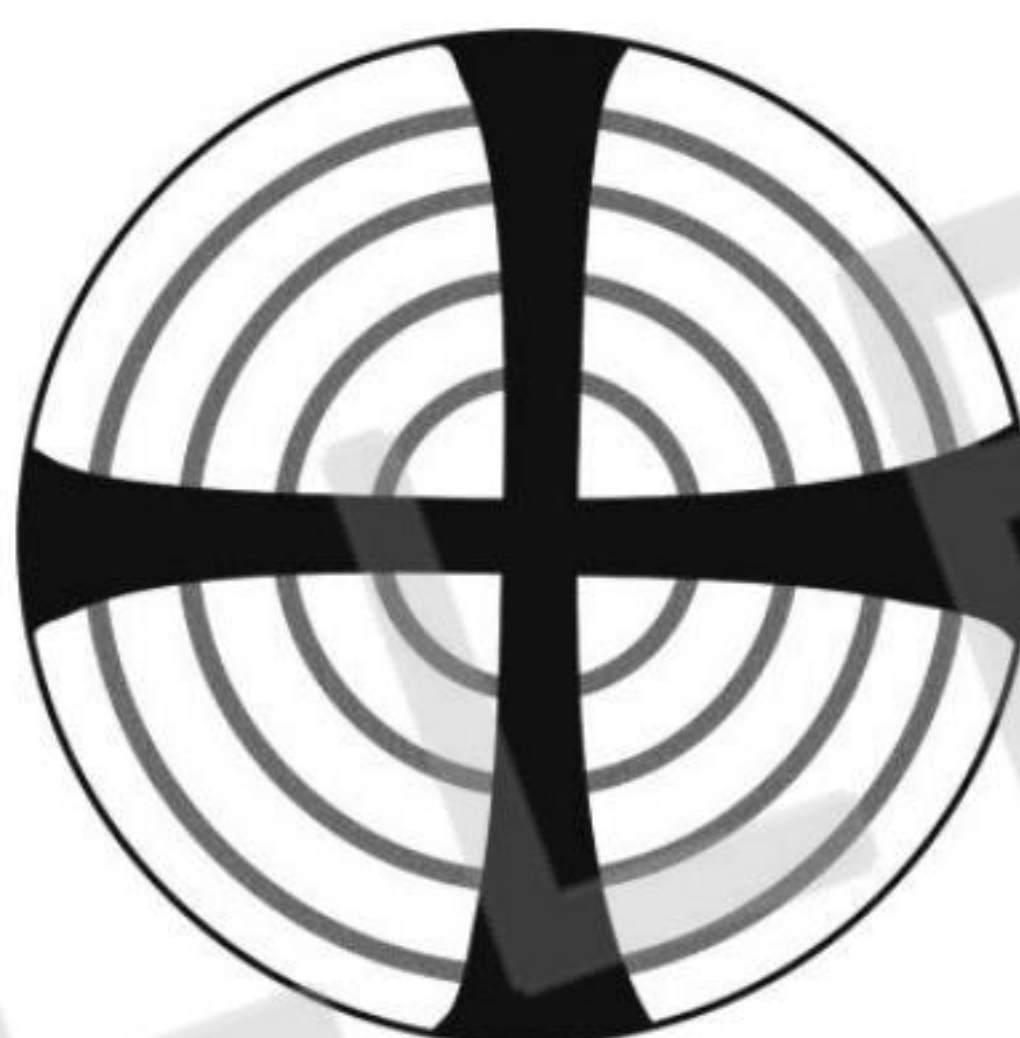
Q.20 The stereographic projection given below represents a



(A) trigonal rhombohedron
(C) trigonal dipyrmaid

(B) hexagonal scalenohedron
(D) hexagonal dipyrmaid

Q.21 Which of the following minerals exhibits the optic interference figure given below?



(A) Quartz

(B) Diopside

(C) Garnet

(D) Orthoclase

Q.22 Match the minerals in Group I with corresponding characteristic properties in Group II.

Group-I

P. Labradorite
Q. Actinolite
R. Fluorite
S. Barite

Group-II

1. High specific gravity
2. Play of colors
3. Acicular habit
4. Four sets of cleavage

(A)
P-4
Q-1
R-2
S-3

(B)
P-4
Q-1
R-3
S-2

(C)
P-2
Q-3
R-4
S-1

(D)
P-2
Q-3
R-1
S-4

Q.23 Match the metamorphic rocks in Group I with corresponding parent rocks in Group II.

Group-I		Group-II	
P.	Amphibolite	1.	Marl
Q.	Khondalite	2.	Shale
R.	Calc-gneiss	3.	Sandstone
S.	Quartzite	4.	Basalt

(A)	(B)	(C)	(D)
P-4	P-4	P-2	P-4
Q-3	Q-2	Q-4	Q-3
R-1	R-1	R-1	R-2
S-2	S-3	S-3	S-1

Q.24 Match the fuels in Group I with corresponding areas of occurrence in Group II.

Group I		Group II	
P.	Uranium	1.	Vastan, Gujarat
Q.	Lignite	2.	Singrauli, Madhya Pradesh
R.	Bituminous Coal	3.	Digboi, Assam
S.	Petroleum	4.	Jaduguda, Jharkhand

(A)	(B)	(C)	(D)
P-4	P-4	P-3	P-2
Q-1	Q-1	Q-4	Q-4
R-3	R-2	R-2	R-1
S-2	S-3	S-1	S-3

Q.25 Match the features in Group I with their characteristic rocks / rock suite in Group II.

Group I		Group II	
P.	Continental arc	1.	Olivine tholeiite
Q.	Mid-oceanic ridge	2.	Alkaline rock
R.	Collision zones	3.	Andesite
S.	Continental rift	4.	Ophiolite

(A)	(B)	(C)	(D)
P-2	P-1	P-3	P-3
Q-1	Q-3	Q-1	Q-2
R-3	R-4	R-4	R-1
S-4	S-2	S-2	S-4

Q.26 Which of the following statements are correct?

- I. In a planar tabular cross-bedding, the upper and lower bounding surfaces are planar and parallel
- II. In a planar tabular cross-bedding, the upper and lower bounding surfaces are planar but not parallel
- III. In a trough cross-bedding, both the upper and the lower bounding surfaces are curved
- IV. In a trough cross-bedding, the upper bounding surface is planar and the lower bounding surface is curved

- (A) II and III (B) II, III and IV (C) I, II and III (D) I, III and IV

Q.27 Match the sedimentary structures in Group I with the corresponding processes in Group II.

Group I

- P. Stromatolite
- Q. Flute cast
- R. Mud crack
- S. Dish and pillar

Group II

- 1. Desiccation
- 2. Liquefaction
- 3. Biostratification
- 4. Erosion

- | | | | |
|-----|-----|-----|-----|
| (A) | (B) | (C) | (D) |
| P-3 | P-3 | P-4 | P-2 |
| Q-4 | Q-4 | Q-3 | Q-3 |
| R-1 | R-2 | R-1 | R-4 |
| S-2 | S-1 | S-2 | S-1 |

Q.28 An ore mineral has the following physical properties: (1) metallic lustre, (2) steel-grey color, (3) two sets of octahedral cleavage, (4) high specific gravity, and (5) makes mark on paper. Identify the ore mineral.

- (A) sphalerite (B) magnetite (C) galena (D) bornite

Q.29 Which of the following are the characteristics of a typical porphyry copper deposit?

- I. Associated with granitic rocks
- II. Low-grade and high tonnage of ore
- III. Presence of alteration zones
- IV. Occurrence in convergent tectonic setting

- (A) II only (B) I and IV only (C) I, II, III and IV (D) I, III and IV only

Q.30 Match the metal deposits in Group I with the corresponding processes in Group II.

Group I

P. Aluminum
Q. Iron
R. Tungsten
S. Thorium

Group II

1. Mechanical concentration
2. Contact metasomatism
3. Residual concentration
4. Chemical sedimentation

(A)	(B)	(C)	(D)
P-1	P-3	P-3	P-2
Q-3	Q-4	Q-4	Q-3
R-2	R-2	R-1	R-4
S-4	S-1	S-2	S-1

SECTION - B**MULTIPLE SELECT QUESTIONS (MSQ)**

Q. 31 – Q. 40 carry two marks each.

Q.31 Which of the following statement(s) is/are correct for a plot of ($^{87}\text{Sr}/^{86}\text{Sr}$) versus ($^{87}\text{Rb}/^{86}\text{Sr}$) of a rock which has evolved in a closed system?

- (A) The slopes of the lines of evolution for the minerals in the rock are all equal and positive
- (B) The slopes of the lines of evolution for the minerals in the rock are all equal and negative
- (C) The slope of the isochron is identical in direction to the slope of the lines of evolution for the minerals in the rock
- (D) The slope of the isochron is opposite in direction to the slope of the lines of evolution for the minerals in the rock

Q.32 Which of the following statements is/are correct with reference to subsurface water?

- (A) The perched water table occurs below the water table
- (B) Vadose water occurs in the zone of aeration
- (C) For significant groundwater underflow, the medium must be highly permeable
- (D) Intersection of the water table with the land surface can result in the formation of a spring

Q.33 Which of the following geomorphic features indicate(s) the presence of a fault?

- (A) Triangular facets
- (B) Sudden topographic jump
- (C) Ox-bow lake
- (D) Point bar

Q.34 Which of the following gastropods has/have siphonal canal?

- (A) *Cerithium*
- (B) *Cypraea*
- (C) *Fusus*
- (D) *Murex*

Q.35 Which of the following is/are mode(s) of preservation of fossils?

- (A) Small organisms get trapped on viscous resins secreted by trees
- (B) Leaves preserved as thin films of carbon
- (C) Negative impressions of hard parts of organisms
- (D) Mineral growths that branch like ferns

Q.36 Select the pair(s) that is/are correctly matched.

- (A) Lathi Formation – Jurassic wood fossils
- (B) Pinjor Formation – Cretaceous ammonoid fossils
- (C) Panchet Formation – Triassic reptile fossils
- (D) Kota Formation – Permian glossopterid fossils

Q.37 Choose the reaction(s) indicating metamorphism of pelites at $T > 600\text{ }^{\circ}\text{C}$ and $P < 8\text{ kbar}$.

- (A) albite + actinolite $\rightarrow$ hornblende + quartz
- (B) muscovite + quartz $\rightarrow$ sillimanite + K-feldspar + H_2O
- (C) muscovite + biotite + quartz + H_2O $\rightarrow$ sillimanite + melt
- (D) albite $\rightarrow$ jadeite + quartz

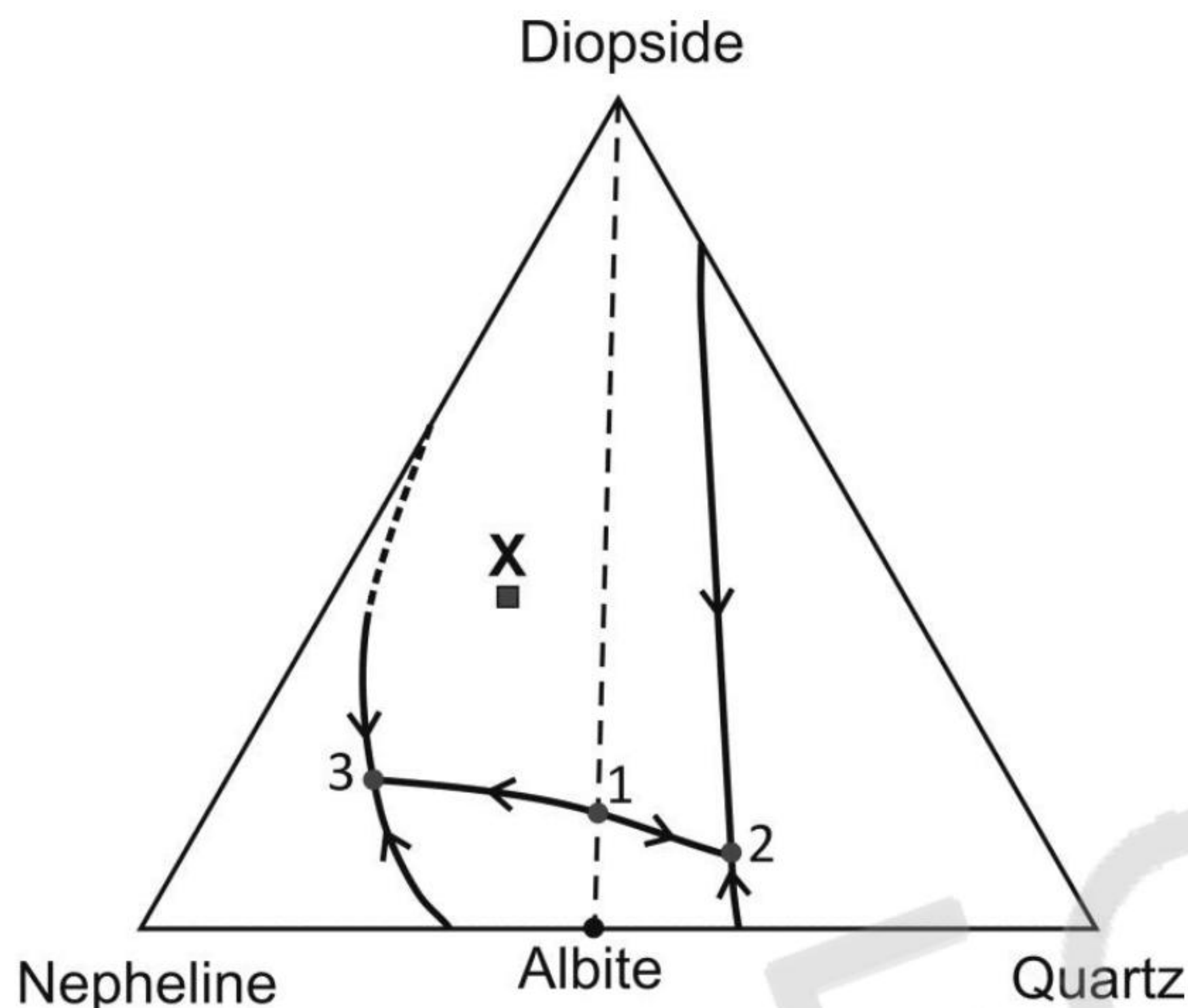
Q.38 Select the correct statement(s).

- (A) Laccoliths are convex upward whereas lopoliths are convex downward bodies
- (B) Laccoliths can form from any type of magma whereas lopoliths form only from basaltic magma
- (C) Laccoliths show layered structures whereas lopoliths lack any layering
- (D) Laccoliths are smaller in dimensions than lopoliths

Q.39 Select the correct statement(s).

- (A) Phenocrysts are found in igneous rocks whereas porphyroblasts are found in metamorphic rocks
- (B) Phenocrysts are indicators of crystallization history whereas porphyroblasts indicate metamorphic history
- (C) Porphyroblasts are relict grains, relatively larger than matrix minerals in deformed igneous rocks
- (D) Poikiloblastic texture is found in igneous rocks whereas poikilitic texture is found in metamorphic rocks

Q.40 Based on the given schematic ternary phase diagram, choose the correct statement(s).



- (A) Point 1 is the thermal minimum in the system.
- (B) The diopside – albite join acts as a thermal barrier in the system.
- (C) Point 2 and 3 are ternary eutectics.
- (D) Melt of composition X will give rise to a rock containing nepheline+albite.

SECTION – C

NUMERICAL ANSWER TYPE (NAT)

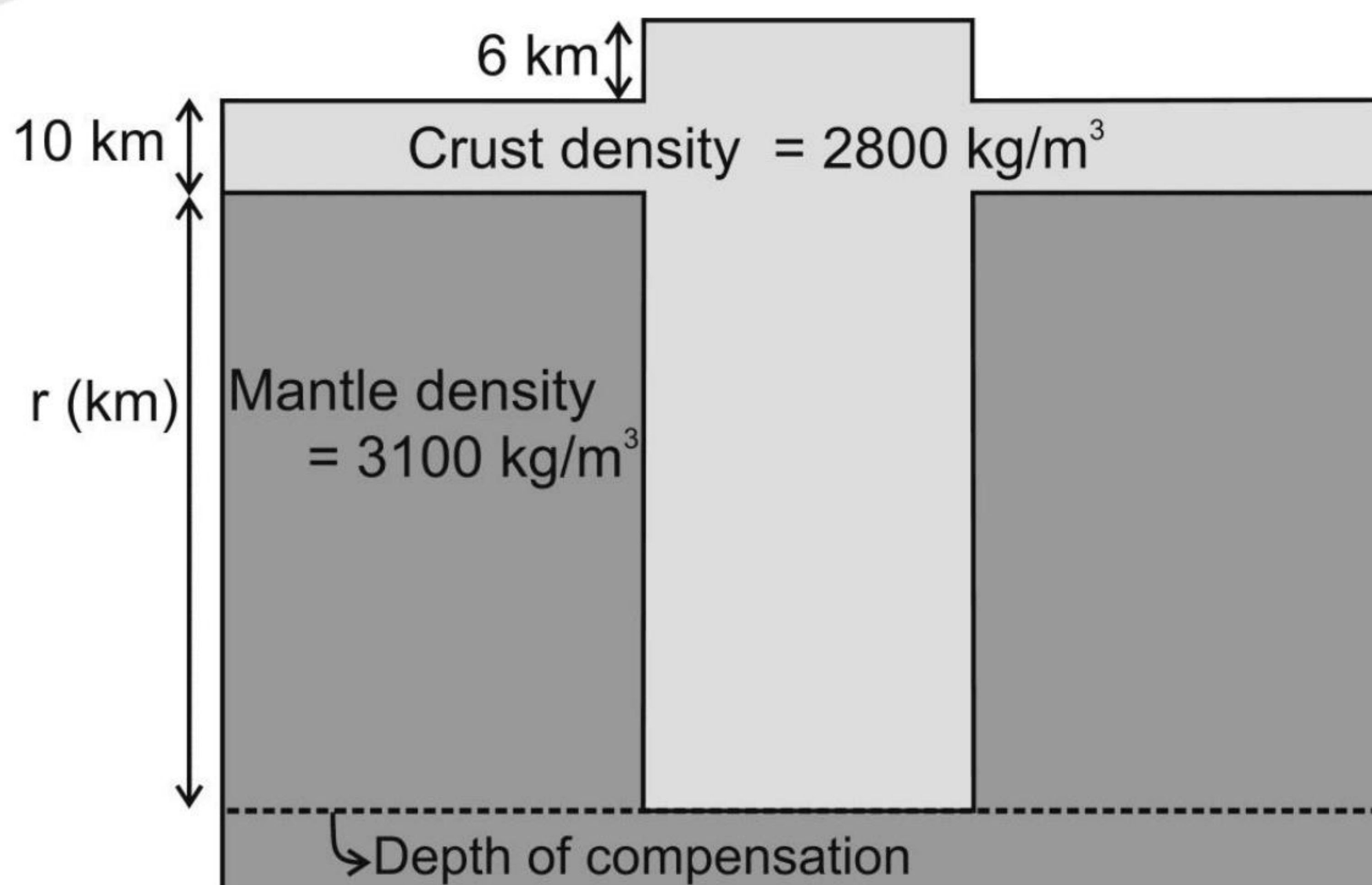
Q. 41 – Q. 50 carry one mark each.

- Q.41 The intensity of an earthquake of magnitude 8 on the Richter scale is greater than the intensity of an earthquake of magnitude 5 on the same scale by _____ times.
- Q.42 Assume: (i) geothermal gradient = $25\text{ }^{\circ}\text{C/km}$ in the crust, (ii) density of the crustal rocks = 3000 kg/m^3 , and (iii) acceleration due to gravity = 10 m/s^2 . Based on these values, the lithostatic pressure at a point where temperature is $400\text{ }^{\circ}\text{C}$ will be _____ MPa.
- Q.43 The radii of A^{+2} and B^{-} ions are $1.12\text{ \AA}$ and $1.31\text{ \AA}$, respectively. The coordination number of A^{+2} in mineral AB_2 is _____.
- Q.44 In a sedimentary rock, the diameters of two grains A and B are 1ϕ and 3ϕ , respectively. The difference in diameters between A and B is _____ mm (rounded off to two decimal places).
- Q.45 A light ray passes from mineral A to mineral B having refractive indices of 1.750 and 1.430, respectively. The limiting value of angle of incidence above which the light ray undergoes total internal reflection is _____ degree (rounded off to one decimal

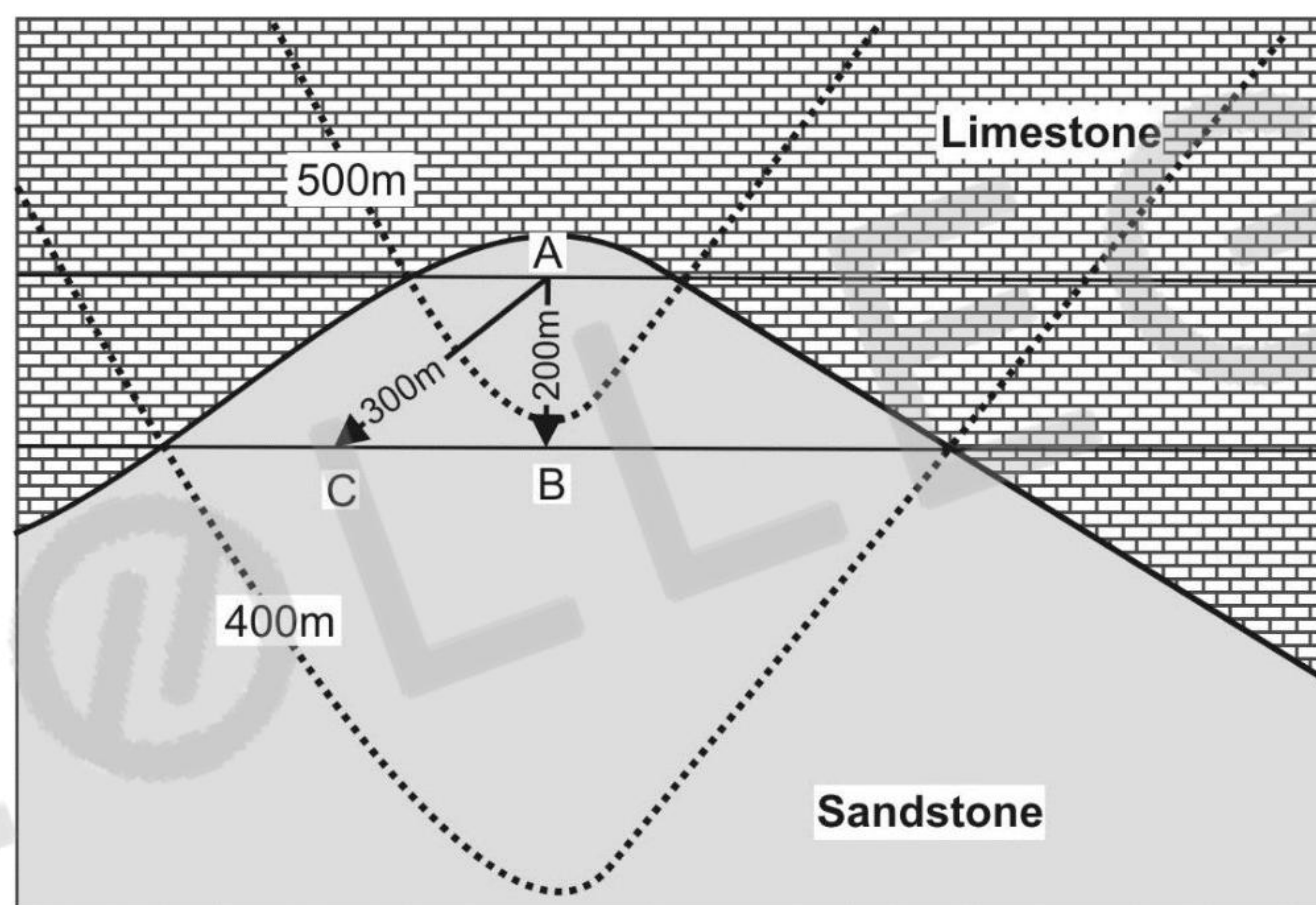
- Q.46 Throw and heave of a bed offset by a normal fault are 100 m and 200 m, respectively. The dip of the fault plane is _____ degree (rounded off to one decimal place).
- Q.47 The difference between Si/O ratios of K-feldspar and olivine is _____ (answer in two decimal places).
- Q.48 If a crystal contains 5 faces and 8 edges, the number of vertices in the crystal is _____.
- Q.49 At a temperature of 298.15 Kelvin, the free energy change of a reaction (ΔG^0) is 19.737 kCal/mole. If the universal gas constant (R) = 1.98717 Calorie/degree/mole, the $\log_{10}$ of the equilibrium constant K is _____ (rounded off to two decimal places).
- Q.50 A normal fault displaces a sandstone bed such that the dip-slip and the strike-slip components are 3 m and 4 m, respectively. The net-slip of the displacement is _____ m.

Q. 51 – Q. 60 carry two marks each.

- Q.51 In the given diagram, a 6 km high plateau is supported by a crustal root of thickness r . The system is in isostatic equilibrium as per Airy's hypothesis of isostasy. Densities of the crust and the mantle are 2800 kg/m^3 and 3100 kg/m^3 , respectively. Assuming the acceleration due to gravity to be same throughout the region, the thickness of the root (r) is _____ km.

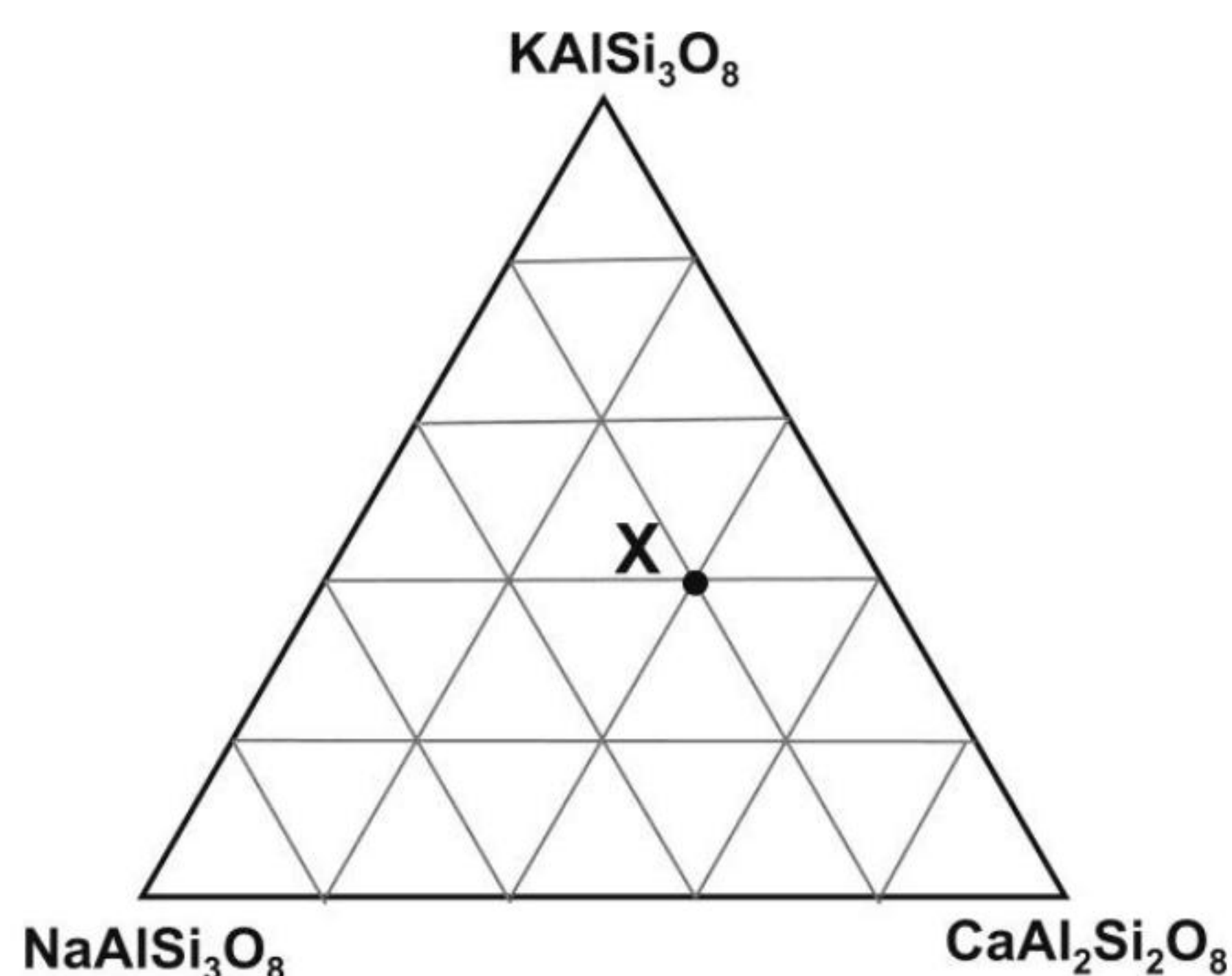


- Q.52 A 50 kg granite boulder gets dislodged from a cliff of height 20 m and undergoes an absolute vertical free fall. If the acceleration due to gravity is 10 m/s^2 , the boulder will hit the ground with a velocity of _____ m/s.
- Q.53 Mass and volume of a fully dried soil sample are 500 g and 250 cm^3 , respectively. The average density of the particles in the soil sample is 2.5 g/cm^3 . The void ratio of the soil sample is _____ %.
- Q.54 The geological map shows the contact between sandstone and limestone. The two dotted curves are the contours of 400 m and 500 m, respectively. The difference between the dip angles of the contact surface along the AB and AC directions is _____ degree (rounded off to two decimal places).



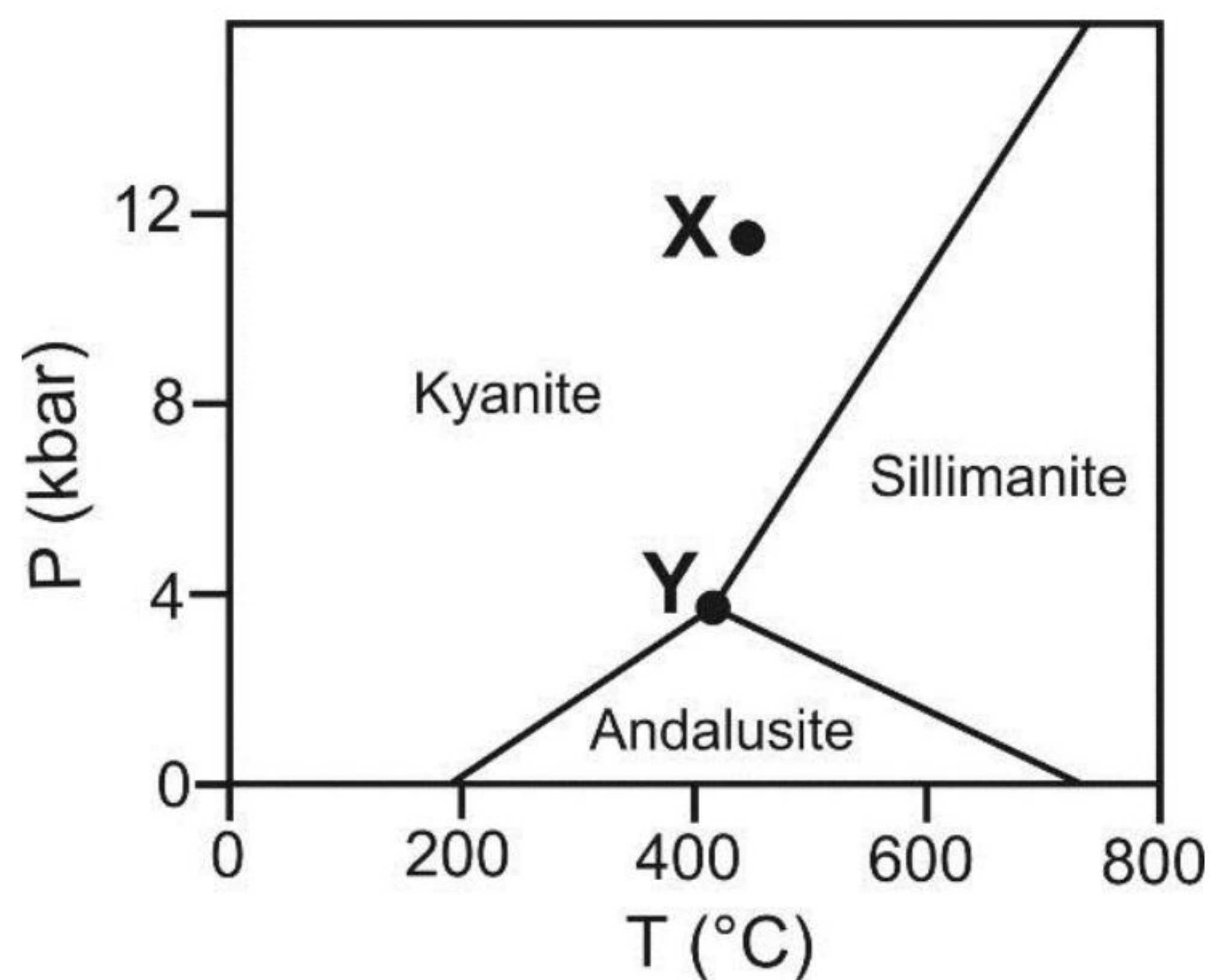
- Q.55 A tabular ore body of 9 km^2 area and an average thickness of 9 m has a density of 3000 kg/m^3 . The tonnage (in million tonnes) of the ore body is _____.
- Q.56 Assume that the orbit of the earth is a circle of radius $150 \times 10^6 \text{ km}$. The gravitational constant and the earth's orbital velocity are given as $6.7 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ and $30 \times 10^3 \text{ m/s}$, respectively. The calculated mass of the sun is _____ $\times 10^{30} \text{ kg}$ (rounded off to two decimal places).

- Q.57 The difference between X_{An} and X_{Ab} in a feldspar represented by X in the given triangular diagram is _____ (answer in one decimal place).



- Q.58 Two vertical wells penetrating a confined aquifer are 200 m apart. The water surface elevations in these wells are 35 m and 40 m above a common reference datum. The discharge per unit area through the aquifer is 0.05 m/day. Using Darcy's law, the coefficient of permeability is _____ m/day.

- Q.59 The given P–T diagram shows the relative stability ranges of andalusite, sillimanite and kyanite. The difference in degrees of freedom at points X and Y is _____.



- Q.60 The core and rim compositions of garnet are $(\text{Fe}_{0.75}\text{Ca}_{0.90}\text{Mn}_{1.35})\text{Al}_2\text{Si}_3\text{O}_{12}$ and $(\text{Fe}_{0.90}\text{Ca}_{1.35}\text{Mn}_{0.75})\text{Al}_2\text{Si}_3\text{O}_{12}$, respectively. The difference in mole fractions of spessertine between the core and the rim is _____ (answer in one decimal place).