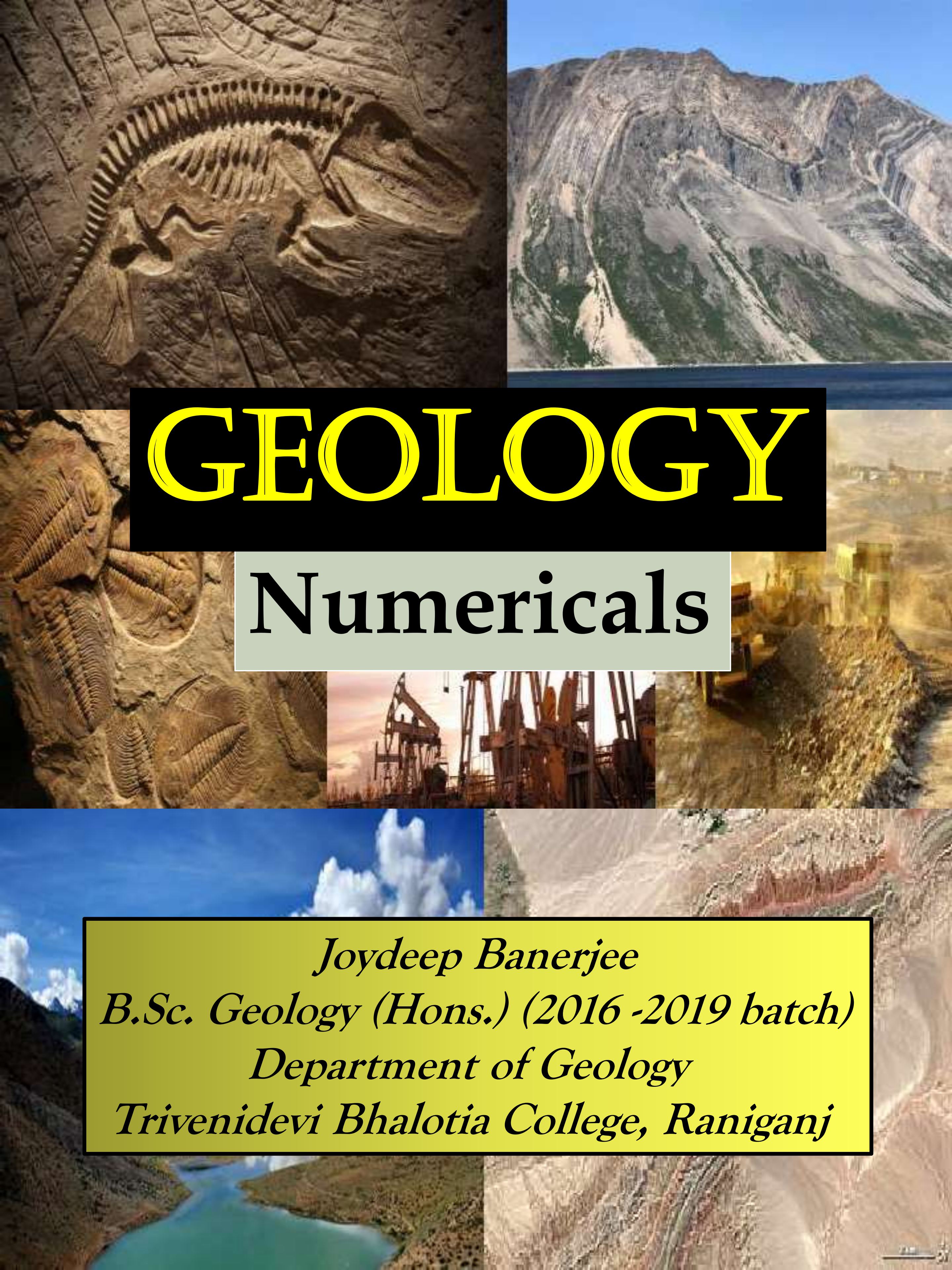

GEOLOGY

Numericals

Joydeep Banerjee
B.Sc. Geology (Hons.) (2016 -2019 batch)
Department of Geology
Trivenidevi Bhalotia College, Raniganj

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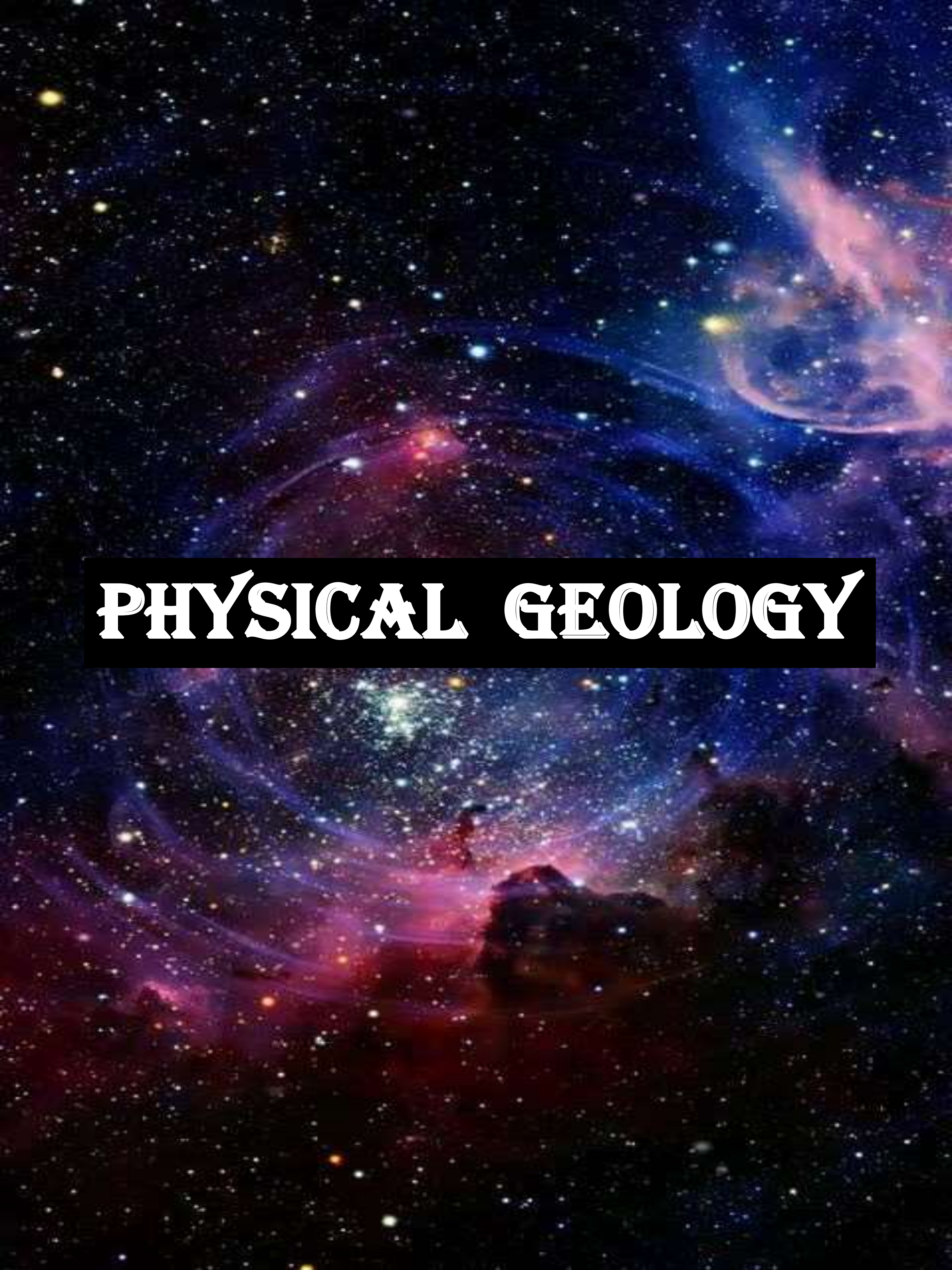


PHYSICAL GEOLOGY

- **Important data about Solar System and the Earth :**

1. Radius of the Earth (Equatorial) : 6378.3 Kms.
2. Radius of the Earth (Polar) : 6356.9 Kms.
3. Radius of the Earth (Mean) : 6371.2 Kms.
4. Mass of the Earth : 5.975 x 10^{27} Grams.
5. Volume of the Earth : 1.08 x 10^{27} Cms^3.
6. Density of the Earth : 5.5 $gram/cms^3$.
7. Age of the Earth : 4600 Ma.
8. Planet with highest density : **Earth.**
9. Planet with lowest density : **Saturn.**
10. Planet with most number of satellite : **Jupiter.**

1. **Gravitational Constant :**

$$F = \frac{Gm_1m_2}{r^2}$$

F – Gravitational Force.
G – Gravitational Constant.
m_1,m_2 – Mass of two particles.
r – Distance between two particles.

2. **Determination of mass of the Sun :**

$$M = \frac{v^2r}{G}$$

M – Mass of the Sun.
G – Gravitational Constant.
v – Velocity of the Earth.
r – Radius of Earth's orbit.

3. **Acceleration due to Gravity :**

$$g = \frac{GM}{r^2}$$

g – Acceleration due to gravity.
G – Gravitational Constant.
M – Mass of Earth.
r – radius of the earth.

4. Rotational period of a planet:

$$T = 2\pi r\sqrt{\frac{r}{MG}}$$

T – Rotational period.
r – Radius of the orbit.
M – Mass of the Sun.
G – Gravitational Constant.

5. Escape velocity :

$$v_e = \sqrt{\frac{2GM}{r}}$$

$$v_e = \sqrt{2gr}$$

v_e – Escape velocity .
G – Gravitational Constant.
M – Mass of the earth.
g – Acceleration due to gravity.
r – radius of the earth.

6. Richter Scale :

As Richter scale is a logarithmic scale ; magnitude of an earthquake of scale **'a'** is **10** times greater than scale **'(a-1)'** and **100** times greater than scale **'(a-2)'**, i.e., the intensity of an earthquake of scale **5** is **10** times greater than scale **4 .**

7. Velocity of P-waves :

$$v_p = \sqrt{\frac{\frac{4}{3}\mu + K}{\rho}}$$

$$v_p = \sqrt{\frac{M}{\rho}}$$

$$\alpha v_p^{\beta} = \rho$$

v_p – Velocity of P waves .
ρ – Density of the material .
μ – Rigidity modulus.
M – Elastic modulus.
K – Bulk modulus.
α – 0.31 for m/s.
β – 0.25.

8. Velocity of S-waves :

$$v_s = \sqrt{\frac{\mu}{\rho}}$$

v_s – Velocity of S waves .
ρ – Density of the material .
μ – Rigidity modulus.

9. Poisson's ratio :

$$v_p = v_s \sqrt{\frac{1 - v}{0.5 - v}}$$

v_s – Velocity of S waves .
v_p– Velocity of P waves.
v– Poisson's ratio

Standard value of Poisson's ratio → 0.25.

10. Young modulus :

$$E = \frac{FL}{A\Delta L}$$

$$E = \frac{\sigma}{\varepsilon}$$

E – Young modulus.
F – Force.
L – Initial length.
ΔL – Change in length.
ε – Uniaxial strain.
σ – Uniaxial stress.

11. Rigidity modulus :

$$\mu = \frac{FL}{A\Delta x}$$

$$\mu = \frac{\tau}{\gamma}$$

μ – Rigidity modulus.
F – Force.
L – Initial length.
Δx – Transverse displacement.
τ – Shear stress.
γ – Shear strain.

11. Bulk modulus:

$$K = -V\frac{dP}{dV}$$

$$K = \rho\frac{dP}{dV}$$

K – Bulk modulus.
P – Pressure.
V – Volume.
ρ– Density.

12. Location of epicentre :

$$D = T\frac{(VP \times VS)}{(Vp - Vs)}$$

D – Distance of the epicentre from the recording station, i.e. the epicentral distance.
T – Time interval between arrival of P waves and S waves.
V_p – Velocity of P waves.
V_s – Velocity of S waves.

13. Radioactive Method :

The basic equation is,

$$\frac{dN}{dt} = -\lambda N \qquad \text{--(i)}$$

Let's rearrange equation (i) and integrate:

$$\int_{N0}^{N}\frac{dN}{N} = -\int_{0}^{t}\lambda\, dt$$

or,

$$N = N_0 e^{-\lambda t} \qquad \text{--(ii)}$$

For half life,

$N = \frac{N_0}{2}$, $t = t_{1/2}$, putting this values in equation (ii),

$$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$$

or,

$$t_{1/2} = \frac{\ln 2}{\lambda}$$

The decay produces some daughter elements,

$$D_p = N_0 - N$$

or,

$$D_p = N(e^{\lambda t} - 1)$$

Since in general there will be some atoms of the daughter nuclide around to begin with, i.e., when t = 0, a more general expression is:

$$\mathbf{D = D_0 + N(e^{\lambda t} - 1)} \qquad \text{--(iii)}$$

Where, D_0 = The number of daughters originally present.
Let's now write equation (iii) using a concrete example, such as the decay of ^{87}Rb to ^{87}Sr:

$$\mathbf{^{87}Sr = {^{87}Sr_0} + {^{87}Rb}(e^{\lambda t} - 1)} \qquad \text{--(iv)}$$

As it turns out, it is generally much easier, and usually more meaningful, to measure to ratio of two isotopes than the absolute abundance of one. We therefore measure the ratio of ^{87}Sr to a non-radiogenic isotope, which by convention is ^{86}Sr. Thus the useful form of equation (iv) is:

$$\mathbf{\frac{^{87}Sr}{^{86}Sr} = \left(\frac{^{87}Sr}{^{86}Sr}\right)_0 + \frac{^{87}Rb}{^{86}Sr}(e^{\lambda t} - 1)} \qquad \text{--(v)}$$

Rewriting equation (v) as,

$$\mathbf{R = R_0 + R_{P/D}\,(e^{\lambda t} - 1)} \qquad \text{--(vi)}$$

Where, R – Ratio of radiogenic and non radiogenic isotope.
R_0 – Ratio of radiogenic and non radiogenic isotope at t = 0.
$R_{P/D}$ – Ration of parent and daughter.

This equation takes the form of **y = mx + c**, whose slope is **m (here, $e^{\lambda t} - 1$)** ; for isochron.

Now, Given a measurement of an isotope ratio, **R**, and a parent daughter ratio, $\mathbf{R_{P/D}}$, two unknowns remain in equation (vi): **t** and the **initial ratio**. We can calculate neither from a single pair of measurements. But if we can measure **R** and $\mathbf{R_{P/D}}$ on a second system for which we believe **t** and $\mathbf{R_0}$ are the same, we have two equations and two unknowns and subtracting the two equations yields:

$$\mathbf{\Delta R = \Delta R_{P/D}\,(e^{\lambda t} - 1)}$$

which we can solve for t. Rearranging,

$$\mathbf{\frac{\Delta R}{\Delta R_{P/D}} = (e^{\lambda t} - 1)}$$

or,

$$\mathbf{t = \ln\left(\frac{\Delta R}{\Delta R_{P/D}} + 1\right)/\,\lambda}$$

Slope of this equation is $\mathbf{\frac{\Delta R}{\Delta R_{P/D}}}$.

14. Average atomic weight of two isotopes :

$$\text{Average atomic weight} = \frac{(a_1m_1 + a_2m_2)}{(a_1+a_2)}$$

a_1 – Abundance of X_1 isotope.
a_2 – Abundance of X_2 isotope.
m_1 – Atomic weight of X_1 isotope.
m_2 – Atomic weight of X_2 isotope.

15. Half-life of some decay system:

(i) U – Pb :

$U^{238} \rightarrow Pb^{206} + 8\alpha$: Half – Life : 4500 Ma.

$U^{235} \rightarrow Pb^{207} + 7\alpha$: Half – Life : 713 Ma.

(ii) Th – Pb :

$Th^{232} \rightarrow Pb^{208} + 6\alpha$: Half – life : 13900 Ma.

(iii) K — Ar :

$K^{40} \rightarrow Ca^{40} + \beta$

$K^{40} \rightarrow Ar^{40} - \beta$: Half – life : 11900 Ma.

(iv) Rb — Sr :

$Rb^{86} \rightarrow Sr^{86} + \beta$: Half – life : 50000 Ma.

16. Amount of daughter element after decay :

$$\text{Amount of daughter element} = \frac{\text{Amount of Parent element}}{2^n}$$

n – Number of half lives.

17. pH scale:

pH value 0 – 7 : Acid.
pH value 7 : Water.
pH value 7 – 14 : Alkali.

$$pH = -\log_{10}[H^+]$$

$$pOH = \log_{10}[OH^-]$$

$$pH + pOH = 14$$

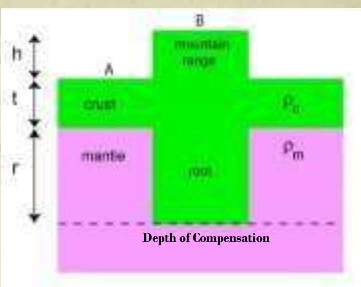
$[H^+]$ – Concentration of H^+ ion.
$[OH^-]$ – Concentration of OH^- ion.

17. Isostasy :

(i) Airy's Hypothesis :

Lets assume,

Height of the mountain – h.
Depth of the crustal root – r.
Normal crustal thickness – t.
Density of crustal rocks – ρ_c.
Density of the mantle – ρ_m.
Acceleration due to gravity – g.



Airy's Hypothesis

Now, equating pressure at the depth of compensation :

$$t\rho_c g + r\rho_m g = (h + t + r)\rho_c g$$

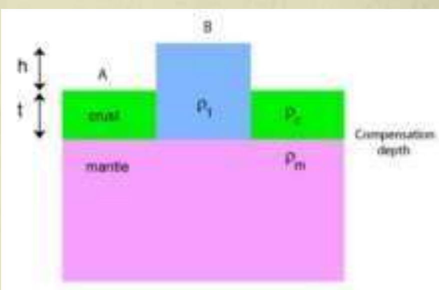
or,

$$r = \frac{h\rho_c}{(\rho_m - \rho_c)}$$

(ii) Pratt's Hypothesis :

Lets assume,

Height of the B block – h.
Crustal thickness – t.
Density of the crustal rocks – ρ_c.
Density of the mantle – ρ_m.
Density of the B block – ρ_1.



Pratt's Hypothesis

Now, equating pressure at the depth of compensation,

$$t\rho_c g = (h + t)\rho_1 g$$

or,

$$\rho_1 = \frac{\rho_c t}{(h + t)}$$

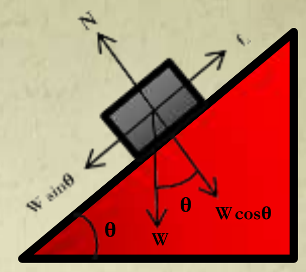
18. Potential energy and Kinetic energy :

$$E_P = mgh$$

$$E_K = \frac{1}{2}mv^2$$

E_P – Potential energy.
E_K – Kinetic energy.
m – Mass.
g – Acceleration due to gravity.
h – Height.
v – Velocity.

19. **Motion of a body down an inclined plane :**



Motion of a body down an inclined plane

Let we assume,

mass of the body – M

acceleration due to gravity – g

Then,

$$W = mg$$

which acts vertically through the down.

Now, from the figure,

$$W\sin\theta = fs$$
$$W\cos\theta = N$$

Now, if the block moves downward $W\sin\theta$ must have to greater than f_s,

$$F = W\sin\theta - f_s$$

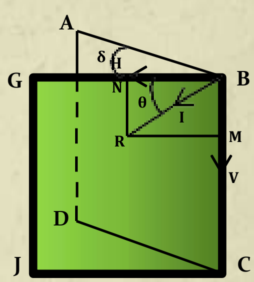
If the plane is frictionless, then,

$$F = W\sin\theta \ (f_s = 0)$$

or,

$$F = Mg\sin\theta$$

20. **Geomagnetic Intensity :**



Geomagnetic Intensity

From the figure,

ABCD – Geographical meridian.

GBCJ – Magnetic meridian.

I – Geomagnetic intensity.

H – Horizontal component of I.

V – Vertical component of I.

δ – Angle od declination.

θ – Angle of dip.

Now,

$$V = I\sin\theta \, , \ H = I\cos\theta$$

or,

$$\frac{V}{H} = \frac{I\sin\theta}{I\cos\theta}$$

or,

$$V = H\tan\theta$$

Again,

$$V^2 + H^2 = I^2\sin^2\theta + I^2\cos^2\theta$$

or,

$$I = \sqrt{(V^2 + H^2)}$$

Near equator,

$$\theta = 0^0 \ ; \quad H_{max} = I$$

Near pole,

$$\theta = 90^0 \ ; \quad H_{min} = 0$$

21. Geothermal gradient :

$$G = \frac{T_d - T_{ma}}{d - d_{ctl}}$$

$$G = \frac{T_d - Ts}{d}$$

G – Geothermal gradient.
d – Depth.
T_d – Temperature at depth d.
T_S – Surface temperature.
T_{ma} – Mean annual temperature.
d_{ctl} – Depth of constant temperature layer.

22. Geothermal step :

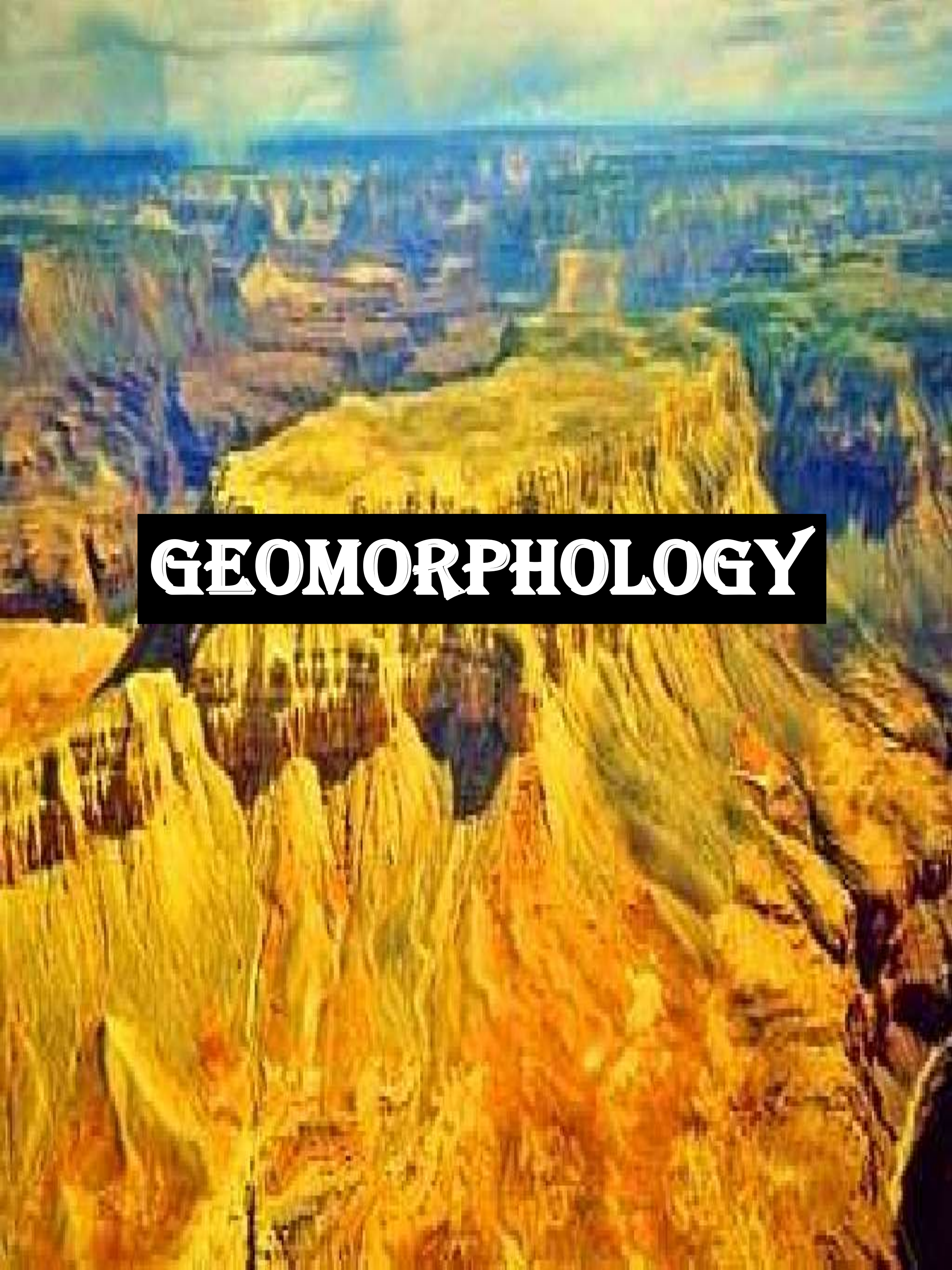
$$G.S = \frac{1}{G}$$

G.S – Geothermal step.
G – Geothermal gradient.

23. Heat flow :

$$q = \gamma G$$

q – Heat flow.
γ – Thermal conductivity.
G – Geothermal gradient.



GEOMORPHOLOGY

1. **Drainage Density :**

$$D_d = \frac{\sigma_1^n L}{A}$$

$$D_d = \frac{\text{Total length of streams of all order}}{\text{Total area of the basin}}$$

D_d = Drainage density.
n = Stream of n^{th} order.
σ L = Total Length.
A = Total area of the basin.

2. **Stream Frequency :**

$$F_s = \frac{N_u}{A}$$

N_u = Total number of stream segment of order 'u'.
F_s = Stream frequency.
A = Area of the basin.

3. **Infiltration number :**

$$I_s = D_d \times F_s$$

I_s = Infiltration number.
D_d = Drainage density.
F_s = Stream frequency.

4. **Bifurcation ratio :**

$$R_b = \frac{N_u}{N_{(u+1)}}$$

R_b = Bifurcation ratio.
N_u = Number of streams of u order.
$N_{(u+1)}$ = Number of streams of (u+1) order.

5. **Drainage texture :**

$$\text{Drainage Texture} = \frac{N}{A}$$

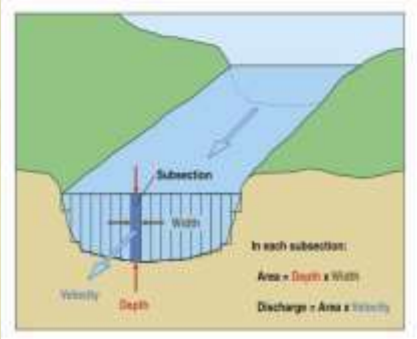
N = Total number of streams.
A = Area of the basin.

6. Mean stream length ratio :

$$S_L = \frac{\text{Total length of streams of } u^{th} \text{ order}}{\text{Stream segment of } u^{th} \text{ order}}$$

S_L = Mean stream length ratio.

7. Stream discharge :



Stream discharge

$$Q = (A \times V)$$

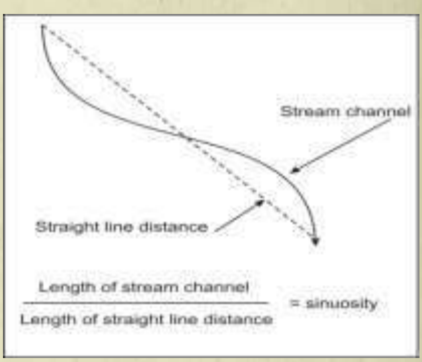
Q = Stream discharge.
A = Area of the channel.
V = Velocity of the stream water.

8. Stream Power :

$$P = (\rho \times Q \times g \times S)$$

P = Stream power.
Q = Stream discharge.
g = acceleration due to gravity.
S = Channel slope.
ρ = Density of the water.

9. Sinuosity index :



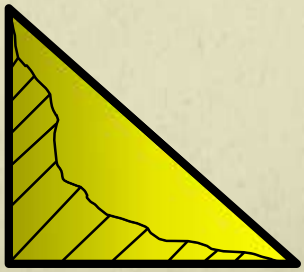
Sinuosity index

$$\text{Sinuosity index} = \frac{\text{Total length}}{\text{Shortest possible length}}$$

10. Stream length gradient index :

$$\text{Stream length gradient index} = \frac{\text{Change in elevation}}{\text{Change in length of the river}} \times \text{length}$$

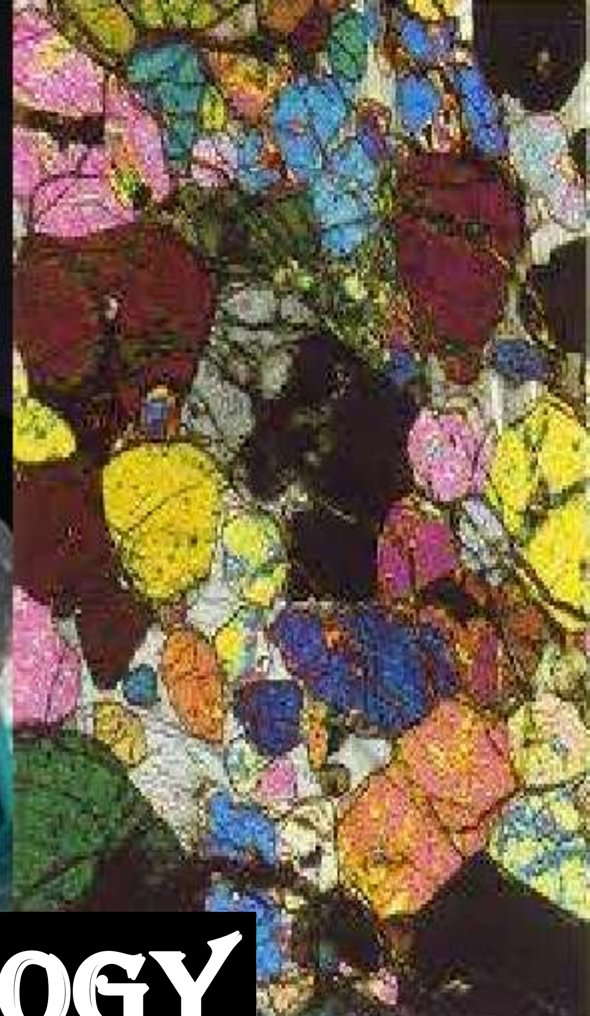
11. Concavity Index :



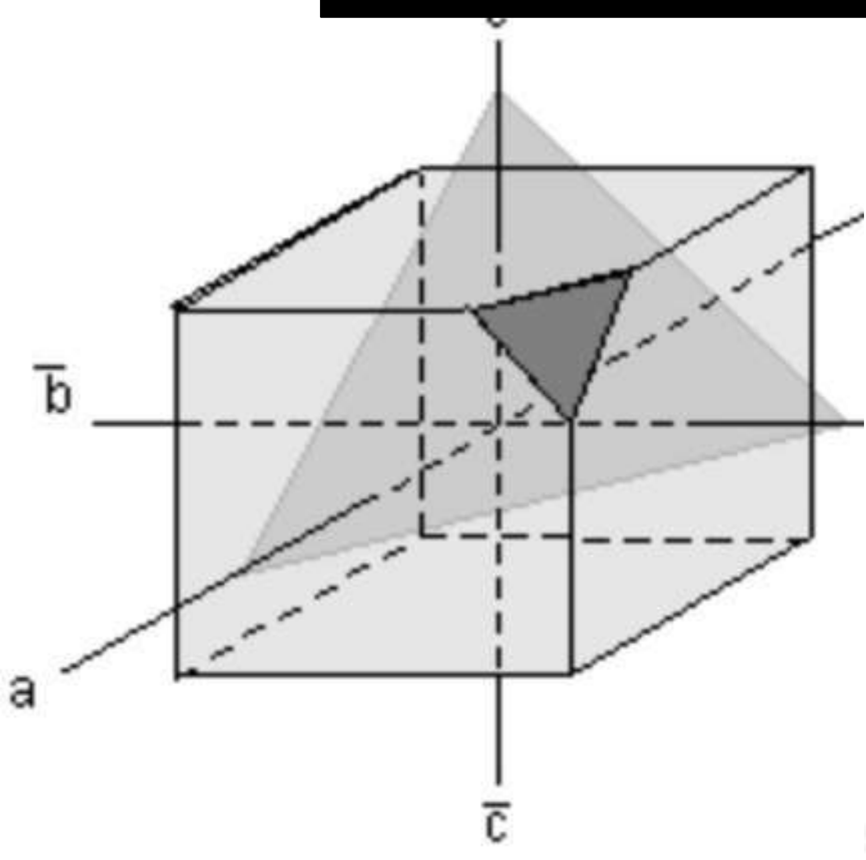
Concavity index

$$C_I = \left(\frac{X-Y}{X}\right) * 100$$

C_I = Concavity Index.
X = Area of ΔABC.
Y = Area of the shaded part.



MINERALOGY



Crystallography

1. **Relationship between faces, edges and vertices of a crystal :**

$$F + C = E + 2$$

F = Number of faces.
C = Number of vertices.
E = Number of edges.

2. **Angle between two faces of a crystal :**

$$\mathrm{Cos}\theta = \frac{h_1h_2 + k_1k_2 + l_1l_2}{\sqrt{(h_1^2 + k_1^2 + l_1^2)} * \sqrt{(h_2^2 + k_2^2 + l_2^2)}}$$

$(h_1\ k_1\ l_1)$ and $(h_2\ k_2\ l_2)$ are the two faces.

3. **Zonal symbol :**
If two tautozonal faces **(h k l)** and **(p q r)** are given , then the zonal symbol **[u v w]** is obtained as follows :

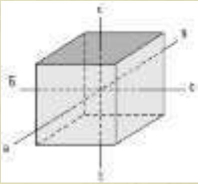
$$u = kr - lq$$
$$v = lp - rh$$
$$w = hq - pk$$

4. **Zonal equation :**
A face **(x y z)** is in the zone **[u v w]** if it satisfies the zonal equation given below :

$$ux + vy + wz = 0$$

5. **Constancy of interfacial angles in same species :**
The angle of inclination between the like faces of a crystal of any species are essentially constant wherever they are found and whether they are the product of nature or laboratory. These angles are one of the distinguishing characteristics of the species.

6. **Weiss symbol :**

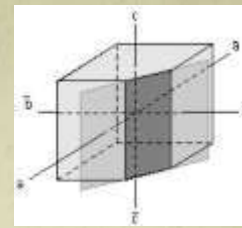


a) A crystal face intersects only one of the crystallographic axis :

Weiss symbol : αa , αb, Zc

Where the face is parallel to 'a' and 'b' crystallographic axis and cuts 'c' crystallographic axis at a distance of Z units.

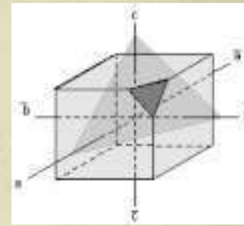
b) A crystal face intersects two of the crystallographic axis :



Weiss symbol : Xa , Yb, ∞c

Where the face cuts 'a' and 'b' crystallographic axis at a distance of X and Y units respectively and parallel to 'c' crystallographic axis.

c) A crystal face intersects all of the crystallographic axis:



Weiss symbol : Xa , Yb , Zc

Where the face cuts 'a' , 'b' , 'c' crystallographic axis at a distance of X , Y , Z units respectively.

7. Miller indices :

Miller indices of a given parameter **(Xa, Yb, Zc)** can be obtained by the following steps:

(i) Step 1 → The parameters are re-written by dropping the letters : **X Y Z.**
(ii) Step 2 → The numbers obtained are reciprocated : $\frac{1}{X}\frac{1}{Y}\frac{1}{Z}$.–
(iii) Step 3 → Find the LCM of the numbers : **Let us consider, the LCM of X Y Z is 'P'.**
(iv) Step 4 → Fractions are removed by multiplying the fractions with LCM : $\frac{P}{X}\frac{P}{Y}\frac{P}{Z}$. –
(v) Step 5 → Final Miller indices is : $\frac{P}{X}\frac{P}{Y}\frac{P}{Z}$.

8. Crystal Systems and their properties :

Crystal System	Unit cell edge lengths	Unit cell edge intersection angles
Isometric (cubic)	**(a = b = c)**	**$\alpha = \beta = \gamma = 90°$**
Tetragonal	**(a = b ≠ c)**	**$\alpha = \beta = \gamma = 90°$**
Hexagonal (hexagonal)	**($a_1 = a_2 = a_3 \neq c$)**	**$\alpha = \beta = 90° \neq \gamma = 120°$**
Hexagonal (trigonal)	**(a = b = c)**	**$\alpha = \beta = \gamma \neq 90°$**
Orthorhombic	**(a ≠ b ≠ c)**	**$\alpha = \beta = \gamma = 90°$**
Monoclinic	**(a ≠ b ≠ c)**	**$\alpha = \gamma = 90° \neq \beta$**
Triclinic	**(a ≠ b ≠ c)**	**α , β and $\gamma \neq 90°$**

Descriptive Mineralogy

1. **Specific gravity :**

$$S.G = \frac{\rho_m}{\rho_w}$$

$$S.G = \frac{W_a}{W_a - WL} \times L$$

ρ_m = Density of the mineral.
ρ_w = Density of water.
W_a = Weight of the mineral in air.
W_L = Weight of the mineral in liquid.
L = Specific gravity of the liquid.

2. Hardness Scale :

Hardness	Mineral	Chemical Formula
1	Talc	$Mg_3Si_4O_{10}(OH)_2$
2	Gypsum	$CaSO_4 , 2H_2O$
3	Calcite	$CaCO_3$
4	Fluorite	CaF_2
5	Apatite	$Ca_5(PO_4)_3(F, Cl, OH)$
6	Orthoclase	$KAlSi_3O_8$
7	Quartz	SiO_2
8	Topaz	$Al_2SiO_4(F, OH)_2$
9	Corundum	Al_2O_3
10	Diamond	C

- **Hydrous mineral :** Talc, Gypsum, Apatite, Topaz
- **Ca—Bearing :** Gypsum, Calcite, Fluorite, Apatite.
- **Al—Bearing :** Orthoclase, Topaz, Corundum.
- **F—Bearing :** Fluorite, Apatite, Topaz.
- **Si—Bearing :** Talc, Orthoclase, Topaz, Quartz.

3. Si – Structure:

Si – structure	Number of sharing oxygen	Si : O
Nesosilicate	0	1 : 4
Sorosilicate	1	2 : 7
Ring silicate	2	1 : 3
Inosilicate (single chain)	2	1 : 3
Inosilicate (double chain)	3(2)	4 : 11
Phyllosilicate	3	2 : 5
Tectosilicate	4	1 : 2

4. Co-ordination table:

r_{cation}/ r_{anion}	Co-ordination Number
< 0.155	2
0.155 – 0.225	3
0.225 – 0.414	4
0.414 – 0.732	6
0.732 – 1.0	8

Optical Mineralogy

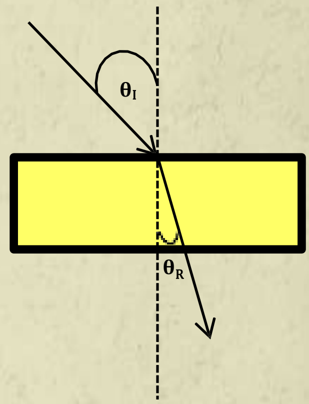
1. **Refractive Index :**

$$n = \frac{V_a}{V_m}$$

$n = \frac{1}{V}$ **(The velocity of light is generally considered equal to 1)**

n = Refractive index.
V_a = Velocity of light in the air.
V_m = Velocity of light in the mineral.
V = Velocity of light in the mineral

2. **Snell's law :**



Refractive Index

$$\frac{\sin \theta_I}{\sin \theta_R} = n$$

n = Refractive index.
θ_I = Angle of incidence.
θ_R = Angle of refraction.

3. **Cauchy's Law :**

$$n = A + \frac{B}{\lambda^2}$$

n = Refractive index.
A,B = Constant.
λ = Wave length.

4. **Birefringence of an uniaxial mineral :**

$$B_f = \epsilon - \omega \text{ (For positive minerals)}$$
$$B_f = \omega - \epsilon \text{ (For negative minerals)}$$

B_f = Birefringence.
ω = Refractive index of O-ray.
ϵ = Refractive index for E-ray.

5. **Birefringence of a biaxial mineral :**

$$B_f = \gamma - \alpha$$

B_f = Birefringence.
γ = Refractive index of slowest ray.
α = Refractive index for fastest ray.

6. **Retardation :**

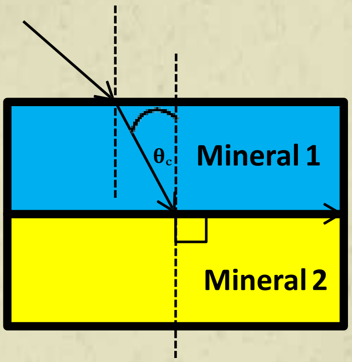
$$R = (T \times B_f)$$

R = Retardation.
T = Thickness.
B_f = Birefringence.

7. Critical angle & Total internal reflection :

$$n_1 \sin 90^0 = n_2 \sin \theta_c$$

Where, n_1 = Refractive index of mineral 1.
N_2 = Refractive index of mineral2.
θ_c = Critical angle.



Total Internal Reflection

STRUCTURAL GEOLOGY

1. **General :**

a) **Strike = True dip ± 90^0**

b) **If,** (i) Pitch of the lineation= 0^0,
(ii)Trend of the lineation = strike ,
Then, **Plunge of the lineation= 0^0 .**

c) **If,** (i) Pitch of the lineation = 90^0.
(ii)Trend of the lineation = strike ± 90^0 , Then,
Plunge of the lineation = True dip angle.

d) **Relation between pitch, plunge and true dip :**

$$\tan \varphi = (\tan \gamma \times \cos \theta)$$

$$\tan \alpha = (\tan \gamma \times \sin \theta)$$

φ = Angle between trend of the lineation and strike.
θ = True dip angle.
γ = Pitch of the lineation.
α = Plunge of the lineation.

2. Fault :

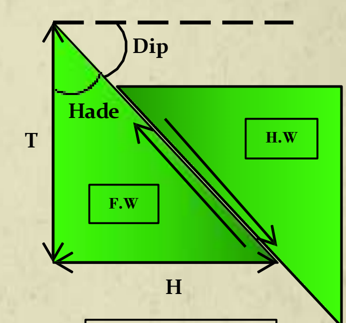
a) Relation between Dip and Hade :

$$\text{Dip} + \text{Head} = 90^0$$

b) Relation between Throw, Heave and Net slip :

$$N.S = \sqrt{(T^2 + H^2)}$$

N.S = Net slip.
T = Throw.
H = Heave .



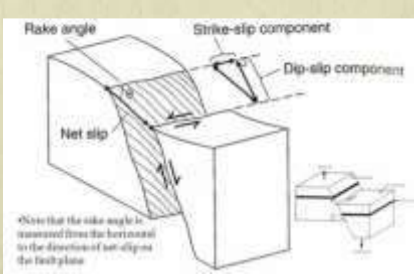
Different parts of fault

c) Components of Net slip :

Dip slip component = (Net slip × sin θ)

Strike slip component = (Net slip × cos θ)

θ = True dip angle.



Components of Net slip

3. Determination of true dip:

a) $\tan \theta = \frac{V}{H}$

θ = True dip angle.
V = Vertical drop .
H = Horizontal distance.

b) $\tan \alpha = (\tan \theta \times \cos \beta)$

α = Apparent dip angle.
θ = True dip angle.
β = Horizontal angle between true dip direction and apparent dip direction.

c) $\tan \alpha = (\tan \theta \times \sin \beta)$

α = Apparent dip angle.
θ = True dip angle.
β = Angle between strike and apparent dip direction.

d) $\tan \varphi = \operatorname{cosec} \gamma \, [(\cot \alpha_1 \times \tan \alpha_2) - \cos \gamma\,]$

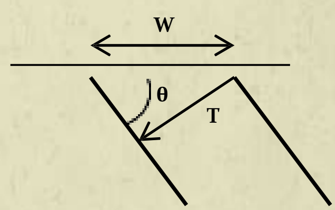
θ_1 and θ_2 = Direction of two apparent dip.
α_1 and α_2 = Two apparent dip angle.
φ = Angle between θ_1 and true dip direction.
γ = Angle between θ_1 and θ_2.

4. Determination of true thickness:

a) Case 1 → Ground surface is horizontal:

$$\sin \theta = \frac{T}{W}$$

θ = True dip angle.
T = True thickness.
W = Outcrop width.

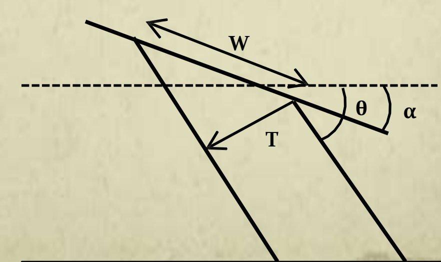


Ground surface horizontal

b) Case 2 → Ground surface slopes in the same direction that the bed dips:

$$\sin (\theta - \alpha) = \frac{T}{W}$$

α = Ground surface slope.
θ = True dip angle.
T = True thickness.
W = Outcrop width.

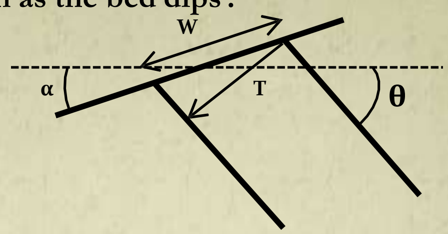


Ground surface dips in the same direction as the bed dips

c) Case 3 → Ground surface slopes in the opposite direction as the bed dips :

$$\sin(\theta + \alpha) = \frac{T}{W}$$

α = Ground surface slope.
θ = True dip angle.
T = True thickness.
W = Outcrop width.

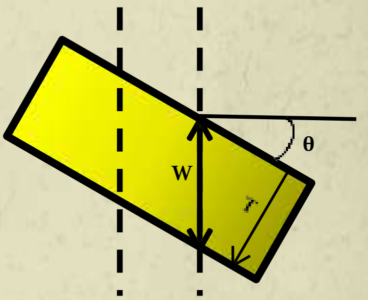


Ground surface slopes in the opposite direction as the bed dips

d) Case 4 → In case of borehole :

$$\cos\theta = \frac{T}{W}$$

θ = True dip angle.
T = True thickness.
W = Width of the bed



Borehole condition

6. Different types of maps and their properties :

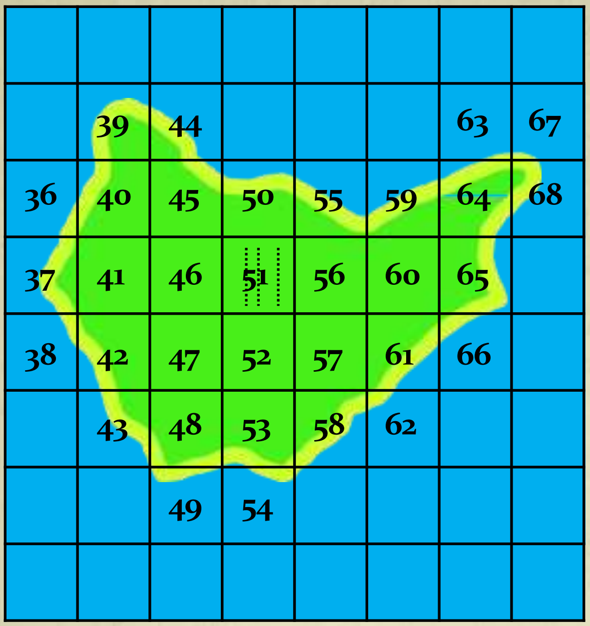
a) **Million maps :**
This map has 4^0 x 4^0 latitudinal and longitudinal coverage. Each map under this map is given a serial number as e.g., 39, 40, 41 etc.
Scale → 1 : 10,00,000

b) **Degree maps :**
This million sheets are further subdivided into 16 equal parts of 1^0 x 1^0. These sheets are numbered from A to P as e.g., 57A, 34D, 73J etc.
Scale → 1 : 2,50,000

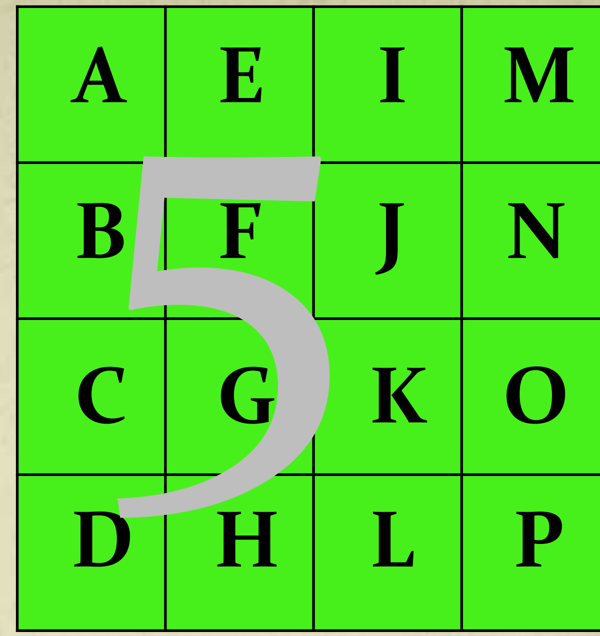
c) **Quarter maps :**
The degree maps are further subdivided into 16 equal parts each of 15' of latitude and longitude in extent. These sheets are numbered from 1 to 16 as e.g., 57A/4, 34D/9, 73J/15 etc.
Scale → 1 : 50,000

d) **Topographical maps :**
The quarter maps are again subdivided into 4 equal parts of 7.5' latitude x 7.5' longitude. These sheets are numbered as e.g., A/1/NW, A/1/NE, A/1/SW, A/1/SE etc.
Scale → 1 : 25,000

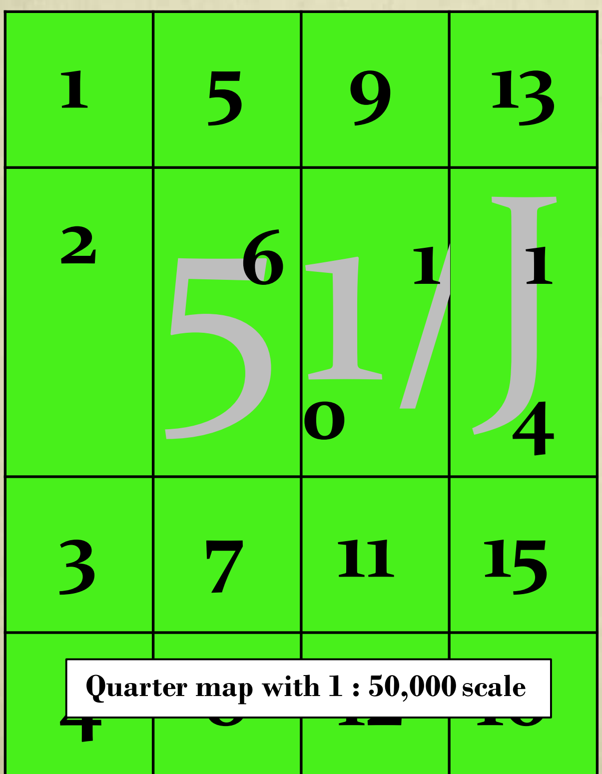
e) R.F → 1 : 50,000 means 1 unit in map = 50,000 units in field



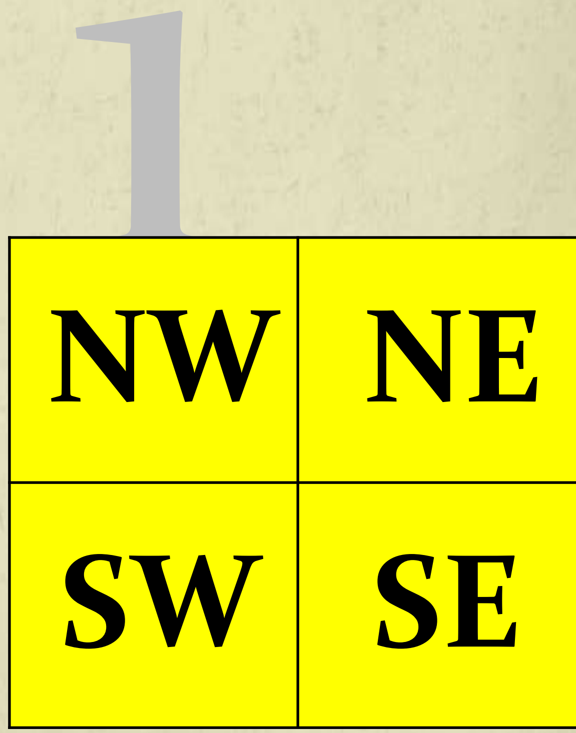
Million map with 1 : 10,00,000 scale



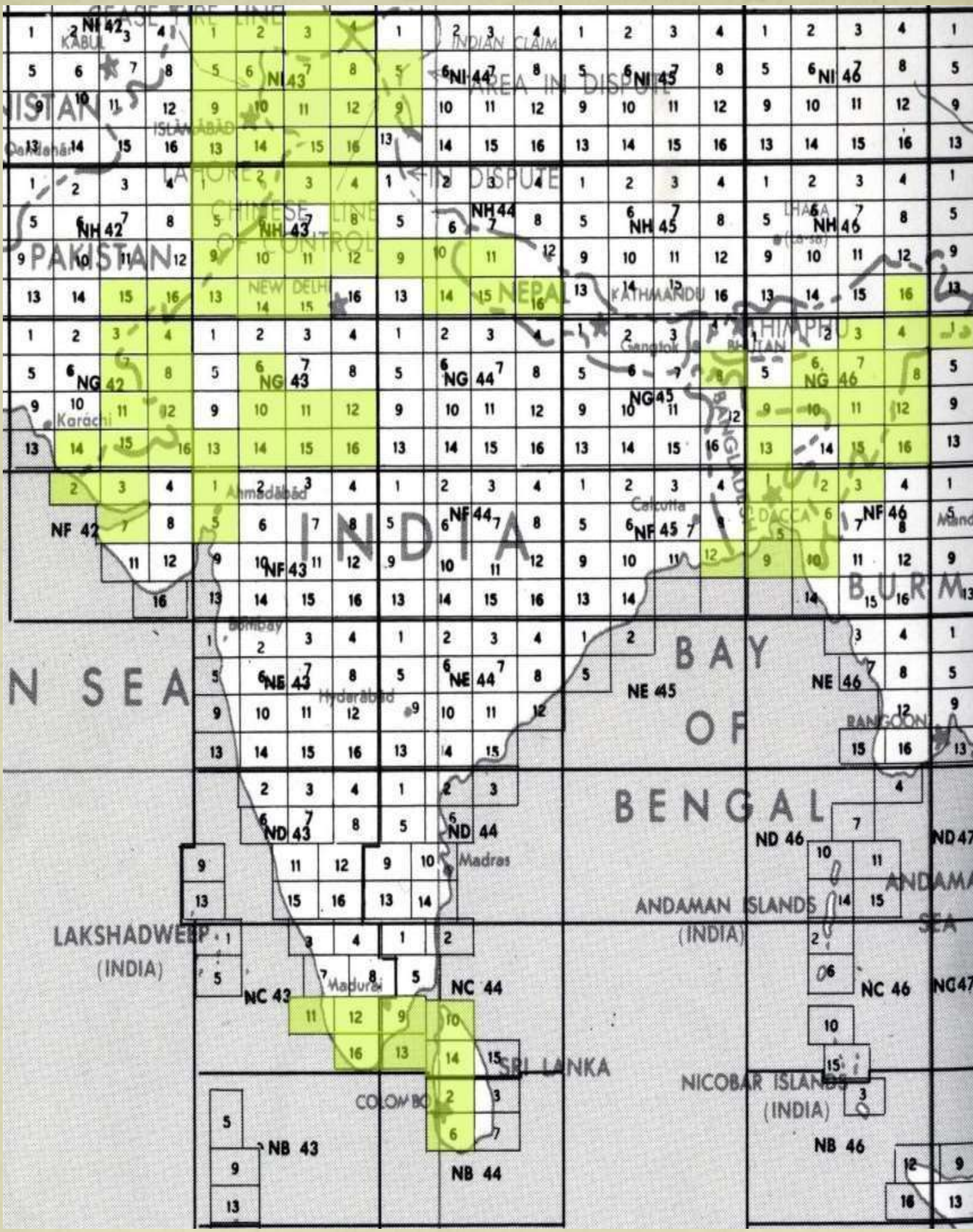
Degree map with 1 : 2,50,000 scale



Quarter map with 1 : 50,000 scale



Topographic map with 1 : 25,000 scale



Degree map of INDIA

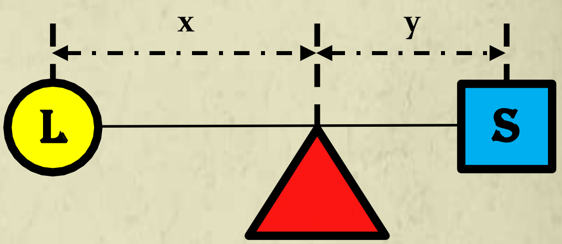
PETROLOGY

Igneous Petrology

1. **Phase rule :**

$$P + F = C + 2$$

P = Number of phases.
F = Degree of freedom.
C = Number of components.



Phase Rule

2. Lever rule :

$$S = \frac{x}{(y+x)}$$

$$L = \frac{y}{(y+x)}$$

S = Solid.
L = Liquid.

Sedimentary Petrology

1. **Phi — scale :**

$$\varphi = -\log_2 d$$

φ = Grain size value in Phi – scale .
d = Grain size in millimetre.

2. **Graphic Mean :**

$$M_z = \frac{\varphi_{16} + \varphi_{50} + \varphi_{84}}{3}$$

3. **Inclusive graphic skewness :**

$$SK_t = \frac{\varphi_{84} + \varphi_{16} - 2\varphi_{50}}{2(\varphi_{84} - \varphi_{16})} - \frac{\varphi_{95} + \varphi_{5} - 2\varphi_{50}}{2(\varphi_{95} - \varphi_{5})}$$

4. **Graphic kurtosis :**

$$K_G = \frac{(\varphi_{95} - \varphi_{5})}{2.44(\varphi_{75} - \varphi_{25})}$$

Metamorphic Petrology

1. Thermodynamics :

(a) Gibbs Free Energy :

$$\Delta G = \Delta H - T\Delta S$$

ΔG = Gibbs free energy.
ΔH = Change in enthalpy.
ΔS = Change in entropy.
T = Temperature.

(b) Equilibrium constant :

$$\Delta G^0 = -RT\ \ln K$$

or,

$$\Delta G^0 = -2.303\ RT\ \log K$$

ΔG^0 = Gibbs free energy.
R = Molar gas constant.
T = Temperature.
K = Equilibrium constant.

(c) Reaction quotient :

$$\Delta G = \Delta G^0 + RT\ \ln Q$$

ΔG = Gibbs free energy.
ΔG^0 = Gibbs free energy at initial.
R = Molar gas constant.
T = Temperature.
Q = Reaction quotient.

(d) Internal energy :

$$\Delta U = \Delta Q - \Delta W$$

ΔU = Change in internal energy.
ΔQ = Heat.
ΔW = Work.

(e) Derivation of $Q = \Delta H$:

We know, $W = F \times D$ ---- (1)

again, $F = P \times A$

Put this value in equation (1),

$$W = P \times A \times D$$

or,

$$W = P \times V$$

Now, from first law of thermodynamics:

$$\Delta U = Q - \Delta W$$

or,

$$U_2 - U_1 = Q - (W_2 - W_1)$$

or,

$$Q = (U_2 + PV_2) - (U_1 + PV_1)$$

or,

$$Q = \Delta H \quad (\text{as, } H = U + PV)$$

W = Work.
F = Force.
D = Distance.
P = Pressure.
A = Area.

2. Clausius Clapeyron equation :

$$\frac{dP}{dT} = \frac{\Delta S}{\Delta V} = \frac{L}{T\Delta V}$$

$\frac{dP}{dT}$ = Slope.
ΔS = Specific entropy change.
ΔV = Specific volume change.
T = Temperature.
L = Specific latent heat.

HYDROGEOLOGY

1. **Porosity :**

$$\alpha = \frac{V_T - VS}{V_T} = \frac{V_V}{V_T}$$

$$\alpha = \frac{\rho_m - \rho_d}{\rho_m}$$

α = Porosity.
V_T = Total volume of the sample.
V_S = Volume of solids.
V_V = Volume of voids.
ρ_m = Density of the grains.
ρ_d = Bulk density.

2. **Capillary rise :**

$$h_c = \frac{2\tau}{r\gamma}\cos\theta$$

h_c = Capillary rise.
r = Radius of the tube.
γ = Specific weight of water.
τ = Surface tension.
θ = Angle of contact between meniscus and tube.

For, pure water in a clean glass,

$$h_c = \frac{0.15}{r}$$

3. **Specific retention :**

$$S_r = \frac{W_r}{V_T}$$

S_r = Specific retention.
W_r = Volume occupied by retained water.
V_T = Bulk volume of the soil or rock.

4. **Specific yield :**

$$S_y = \frac{W_y}{V_T}$$

S_y = Specific yield.
W_y = Volume of water drained.
V_T = Bulk volume of the soil or rock.

5. **Relation between specific retention, specific yield and porosity :**

As, W_r and W_y contribute to the total water volume in a saturated material.
So, $V_V = W_r + W_y$.
So, Porosity = $S_r + S_y$.

6. **Darcy's law :**

$$\mathbf{Q = -KA\frac{dh}{dl}}$$

Q = Discharge.
K = Hydraulic conductivity.
A = Area.
$\frac{dh}{dl}$ = Hydraulic gradient.

7. **Darcy's velocity / Specific discharge :**

$$\mathbf{v = \frac{Q}{A} = -K\frac{dh}{dl}}$$

8. **Reynolds's number :**

$$\mathbf{N_R = \frac{\rho v D}{\mu}}$$

N_R = Reynolds's number.
ρ = Density of fluid.
v = Velocity.
D = Diameter of the pipe.
μ = Dynamic viscosity.

9. **Intrinsic permeability :**

$$\mathbf{k = \frac{K\mu}{\rho g}}$$

$$\mathbf{k = -\frac{v\mu}{\rho g\frac{dh}{dl}}}$$

k = intrinsic permeability.
K = Hydraulic conductivity.
g = Acceleration due to gravity.
v = Darcy's velocity.
$\frac{dh}{dl}$ = Hydraulic gradient.
ρ = Fluid density.
μ = Dynamic viscosity.

10. Hydraulic conductivity / Permeability co – efficient :

$$K = \frac{v}{\frac{dh}{dl}}$$

K = Hydraulic conductivity.
V = Darcy velocity.
$\frac{dh}{dl}$ = Hydraulic gradient.

11. Transmissivity :

$$T = Kb$$

T = Transmissivity.
K = Hydraulic conductivity.
b = Saturated thickness of the aquifer.

12. Void ratio :

$$R_V = \frac{V_V}{V_S}$$

V_V = Volume of voids.
V_S = Volume of solids.

13. Storage co-efficient / Storativity :

$$\text{Storage co-efficient} = S_S b + S_Y$$

S_S = Specific storage.
b = thickness of aquifer.
S_Y = Specific yield.

14. Degree of saturation :

$$\text{Degree of saturation} = \left(\frac{V_W}{V_V} \times 100\right) \%.$$

V_W = Volume of water.
V_V = Volume of voids.

ECONOMIC GEOLOGY

1. **Reserve of ore :**

Reserve of the ore = (Volume of the ore × density of the ore)

2. **Metal content :**

Metal content = (Reserve of the ore × Assay value)

APPLIED GEOLOGY

1. **RQD (Rock Quality Designation) :**

$$\mathbf{RQD} = \left(\frac{\text{Total length of recovered core}}{\text{Total length of the core}} \times 100\right)\%$$

2. **Q value :**

$$\mathbf{Q\ value} = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF}$$

RQD = Rock quality designation.
Jn = Joint set number.
Jr = Joint roughness number.
Ja = Joint alteration number.
Jw = Joint water reduction factor.
SRF = Stress reduction factor.

add 3 more si structure, cordination, internal reflection.

IIT – GATE

Numerical Solutions

1. **The scale factor of an aerial photo of a planar ground surface, taken vertically downwards by a camera with a focal length of 300 mm, from a flying height of 3000 m is ___________ .**

➔ Focal length = 300 mm ; Flying height = 3000 m = 3000×10^3 mm.

So, Scale factor of that aerial photo = $\frac{\text{Flying height}}{\text{Focal length}} = \frac{3000 \times 10^3}{300} = 10^4 = 10000.$

(answer)

2. **In a soil sample, specific gravity of soil particles is 2.5 and the void ratio is 0.5. The density of the soil sample when it is fully saturated with water is ________________ kg/m^3 . (Assume density of water = 1000 kg/m^3 , and no volume change of the soil sample with saturation).**

➔ Specific gravity of the soil particles = 2.5 ; then density = 2500 kg/m^3 .
Void ratio = 0.5.
Density of water = 1000 kg/m^3
Let we consider, volume of void is X m^3 and volume of solid is Y m^3 .
Now, as void ratio = 0.5,
So, $\frac{X}{Y} = 0.5$; Y = 2X.
So, volume of solid = 2X m^3 ; Total volume of the specimen = (2X + X) m^3 = 3X m^3 .

Now, when the soil sample is fully saturated with water, the water occupies the pore spaces or void spaces , i.e. , volume of pore spaces = volume of water .

So, mass of the soil sample when fully saturated = $(2500 \times 2X) + (1000 \times X)$ Kg

= 6000X Kg.

Now, density of the soil sample when fully saturated = $\frac{6000X}{3X} = 2000$ kg/m^3.

(answer)

3. **Nuclide A decays to nuclide B exclusively through α and β decay, such that the mass number is reduced by 32 and the atomic number is reduced by 10. The number of β particles emitted during the decay of nuclide A to nuclide B is ______________________.**

➔ A → B through α and β decay.
Mass number is reduced to 32.
Atomic number is reduced to 10.
Now, an α decay reduced mass number by 4 and proton number 2 ; where as an β decay reduced electron number by 1.

So, number of α decays happen = 8.
number of protons reduce = $(8 \times 2) = 16$.
But the atomic number is reduced to 10.
So, number of electrons emitted = (16 – 10) = 6.

So, Number of β decays happen = 6. (answer).

4. A cylindrical specimen (diameter = 54.7 mm ; length = 110 mm) of basalt shows linear elastic behaviour under uniaxial compression. At an axial stress of 100 MPa, the absolute value of measured axial strain is 0.2 %. The Young's modulus is calculated to be ___________GPa.

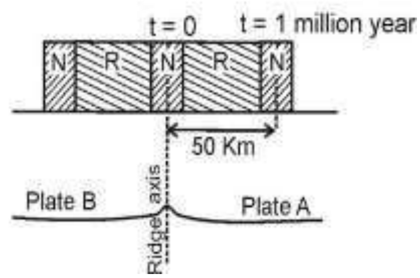
➔ Linear axial stress is = 100 Mpa = 100×10^6 Pa .

Linear axial strain is 0.2 % = $\frac{0.2}{100} = 2 \times 10^{-3}$.

So, Young's modulus = $\frac{\text{Linear axial stress}}{\text{Linear axial strain}} = \frac{100 \times 10^6}{2 \times 10^{-3}}$ Pa = 50×10^9 Pa = 50 GPa.

(answer)

5. A mid oceanic ridge has symmetric magnetic anomalies about the ridge axis as shown below. Using the information given in the figure, the average relative velocity between the plates A and B is calculated to be ____________cm/year.



➔ In case of plate A, distance between two normal magnetic strips = 50 Km = 50×10^5 cms.

Time gap = 1 Ma = 10^6 years.

So, velocity of plate A = $\frac{50 \times 10^5}{10^6}$ cms/year = 5 cms/year.

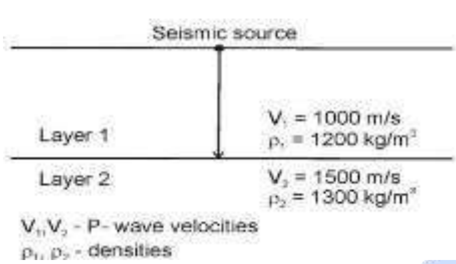
As, the mid oceanic ridge has symmetric magnetic anomalies about the ridge axis,

So, velocity of plate B = 5 cms/year.

So, the average velocity between plate A and plate B = (5 + 5) cms/year .

= 10 cms/year. (answer).

6. The transmission coefficient for the vertically incident seismic wave at the interface between Layer 1 and Layer 2 given in the figure is ______________. *(Round off to two decimal places)*



➔ $V_1 = 1000$ m/s ; $\rho_1 = 1200$ Kg/m³ .

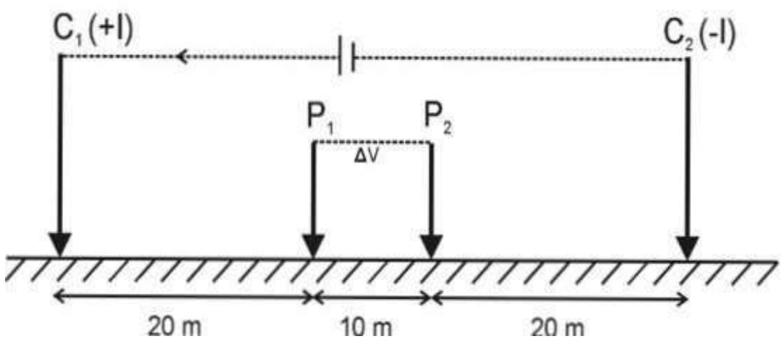
So, Acoustic impedance of layer 1 (Z_1)= ($V_1 \times \rho_1$) = (1000 × 1200) Kg/m²s = 1200000 Kg/m²s.

$V_2 = 1500$ m/s ; $\rho_2 = 1300$ Kg/m³.

So, Acoustic impedance of layer 2 (Z_2) = ($V_2 \times \rho_2$) = (1500 × 1300) Kg/m^2s = 1950000 Kg/m^2 s.

So, Transmission coefficient = $\frac{2 \times Z_1}{(Z_1 + Z_2)} = \frac{2400000}{3150000}$ = 0.76. (answer).

7. **The 'Geometrical factor' for the electrode configuration given below will be ___________m.** *(Round off to 2 decimal places)* **(Use π = 3.14) .**
(C_1 and C_2 are current electrodes ; P_1 and P_2 are potential electrodes)



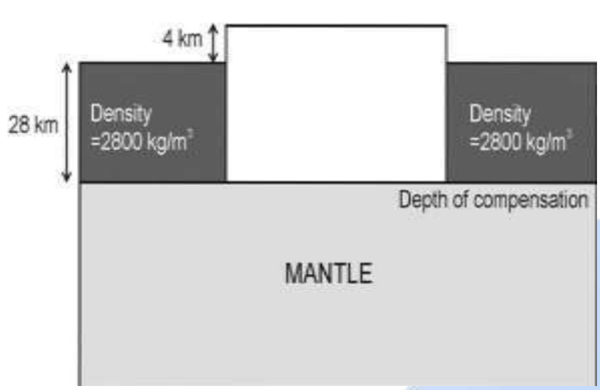
➔ From Schlumberger equation,
Geometrical factor = π × n(n+1) × a .
Where, n = an integer , here 2.
a = electrode separation, here 10.

So, Geometrical factor = {3.14 × 2(2+1) × 10} m = 188.40 m. (answer).

8. **In an electromagnetic measurement, the resultant field shows a phase lag of 30^0 with respect to the primary field at the receiver coil. The ratio of Inphase to Quadrature component of the resultant field is ______** .*(Round off to 2 decimal places).*

➔ Phase lag = 30^0.
So, the ratio of Inphase to Quadrature component of the resultant field = (2 × cos30^0) = 1.73. (answer).

9. **A 4 Km high plateau is isostatically compensated as shown in the figure. Assuming Pratt's hypothesis of Isostasy, the calculated density of the plateau is ____________Kg/m^3.**



➔ Let we consider, density of the plateau = X Kg/m^3.
Height of the plateau = (28 + 4) Km = 32 Km = 32000 m.
So, pressure on the level of compensation due to plateau = $(32000 \times g \times X)$ Pa.
Density of the crust is 2800 Kg/m^3.
Depth of crust is 28 Km = 28000 m.
So, pressure on the level of compensation due to crust = $(28000 \times g \times 2800)$ Pa.
Now, equating pressure at the level of compensation we get,

$$32000 \times g \times X = 28000 \times g \times 2800$$

or,

$$X = \frac{28000 \times 2800}{32000} \text{ Kg/m}^3 = 2450 \text{ Kg/m}^3.$$

So, Density of the plateau = 2450 Kg/m^3 . (answer).

10. What are the miller indices of a plane that intercepts each of the crystallographic axes X, Y and Z, at 20 A^0 ?
(Assume a primitive unit cell with the dimension a = 5 A^0, b = 2 A^0, c = 4 A^0 .)

➔ a = 5 A^0 ; b = 2 A^0 ; c = 4 A^0 .
a, b, c intercepts X, Y, Z respectively at 20 A^0 .

So, 'a' cut X axis at $\frac{20}{5}$ = 4 units.

'b' cut Y axis at $\frac{20}{2}$ = 10 units.

'c' cut Z axis at $\frac{20}{4}$ = 5 units.

So, Weiss symbol : 4 , 10, 5 .
So, Miller indices = (5 2 4). (answer).

11. If density of quartz is 2650 Kg/m^3 and that of orthoclase is 2550 Kg/m^3, the lithostatic pressure due to granite with 68 modal % quartz and 32 modal % orthoclase at a depth of 10 Km will be __________Kbar. *(Round off to 2 decimal places)* **(Acceleration due to gravity, g = 9.8 m/s^2)**

➔ Density of quartz = 2650 Kg/m^3 .
Density of orthoclase = 2550 Kg/m^3.
Granite composed of 68 modal % quartz and 32 modal % orthoclase.

So, density of the granite = $[(\frac{68}{100} \times 2650) + (\frac{32}{100} \times 2550)]$ Kg/m^3 = 2618 Kg/m^3.
Depth = 10 Km = 10000 m.
Acceleration due to gravity = 9.81 m/s^2.

So, Pressure at that depth = $(2618 \times 9.81 \times 10000)$ Pa = 256564000 Pa.
= 2.6 Kbar. (answer).

12. The grade of iron in an ore body containing 80 wt. % hematite and 20 wt. % gangue is ______%. *(Round off to 2 decimal places)* **(Atomic wt. of Fe = 55.85, atomic wt. of O = 16).**

➔ Ore body contains 80 wt. % hematite and 20 wt. % gangue minerals.
Hematite = Fe_2O_3.
Molecular weight of hematite = (55.85 × 2) + (3 × 16) gm. = 159.7 gm.

Now, In 159.7 gm. of Ore, Fe amount is 117.70 gm.
So, in 80 gm. of Ore Fe amount = $(\frac{117.70}{159.7} \times 80)$ gm. = 55.95 gm. (answer).

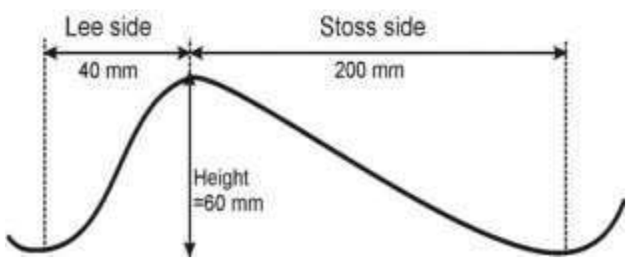
13. The abundance of the isotopes ^{35}Cl (atomic mass = 34.96885 amu) and ^{37}Cl (atomic mass = 36.96590 amu) are 75.77 % and 24.23 % respectively. The calculated atomic weight of Cl is ______ amu *(Round off to 3 decimal places).*

➔ In case of ^{35}Cl : atomic mass = 34.96885 ; abundance = 75.77 %.
In case of ^{37}Cl : atomic mass = 36.96590 ; abundance = 24.23 %.

So, calculated atomic weight of Cl = $\frac{(34.96885 \times 75.77) + (39.96590 \times 24.23)}{(75.77 + 24.23)}$ amu.

= 35.452 amu .(answer).

14. A vertical profile perpendicular to the crest line of an asymmetrical ripple is given in the figure. The calculated ripple index is___________.



➔ Wave length = distance between two adjacent lee side = (40 + 200) mm = 240mm.
Height = 60 mm .

So, ripple index = $\frac{240}{60}$ = 4. (answer).

15. If the ΔH of formation of $CaSiO_3$, SiO_2 and CaO from Ca, Si and O are respectively –1635, —911 and – 635 KJ/mol., the enthalpy of formation of $CaSiO_3$ from CaO and SiO_2 is ___ _ KJ/mol.

➔ $CaO + SiO_2 = CaSiO_3$.
So, ΔH of the reaction = {—1635 – (—911 – 635)} KJ/mol. = –89 KJ/mol.

So, the enthalpy of formation of $CaSiO_3$ from CaO and SiO_2 = –89 KJ/mol. (answer).

16. **The tip-line of an actively propagating thrust fault is located at a depth of 1 Km from the horizontal ground surface. The average density of the material from the ground surface to this depth is assumed to be uniform and can be taken as 2700 Kg/m³. The rock at this depth follows the failure criterion given by the equation : $\sigma_1 = 10$ MPa + $3\sigma_3$, where σ_1 and σ_3 are the maximum and minimum principal stresses. Considering, Anderson's theory of faulting, the calculated maximum principal stress at this depth is __________MPa. (Assume, acceleration due to gravity, g = 10 m/s²).**

➔ Depth = 1 Km = 1000 m.
Density = 2700 Kg/m³.
Acceleration due to gravity = 10 m/s².
Now, Pressure/ Stress at this depth = (1000 × 10 × 2700) Pa = 27000000 Pa
= 27 MPa.
According to Anderson's theory minimum principal stress axis is vertical and the calculated stress act vertically on the rock bed at this depth.
So, σ_3 = 27 MPa.

Now, according to the formula,

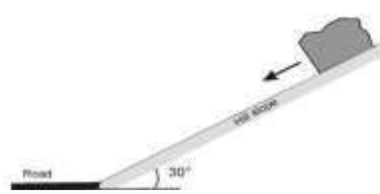
$$\sigma_1 = 10 \text{ MPa} + 3\sigma_3$$

or,

$$\sigma_1 = [10 \text{ MPa} + (3 \times 27)] \text{ MPa} = 91 \text{ MPa}.$$

So, the calculated maximum principal stress is 91 MPa (answer).

17. **During a rockslide, a 20 Kg granite block gets dislodged from the top of a planar hill slope and starts sliding down the slope as shown in the figure. The slope angle is 30⁰ with the horizontal. After travelling a distance of 40 m in the same direction on the slope, the block hits the road. Assuming zero cohesion and zero friction as assuming acceleration due to gravity (g) as 10 m/s², the velocity with which the block hits the road is _______ m/s.**



➔ Mass of the granite block = 20 Kg.
Acceleration due to gravity = 10 m/s².
Slope angle = 30⁰.
Let we consider velocity = v m/s.
So, Force (F) acting on the block = M × f = (20 × 10) N = 200 N. -------(i)
Again, Force (F) = M v Sinθ = (20 × v × Sin 30⁰)N. -------(ii)

Equating (i) & (ii) we get,

$$v = \frac{200}{20 \times 0.5} \text{ m/s} = 20 \text{ m/s}.$$

So, the velocity with which the block hits the road is 20 m/s .(answer).

18. Liquid limit and plastic limit of a soil are 40 % and 20 % respectively. If the natural *(i.e. in situ)* **water content of the soil is 30 % , the liquidity index is______________.**

➔ Liquid limit = 40 %.
Plastic limit = 20 %.
Water content = 30 %.

So, liquidity index $= \frac{(\text{Water content} - \text{Plastic limit})}{(\text{Liquid limit} - \text{Plastic limit})} = \frac{30-20}{40-20} = 0.5$. (answer).

19. A confined aquifer has a uniform area (A) perpendicular to the water flow. The hydraulic gradient and coefficient of permeability are given as 0.005 and 2 m/day respectively. The total daily flow of water is 250 m^3 . Using Darcy's law , the calculated value of 'A' is __________m^2.

➔ Hydraulic gradient = 0.005
Coefficient of permeability = 2 m/day.
Daily flow of water = 250 m^3.
Area = A m^2.

Now, applying Darcy's law ,

$$250 = 2 \times A \times 0.005$$

or,

$$A = \frac{250}{2 \times 0.005} m^2 = 25000\, m^2$$

So, the calculated value of A = 25000 m^2 . (answer).

20. The apparent dip amount of a sandstone bed is 45^0 . The angle between the true dip direction and apparent dip direction is 60^0. The true dip amount of the bed is __________^{0} *(Round off to 2 decimal places).*

➔ Apparent dip amount = 45^0.
Angle between true dip and apparent dip direction = 60^0.
Let we consider true dip amount = θ^0.

So,

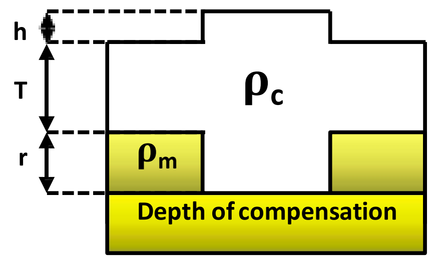
$$\tan 45^0 = \tan \theta \times \cos 60^0$$

or,

$$\theta = \tan^{-1} 2 = 63.43^0 .$$

So, true dip amount of the bed is 63.43^0 (answer).

21. **Assuming Airy isostatic compensation, the depth of Moho from a point located at 2 Km above the mean sea level is___________Km.** *(Round off to 1 decimal place).* **(The depth of compensation T for the crust at mean sea level is 30 Km. The density of crust and upper mantle are 2.67 gm/cc and 3.30 gm/cc respectively).**



➔ Height of that point (h) = 2 Km.
Thickness (T) = 30 Km.
Root (r) = X Km.
Density of crust (ρ_c) = 2.67 gm/cc = 2670 Kg/m^3.
Density of mantle (ρ_m) = 3.30 gm/cc = 3300 Kg/m^3.

Equating pressure at depth of compensation,

Root (r) = $\frac{(2670 \times 2)}{(3300 - 2670)}$ Km = 8.5 Km.

So, Depth to the Moho from that point is (2 + 30 + 8.5) Kms = 40.5 Km. (answer).

22. **On survey of India Toposheet number 45 $\frac{D}{16}$ the distance between two points is 18 cms. The actual ground distance between these two points is________Km.**

➔ Toposheet number = 45 $\frac{D}{16}$; is a quarter degree map. so, R.F = 1 : 50,000.
Now, distance between two points on map is 18 cms.
So, the actual ground distance between these two points = (18 × 50,000) cm.
= 9 Km. (answer).

23. **For a dam site investigation, drilling was carried out upto a depth of 20 m. The total length of recovered core pieces, each over 100 mm. add upto 16 m. The Rock Quality Designation (RQD) of the foundation rock mass is_______________%.**

➔ Depth of drilling = 20 m.
Total length of recovered core pieces add upto 16 m.

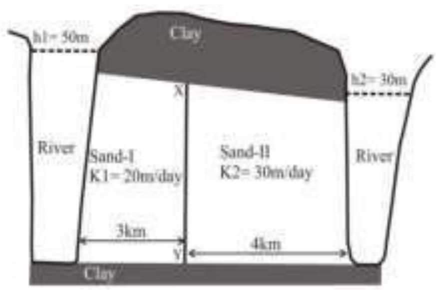
So, RQD = ($\frac{16}{20}$ × 100) % = 80 %. (answer).

24. The shear wave velocity in an igneous rock with a density of 2.7 gm/cc and rigidity modulus of 24.3 GPa is ______ Km/s .*(Round off to 1 decimal place).*

➔ Density of the rock = 2.7 gm/cc = 2700 kg/m^3.
Rigidity modulus = 24.3 GPa = (243×10^9) Pa.

So, Shear wave velocity = $\sqrt{\frac{243 \times 10^9}{2700}}$ m/s = 3000 m/s = 3 Km/s. (answer).

25. Hydrogeological setup of a hypothetical alluvial area (where contact X – Y between two sands is vertical) is given in the schematic section. Hydraulic heads are indicated as h1, h2 and hydraulic conductivities as K1, K2. The hydraulic head at the contact (X – Y) is __________m. *(Round off to 2 decimal places).*



➔ For right hand side aquifer :
h2 = 30 m ; XY = X m.
dh = (X – 30) m.
dl = 4 Km = 4000 m.
Hydraulic gradient = $\frac{(X - 30)}{4000}$.
Hydraulic conductivity (K2) = 30 m/day.

For left hand side aquifer :
h1 = 50 m ; XY = X m.
dh = (50 – X) m.
dl = 3 Kms = 3000 m.
Hydraulic gradient = $\frac{(50 - X)}{3000}$.
Hydraulic conductivity (K1) = 20 m/day.

Assuming area is equal, equating flow rate for both sides,

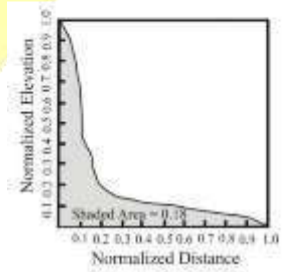
$$- 30 \times A \times \frac{(X - 30)}{4000} = - 20 \times A \times \frac{(50 - X)}{3000}$$

or,

$$X = 39.41$$

So, the hydraulic head at the contact (XY) = 39.41 m (answer).

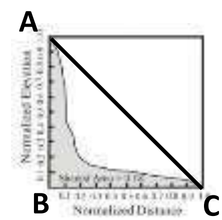
26. **The normalized longitudinal profile of a river is given below. The Concavity Index of the river is__________%.**



➔ Area of the Shaded area = 0.18 square unit.

Area of the ΔABC = $(\frac{1}{2} \times 1 \times 1)$ square unit = 0.50 square unit.

So, concavity index = $(\frac{0.50 - 0.18}{0.50} \times 100)\%$ = 64 %. (answer).



27. **For producing 1 Kg of gold from an ore having an assay of 2 ppm Au.___________× 10³ Kg of ore needs to be processed.**

➔ Metal content = 1 Kg.

Assay value = 2 ppm.

So, mass of the ore = $\frac{\text{Metal content}}{\text{Assay value}} = \frac{1}{\frac{2}{10^6}}$ Kg = 50,000 Kg. = 50×10^3 Kg.

So, 50×10^3 Kg ore needs to be processed. (answer).

28. **A cylindrical core of granite with a radius of 25 mm was subjected to point load test. The load was applied parallel to the diameter of the core and the failure load was 20 KN. The uncorrected point load strength index is__________MPa.**

➔ Radius of the core = 25 mm ; diameter = 50 mm.

Failure load = 20 KN.

So, uncorrected point load strength index = $\frac{20 \times 1000}{50^2}$ MPa. = 8 MPa. (answer).

29. **Given that the velocity of P-waves in a sandstone matrix is 5600 m/s and that in oil is 1200 m/s, the velocity of P-wave propagation in oil saturated sandstone with 30% porosity is ____________m/s. (Use Wyllie time average equation.)**

➔ Velocity in a sandstone matrix (V_m) = 5600 m/s.

Velocity in the oil (V_{oil}) = 1200 m/s.

Porosity = 30 % = 0.3.

Lets we consider, Velocity in the oil saturated sandstone = V m/s.

Now, from Wyllie's time average equation,

$$\frac{1}{V} = \frac{\varphi}{V_{oil}} + \frac{1-\varphi}{V_m}$$

or,

$$\frac{1}{V} = \frac{0.3}{1200} + \frac{1-0.3}{5600}$$

or,

$$V = 2666 \text{ m/s}$$

So, The velocity of P-wave propagation in oil saturated sandstone = 2666 m/s . (answer)

30. If the total porosity of a soil is 20 %, its void ratio is________%.

➔ Porosity of a soil is 20 %, i.e. if the total volume of the soil is 100 then volume of void is 20.
So, volume of solids = (100 – 20) = 80.
So, void ratio = $(\frac{20}{80} \times 100)$ % = 25 % . (answer).

31. During bench blasting in a quarry, 50 Kg of an explosive with a yield of 5 MegaJoule/Kg is required to break 100 m^3 of marble. In this case, the energy expended in breaking a unit volume of marble in MegaNewton/m^2 would be_________.

➔ Mass of the explosive = 50 Kg.
Energy released from 1 Kg of explosive = 5 MegaJoule = 5 MegaNewton – meter .
So, total energy released = (50 × 5) MegaNewton-meter = 250 MegaNewton-meter.
So, the energy expended in breaking a unit volume of marble = $\frac{250}{100}$ MegaNewton/m^2

= 2.5 MegaNewton/m^2. (answer).

32. The difference in the number of faces in forms {hkl} and {111} in the holosymmetric class of the isometric system is________________.

➔ Holosymmetric class of the isometric system = $\frac{4}{m}\bar{3}\frac{2}{m}$
Number of faces in the form {hkl} = 48.
Number of faces in the form {111} = 8.
So, difference in the number of faces = (48 – 8) = 40. (answer).

33. An inclined cylindrical confined aquifer has coefficient of permeability of 40 m/day. The horizontal distance between two vertical wells penetrating the aquifer is 800 m. The water surface elevations in the wells are 50 m and 45 m above a common horizontal datum. The absolute value of Darcy flux through the aquifer is_______________m/day.

➔ Co-efficient of permeability (K) = 40 m/day.
Horizontal distance (dl) = 800 m.
Elevation difference (dh) = (45 – 50) m = –5 m.

➔ Hydraulic gradient $(\frac{dh}{dl}) = \frac{-5}{800}$.

So, Darcy flux/ Darcy velocity (v) = $-K\frac{dh}{dl} = -(40 \times \frac{-5}{800})$ m/day = 0.25 m/day. (answer)

34. The mass and volume of a natural soil sample are 2.1 kg and 1×10-3 m3, respectively. When fully dried, the mass of the soil sample becomes 2 kg without any change in volume. Assuming the specific gravity of soil particles to be 2.5, and water density of 1000 kg/m3, the degree of saturation of the natural soil sample is_______________%.

➔ Mass and volume of a natural soil sample = 2.1 Kg and 1×10^{-3} m^3 respectively.
Mass and volume of fully dried soil sample = 2 Kg and 1×10^{-3} m^3 respectively.
Specific gravity of soil particles = 2.5 ; density = 2500 Kg/m^3.
Density of water = 1000 Kg/m^3.
So, volume of soil particles = $\frac{2}{2500}$ m^3 = 0.8×10^{-3} m^3.
So, volume of voids = $[(1 \times 10^{-3}) - (0.8 \times 10^{-3})]$ m^3 = 0.2×10^{-3} m^3.
Mass of water = (2.1 – 2) Kg = 0.1 Kg.
So, volume of water = $\frac{0.1}{1000}$ m^3 = 0.1×10^{-3} m^3.

So, Degree of saturation of the natural soil sample = $(\frac{\text{volume of water}}{\text{volume of voids}} \times 100)$ %

$= (\frac{0.1 \times 10^{-3}}{0.2 \times 10^{-3}} \times 100)$ % = 50 %. (answer).

35. For a granite rockmass, mass, joint set number (Jn) = 9, joint water reduction factor (Jw) = 1, joint alteration number (Ja) = 1, stress reduction factor (SRF) = 1, rock quality designation (%) = 84 and joint roughness number (Jr) = 3. The Q-value as per Barton's Q-system of rock mass classification (year 1974) is________________.

➔ Joint set number (Jn) = 9.
Joint water reduction factor (Jw) = 1.
Joint alteration number (Ja) = 1.
Joint roughness number (Jr) = 3.
Stress reduction factor (SRF) = 1
Rock quality designation (RQD) = 84.

So, Q value = $\frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF} = (\frac{84}{9} \times \frac{3}{1} \times \frac{1}{1})$ = 28. (answer).

36. A sun synchronous satellite is at an altitude of 300 km and the spectrometer makes an angular coverage angle of 12^0. The Swath (GFOV) of the satellite is________________km.

➔ Altitude (2H) = 300 Km.
Angular coverage angle (θ) = 12^0.
So, GFOV = $2H \times \tan\frac{\theta}{2}$ = $(2 \times 300 \times \tan 6^0)$ Km = 63.06 Km. (answer).

37. The stability field boundary between two minerals A and B is linear with a positive slope in P-T space. The molar entropy of A and B are 85.5 and 92.5 Joules K^{-1}, respectively and their respective molar volumes are 35.5 and 38.2 cc. The slope of the phase boundary in P-T space is______________bar K^{-1}.

➔ Molar entropy of A and B = 85.5 Joules K^{-1} and 92.5 Joules K^{-1} respectively.
Molar volume of A and B = 35.5 cc and 38.2 cc respectively

So, ΔS = (92.5 – 85.5) Joules K^{-1} = 7 Joules K^{-1}.
ΔV = (38.2 – 35.5) cc = 2.7 cc. = 2.7×10^{-6} m^3.

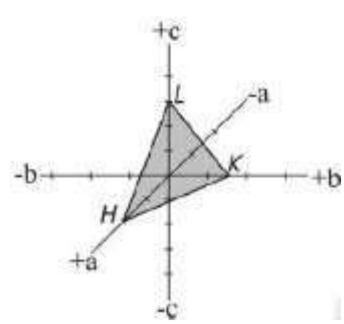
So, Slope of the phase boundary = $\frac{\Delta S}{\Delta V} = \frac{7}{2.7 \times 10^{-6}}$ Pa K^{-1} = (2.59×10^{6}) Pa K^{-1} .
= 25.9 Bar K^{-1} . (answer).

38. Los Angeles abrasion test was conducted for a granite aggregate with an initial weight of 4800 grams. After the test, the aggregate weighted value 3504 grams. The Los Angeles abrasion value is__________%.

➔ Initial weight = 4800 grams.
Aggregate weighted value = 3504 grams.
Change in value = (4800 – 3504) grams = 496 grams.

So, Los Angeles abrasion value = $(\frac{496}{4800} \times 100)$ % = 27 %. (answer).

39. The figure below shows the intercepts of the plane HKL with the crystallographic axes a, b, c. The Miller index of the plane HKL is________.



➔ The face cuts axis a at 2 unit, b at 1.5 unit and c at 3 unit.
So, Weiss symbol = 2 $\frac{3}{2}$ 3 .
Reciprocal = $\frac{1}{2} \frac{2}{3} \frac{1}{3}$.

So, miller index of the face HKL = (3 4 2). (answer).

40. The travel time difference between the arrival times of a shear wave (S) and primary wave (P) observed on a seismogram recorded at an epicentral distance of 100 Km. from a near surface earthquake is ________s.
(Assume the average P-wave and S-wave velocities to be 6.0 Km/s and 3.5 /km/s respectively).

➔ Velocity of P-wave = 6.0 Km/s.
Velocity of S-wave = 3.5 Km/s.
Epicentral distance = 100 Km.

So, travel time for P-wave = $\frac{100}{6}$ s.

travel time for S-wave = $\frac{100}{3.5}$ s.

So, Difference between the travel time = $(\frac{100}{3.5} - \frac{100}{6})$ s = 11.90 s. (answer).

41. The percentage increase in P-wave velocity (Km/s) across the Mohorovicic discontinuity from the lower crust to the upper mantle beneath a craton approximately________%.

➔ P-wave velocity at lower crust = 7.6 Km/s.
P-wave velocity at upper mantle = 9.2 Km/s.
So, velocity increase = (9.2 – 7.6) Km/s = 1.6 Km/s.

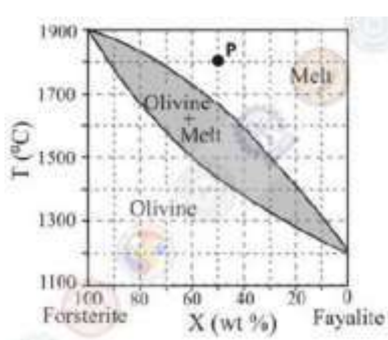
So, velocity increase percentage = $(\frac{1.6}{7.6} \times 100)$ % = 21.05 %. (answer).

42. The pressure on a rock overlain by a 7 km thick basaltic crust (ρ = 3100 Kg m^{-3}) is _______ Kilobar. (Use g = 9.8 m s^{-2}; 10^{-5} Pa = 1 bar).

➔ Thickness of the crust = 7 Km. = 7000 m.
Density = 3100 Kg m^{-3}.
Acceleration due to gravity = 9.8 m s^{-2}.

So, Pressure on the rock = (7000 × 3100 × 9.8) Pa = 212660 Pa = 2.13 Kilobar. (answer)

43. The given T–X diagram shows the phase relations in olivine solid solution at 1 bar pressure. If 'P' is the initial position of melt , the proportion of melt at 1500°C is________%.



➔ Applying Lever rule we get,

Proportion of melt at 1500^{0}C = ($\frac{10}{30}$ × 100) % = 33.3 %. (answer).

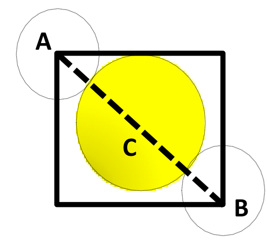
44. Fluorite crystal (CaF_2) adopts face – centred cubic structure with lattice parameter a = 5.463 A^0. If the ionic radius of anion (F^-) is 1.71 A^0, the ionic radius of cation is________A^0.

➔ Lattice parameter = 5.463 A^0.

Ionic radius of anion (F^-) = 1.71 A^0.

Fluorite adopts face – centred cubic crystal.

So, diagonal of the cube (AB) = (5.463 × $\sqrt{2}$) A^0 = 7.73 A^0.



Now, AC = $\frac{7.73}{2}$ A^0 = 3.80 A^0.

Again, AC = (radius of cation + radius of anion).

So, Radius of cation = (3.80 – 1.71) A^0 = 2.15 A^0. (answer).

45. The standard thermodynamic data for enstatite ($Mg_2Si_2O_6$), quartz (SiO_2) and forsterite (Mg_2SiO_4) is given in the table below. The Gibbs free energy of the reaction Mg_2SiO_4 + SiO_2 = $Mg_2Si_2O_6$ at 600 K and 1 bar is_____________J. (Assuming C_p = 0 for all minerals in the reaction).

Mineral	$\Delta H^0_{f, 298}$ (KJ)	S^0 (JK^{-1})
Enstatite	– 3090.47	132.5
Quartz	– 910.83	41.5
Forsterite	– 2172.2	95.1

➔ Mg_2SiO_4 + SiO_2 = $Mg_2Si_2O_4$; Temperature = 600 K, Pressure = 1 bar.

Resultant ΔH^0 = [- 3090.47 – (- 910.83 – 2172.2)] KJ. = – 7.44 KJ = – 7440 Joule.

Resultant ΔS = [132.5 – (41.5 + 95.1)] JK^{-1} = – 4.1 JK^{-1}.

So, Gibbs Free energy = [– 7440 – (600 × – 4.1)] J = – 4980 J. (answer).

46. The hydraulic conductivity (K) of an isotropic aquifer is 10 m/day. If the hydraulic head within the aquifer drops 4 m over a distance of 750 m, the groundwater flow velocity within the aquifer__________m/day. (upto 3rd decimal place).

➔ Hydraulic conductivity (K) = 10 m/day.

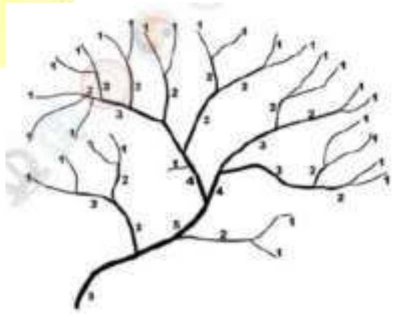
Hydraulic head drop (dh) = 4 m.

Distance (dl) = 750 m.

Hydraulic head ($\frac{dh}{dl}$) = $\frac{4}{750}$.

So, groundwater flow velocity (v) = (10 × $\frac{4}{750}$) m/day = 0.053 m/day. (answer).

47. **Drainage network of a watershed ordered as per Strahler method is given below. Maximum observed bifurcation ratio for the given network is_________.**



➔ Number od 1st order, 2nd order, 3rd order, 4th order and 5th order streams are 28, 13, 5, 2 and 1 respectively.

So, bifurcation ratio between 1st order and 2nd order streams = $\frac{28}{13}$ = 2.15.

bifurcation ratio between 2nd order and 3rd order streams = $\frac{13}{5}$ = 2.6.

bifurcation ratio between 3rd order and 4th order streams = $\frac{5}{2}$ = 2.5.

bifurcation ratio between 4th order and 5th order streams = $\frac{2}{1}$ = 2.

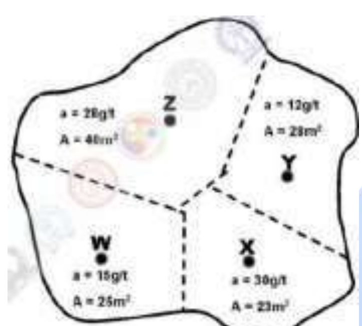
So, Maximum observed bifurcation ratio for the given network = 2.6. (answer).

48. **Brazilian Test was conducted on a rock sample having radius of 27 mm and thickness of 22 mm. The failure load was 5 KN. The tensile strength of the rock_________N/mm².**

➔ Radius of the rock sample = 27 mm.
Thickness of the rock sample = 22 mm.
Failure load = 5 KN = 5000 N.

So, tensile strength of the rock = $\frac{5000}{(\pi \times 22 \times 27)}$ N/mm² = 2.68 N/mm². (answer).

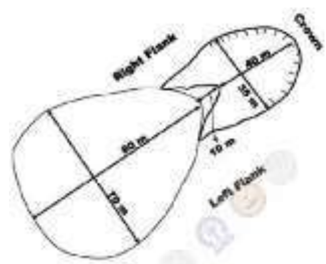
49. **The average assay (a) and area of influence (A) of a placer gold deposit of uniform thickness sampled at four locations W, X, Y and z are given below. The weighted average assay of the ore body is__________g/t.**



➔ Assay value of W, X, Y, Z are 15 g/t, 30 g/t, 12 g/t, 28 g/t respectively. Thickness is uniform.

So, Weighted average assay value = $\frac{(15 + 30 + 12 + 28)}{4}$ g/t = 21.25 g/t . (answer).

50. The length and width of concave and convex sides of a landslide is shown in the figure below. The Dilation Index of the land slide is___________.



➔ Width of the concave side = 35 m.

Width of the convex side = 70 m.

So, Dilation Index = $\frac{70}{35}$ = 2. (answer).

51. Water content and total porosity of a soil are given as 10% and 25%, respectively. Specific gravity of soil particles is 2.5. The volume of water that should be added to 100 m³ of this soil for full saturation is_______________m³.

➔ Volume of the soil = 100 m³.

Porosity = 25 %.

Water content = 10 %.

Specific gravity = 2.5 ; density = 2500 Kg/m³.

So, volume of the pore spaces = $(\frac{25}{100} \times 100)$ m³ = 25 m³.

volume of solids = (100 – 25) m³ = 75 m³.

So, weight of solids = (2500 × 75) Kg = 187500 Kg.

weight of water currently present = $\frac{(10 \times 187500)}{100}$ Kg = 18750 Kg.

So, volume of water currently present = $\frac{18750}{100}$ m³ = 18.75 m³.

So, volume of water to be added for full saturation = (25 – 18.75) m³ = 6.25 m³ . (answer)

52. In a rock sample, the values of $(^{87}Sr/^{86}Sr)_{Present}$ and $(^{87}Rb/^{86}Sr)_{Present}$ are 0.7125 and 0.2, respectively. The decay constant (λ) of ^{87}Rb is 1.42×10^{-11} $year^{-1}$, and time before present (t) is 1000 million years. The value of the initial ratio $(^{87}Sr/^{86}Sr)_0$ is___________.

➔ $(\frac{^{87}Sr}{^{86}Sr})_{present}$ = 0.7125.

$(\frac{^{87}Rb}{^{86}Sr})_{present}$ = 0.2.

$\lambda = 1.42 \times 10^{-11}$ $Year^{-1}$. ; time = 1000×10^6 Years.

Now,

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_{present} = \left(\frac{^{87}Sr}{^{86}Sr}\right)_0 + \left(\frac{^{87}Rb}{^{86}Sr}\right)_{present} \times (e^{\lambda t} - 1).$$

or,

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_0 = 0.7125 - 0.2\,(e^{1.42 \times 10^{-11} \times 1000 \times 10^{6}} - 1).$$

$$= 0.7096. \text{ (answer)}.$$

53. Considering the Airy isostatic compensation for a mountain having elevation of 2.0 Km above the mean sea level at a point P , the thickness of its root below P would be _______ Km. (consider density of the crustal rocks and upper mantle as 2.7 gm/cc and 3.3 gm/cc respectively).

➔ Height = 2 Km.
Density of the crust = 2.7 gm/cc.
Density of the upper mantle = 3.3 gm/cc.

So, Thickness of the root = $\frac{(2 \times 2.7)}{(3.3 - 2.7)}$ Km = 9 Km. (answer).

54. The reflection coefficient at the interface separating sandstone (V_p = 2000 m/s ; ρ = 1.5 gm/cc) underlain by shale (V_p = 2500 m/s ; ρ = 2.0 gm/cc) is_________.

➔ V_p in sandstone = 2000 m/s. ; $\rho_{sandstone}$ = 1.5 gm/cc = 1500 Kg/m³.
V_p in shale = 2500 m/s. ; ρ_{Shale} = 2.0 gm/cc = 2000 Kg/m³.

So, the acoustic impedance at shale (Z_2) = (2500 × 2000) Kg/m².s = 5 × 10^6 Kg/m²s.
the acoustic impedance at sst. (Z_1) = (1500 × 2000) Kg/m².s = 3 × 10^6 Kg/m²s.

So, Reflection coefficient = $\frac{(5 \times 10^6) - (3 \times 10^6)}{(5 \times 10^6) + (3 \times 10^6)}$ = 0.25. (answer).

55. A drainage area with an area of 2.0 × 10^6 m² receives continuous rainfall for 48 hours at a uniform rate of 3 mmh^{-1} . The volume of precipitation is___________m³ of water.

➔ Area of the drainage basin = (2 × 10^6) m².
Continuous rainfall for 48 hours at an uniform rate of 3 mmh^{-1}.
So, total rainfall height = (48 × 3) mm = 144 mm = 0.144 m.
So, Volume of precipitation = (2 × 10^6 × 0.144) m³ = 288000 m³ . (answer).

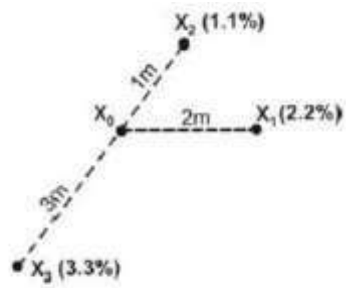
56. A sandstone bed whose attitude is 090°, 30° is exposed on a flat surface. The true thickness of the bed is 100 m. The width of the outcrop of the sandstone bed along N—S traverse on the ground is_________m.

➔ True dip of the bed = 30°.
True thickness = 100 m.
So, outcrop width = $\frac{100}{\sin 30^0}$ = 200 m . (answer).

57. **If the total volume of water in the Earth's atmosphere, estimated to be about $1.29 * 10^4$ Km^3, were to completely precipitate and uniformly cover the Earth's surface, estimated to be $5.1 * 10^8$ Km^2, the height of the resulting water column would be________________cm.**

➔ Total estimated water volume in the earth's atmosphere = (1.29×10^4)Km^3.
Area of the earth's surface = (5.1×10^8) Km^2.
So, the height of the resulting water column = $\frac{1.29 \times 10^4}{5.1 \times 10^8}$ Km = 2.52 cm. (answer).

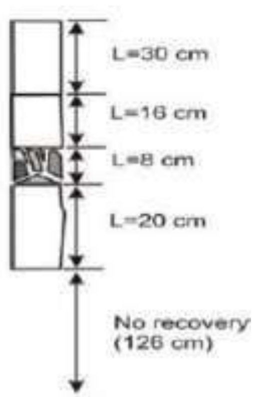
58. **Samples of copper ores are drawn from location X_1, X_2, X_3, as shown in the figure. The values of (% Cu) at sampling locations are given in brackets. The estimated grade at point X_0 using inverse distance weighting is_________%.**



➔ Using inverse grade weighting the estimated grade at point X_0 = $\frac{\left(\frac{1.1}{1} + \frac{2.2}{2} + \frac{3.3}{3}\right)}{\left(\frac{1}{1} + \frac{1}{2} + \frac{1}{3}\right)}$

= 1.8 %. (answer).

59. **From the figure given below depicting a recovered core of a total length of 200 cm. The RQD (Rock Quality Designation) is__________%.**



➔ Total recovered core = (30 + 16 + 20) cm = 66 cm.
Total length = 200 cm.

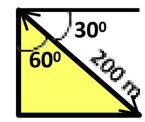
So, RQD = $(\frac{66}{200} \times 100)$ % = 33 %. (answer).

60. The scale of an aerial photograph acquired from a height of 5000 m using a camera having focal length of 200 mm, is________.

➔ Height = 5000 m = (5000×10^3)mm.
Focal length of the camera = 200 mm.
So, scale of the photograph = $\frac{200}{5000 \times 10^3}$ = 1 : 25000. (answer).

61. The dip slip of a fault is 200 m and dip amount is 30^0 . The throw of the fault is______m.

➔ Dip slip component of the fault = 200 m.
Dip amount = 30^0 ; Hade = $(90^0 - 30^0) = 60^0$.
So, throw of the fault = $(200 \times \cos 60^0)$ = 100 m. (answer).



62. If the solubility product of gypsum is $10^{-4.36}$, the solubility of gypsum (mol/litre) in an ideal aqueous solution will be________________.

➔ $CaSO_4 = Ca^{2+} + SO_4^{2-}$
If solubility = S.
So, $K_{sp} = S^2$
Again, $K_{sp} = 10^{-4.36}$

So, $S^2 = 10^{-4.36}$; $S = 10^{-8.72}$. (answer).

63. A radioactive substance decays to one third of its original value in 6 hours of time. What is the half life (in hours) of the substance_________.

➔ Let we consider, the atoms present at t = 0 is N_0 , when t = 6 hours , N = $\frac{N_0}{3}$.
Now, from the basic equation of radioactive decay, we get,

$$\frac{N_0}{3} = N_0 \, e^{-(\lambda \times 6)}$$

or,

$$\lambda = \frac{\ln 3}{6}$$

Now, from half life equation,

$$t = \frac{\ln 2}{\frac{\ln 3}{6}} = 3.78 \text{ hours. (answer).}$$

64. If the P-wave velocity is twice that of S-wave velocity in a medium, the Poisson's ratio of the material is__________________.

➔ Let we consider, V_s = X Km/s ; so, V_p = 2X Km/s.
Poisson's ratio = P

Now from Poisson's ratio equation,

$$\frac{2X}{X} = \sqrt{\frac{(1-P)}{(0.5-P)}}$$

or,

$$P = 0.33 \text{ (answer)}$$

65. **The amplitude of ground motion generated by an earthquake of magnitude 8 is greater than that of an earthquake of magnitude 5 by a factor of________.**

➔ As, Richter scale is a logarithmic scale. So magnitude 8 is greater than that of an earthquake of magnitude 5 by a factor of 10^3 = 1000 .(answer).

66. **A basaltic lava flow is found to have a $^{87}Sr/^{86}Sr$ ratio of 0.720 and a $^{87}Rb/^{86}Sr$ ratio of 0.750. If the initial $^{87}Sr/^{86}Sr$ value is determined to be 0.704, what is the age of the flow ? (Assume $\lambda = 1.42 * 10^{-11}$ year^{-1}).**

➔ $\frac{^{87}Sr}{^{86}Sr} = 0.720$; $\frac{^{87}Rb}{^{86}Sr} = 0.750$; $(\frac{^{87}Sr}{^{86}Sr})_0 = 0.704$; $\lambda = 1.42 * 10^{-11}$ year^{-1}

Now, from the equation,

$$\left(\frac{^{87}Sr}{^{86}Sr}\right) = \left(\frac{^{87}Sr}{^{86}Sr}\right)_0 + \left(\frac{^{87}Rb}{^{86}Sr}\right)(e^{\lambda t} - 1)$$

or,

$$0.720 = 0.704 + 0.750\,(e^{(1.42 \times 10^{-11} \times t)} - 1)$$

or,

$$t = 1.48 \times 10^9$$

So, Age of the flow is 1.48×10^9 years . (answer).

67. **After decaying through 7 half life periods , the original amount of radioactive substance that reduces to an amount of $\frac{1}{64}$ g, is_________.**

➔ Let we consider, Original amount = X g. Number of half-life = 7.

Amount present = $\frac{1}{64}$ g.

So, $\frac{1}{64} = \frac{X}{2^7}$; X = 2 g

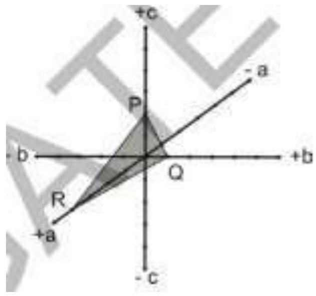
So, the original amount of radioactive substance = 2 g. (answer)

68. **Structure contours of a bedding plane at 100 m interval are spaced in such a manner that the horizontal equivalent is also 100 m. The dip of the bedding plane is_________.**

➔ Vertical distance = 100 m.
Horizontal distance = 100 m.

So, dip amount of the bedding plane = $\tan^{-1}\frac{100}{100} = 45^0$ (answer).

69. **In the figure given below, a, b and c are the crystallographic axes of a crystal. The Miller index of the crystal face PQR is________.**



➔ The face PQR intersect 'a' axis at 4 unit, 'b' axis at 1 unit, 'c' axis at 2 unit.

So, Weiss parameter = 4 1 2 .

reciprocal = $\frac{1}{4}\frac{1}{1}\frac{1}{2}$

So, Miller Index = (1 4 2). (answer).

70. **If $Fe^{2+} \rightarrow Fe^{3+} + e$, $E^0 = + 0.77$ Volt , Eh = 0.6 Volt, $K = \frac{[Fe^{3+}]}{[Fe^{2+}]}$ and the basic equation to be used is $Eh = E^0 + \frac{0.059}{n} \log K$, then the value of $\frac{Fe^{2+}}{Fe^{3+}}$ ratio in the solution is____________.**

➔ $E^0 = + 0.77$ Volt .

Eh = + 0.60 Volt.

$K = \frac{[Fe^{3+}]}{[Fe^{2+}]}$.

n = 1.

Now, from the equation,

$$Eh = E^0 + \frac{0.059}{n} \log K$$

or,

$$0.60 = 0.77 + 0.059 \log K.$$

or,

$$K = 1.3 \times 10^{-3}$$

Now, $K = \frac{[Fe^{3+}]}{[Fe^{2+}]}$

So, $\frac{Fe^{2+}}{Fe^{3+}} = \frac{1}{K} = 760.95$. (answer).

71. **Metal content (in metric tonnes) of an ore having specific gravity and assay values of 2.86 and 1.49 % respectively in a mining block 40 m long, 30 m wide and with an average thickness of 2.13 m is__________.**

➔ Length , wide and thickness of the ore body = 40 m, 30 m , 2.13 m respectively.
So, volume of the ore body = (40 × 30 × 2.13) m^3 = 2556 m^3.
Specific gravity = 2.86.
So, Reserve of the ore body = (2556 × 2.86) tonne = 7310.16 tonne.
Assay value = 1.49 %.
So, metal content of the ore body = $(\frac{1.49}{100} \times 7310.6)$ tonne = 108.9 tonne. (answer).

72. **A confined sandy aquifer has a thickness of 10 m and transmissivity of 0.75 m^2/day . Its hydraulic conductivity is_________m/day.**

➔ Aquifer thickness (b) = 10 m.
Transmissivity (T) = 0.75 m^2/day.
So, Hydraulic conductivity = $\frac{T}{b} = \frac{0.75}{10}$ m/day = 0.075 m/day. (answer).

73. **The standard free energy change (in KJ) at 25⁰C of the dissolution of anhydrite at equilibrium in the equation $CaSO_4 \rightarrow Ca^{2+} + SO_4^{4-}$, given K = 3.4 × 10^{-5} and R = 8.314 J/mol/K, is _________.**

➔ $CaSO_4 \rightarrow Ca^{2+} + SO_4^{4-}$
T = 25^0C = (273 + 25) K = 298 K.
K = 3.4 × 10^{-5} .
R = 8.314 J/mol/K .

So, ΔG^0 = — R T ln K = - [8.314 × 298 × ln (3.4 × 10^{-5})] J = 25.5 KJ. (answer).

74. **The S-wave velocity of a medium having a Poisson's ratio and a P-wave velocity of 0.5 and 3 km/s respectively is_________Km/s.**

➔ Poisson's ratio = 0.5.
V_P = 3 Km/s.
Let we consider V_s = X Km/s.

So, $\frac{3}{X} = \sqrt{\frac{(1 - 0.5)}{(0.5 - 0.5)}}$; X = 0 Km/s. (answer).

75. **If a radioactive isotope has a decay constant of 1.55 × 10^{-10} $year^{-1}$, its half-life (in years) would be______________.**

➔ Decay constant = 1.55 × 10^{-10} $year^{-1}$.
So, half-life = $\frac{\ln 2}{1.55 \times 10^{-10}}$ years = 4.47 × 10^9 years. (answer).

76. On a 1 : 10,000 scale map, the length of a fault trace on a horizontal plane is represented as 5 cm. The same on a 1 : 25,000 scale vertical aerial photograph is__________cm.

➔ Map scale = 1 : 10,000
Length of the fault plane on map = 5 cm.
So, Length of the fault plane on field = (5 × 10,000) cm = 50,000 cm.
Now, on a vertical aerial photograph, scale = 1 : 25,000.
So, Length of the fault plane on photograph = $\frac{50,000}{25,000}$ cm = 2 cm. (answer).

77. The void ratio (in percentage) of sandstone is 25. Its porosity in percentage is ________.

➔ Let we consider, Volume of void = V ; Volume of solid = S ; Total volume = T.
Void ratio = 25 %.

So,

$$\frac{V}{S} \times 100 = 25$$

or,

$$\frac{V}{(T - V)} = 0.25$$

or,

$$\frac{V}{T} \times 100 = 20$$

So, porosity of the sandstone = 20%. (answer) .

78. On a photo-scale of 1 : 40,000, a square shaped open cast coal mine of 1 Km^2 area would have an area of (in cm^2)___________.

➔ Scale = 1 : 40,000.
Area of the square shaped coal mine on field = 1 Km^2 .
So, area of the coal mine on photo = $\left(\frac{1 \times 10^5}{40,000}\right)^2$ cm^2 = 6.25 cm^2. (answer).

79. Specific discharge of 1 cm per day is observed in a porous medium where hydraulic head difference is 0.5 m and flow length is 20 m. Calculate the hydraulic conductivity (in m/day).

➔ Specific discharge (v) = 1 cm/day = 0.01 m/day.
Hydraulic head difference = 0.5 m.
Flow length = 20 m.
So, hydraulic gradient = $\frac{0.5}{20}$.

So, Hydraulic conductivity = $\frac{(0.01 \times 0.5)}{20}$ m/day = 0.4 m/day . (answer).

80. **A sandstone bed dipping 30° has an outcrop width of 20 m in a flat terrain. What is the true thickness (in m) of the bed?**

➔ True dip = 30^0 ; Outcrop width = 20 m.
So, True thickness = ($20 \times \sin 30^0$) m = 10 m . (answer).

81. **An analysis of augite yields 3 silicon atoms calculated on the basis of 12 oxygen atoms. If only Al replaces Si, calculate the number of tetrahedral-Al in the mineral.**

➔ Chemical formula of Augite based on 12 Oxygen basis = $(Ca, Mg)(Mg, Fe, Al)(Al, Si)_4O_{12}$
Now, Si occurs in tetrahedral co-ordination and Al replaces Si,
So, the Al, that replacing Si also occurs in tetrahedral co-ordination.
From the above formula it is clear that ,

Tetrahedral Si + Tetrahedral Al = 4

Now, the augite already yields 3 Si atoms.
So, Number of tetrahedral Al = (4 – 3) = 1 . (answer).

82. **Calculate the degree(s) of freedom of the assemblage orthopyroxene + clinopyroxene + plagioclase + hornblende + quartz + fluid in the chemical system $CaO–FeO–MgO–Al_2O_3–SiO_2–H_2O$ with pressure and temperature as physical variables.**

➔ Number of Phases (P) = 6.
Number of components (C) = 6.
Number of variables = 2.
Applying Phase rule,

Degree of freedom (F) = 6 + 2 – 6 = 2. (answer).

83. **If the dissociation constant of pure natural water at 50^0C is $10^{-13.10}$, the pH of the water will be_______________.**

➔ Dissociation constant (k_w) = $10^{-13.10}$.
Now, $k_w = [H^+] [OH^-]$; $[H^+] = [OH^-]$.
So, $k_w = [H^+]^2$; $[H^+] = \sqrt{k_w}$.
So, pH = $-\log \sqrt{k_w}$ = 6.55 . (answer).

84. **If the average crustal thickness is 35 Km and the height of a mountain is 5 Km above mean sea level, the crustal thickness based on Airy's model beneath the mountain will be approximately______________Km.**

➔ Crustal thickness (T) = 35 Km.
Height (h) = 5 Km.
Density of the crust = 2700 Kg/m^3.
Density of the mantle = 3300 Kg/m^3.
So, crustal thickness beneath the mountain = $\frac{(2700 \times 5)}{(3300 - 2700)}$ Km = 22.5 Km.

(answer)

IIT – JAM

Numerical Solutions
(2015 – 2019)

Contents

IIT - JAM (2015)

Indian Institute of Technology Guwahati

1. **On a toposheet of 1 : 50,000 scale, the distance between upper and lower traces of a bed is 5 cm. The actual distance on ground in kilometres is________.**

➔ Scale of the toposheet = 1 : 50,000 .
Distance between upper and lower traces of a bed on toposheet = 5 cm.

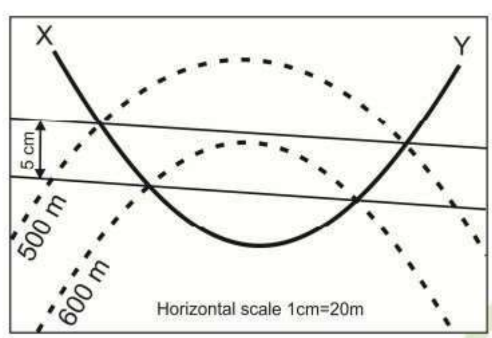
So, The actual distance on ground = (50,000 × 5) cm = 2,50,000 cm= 2.5 km. (answer).

2. **On a flat topography the outcrop width of a bed is 30m. If the true dip of the bed is 30^o , the actual thickness of the bed in meters is_______.**

➔ Outcrop width of the bed (W) = 30m.
True dip of the bed (θ) = 30^0.

So, True thickness of the bed (T) = W × Sin θ = (30 × Sin 30^0) m = 15 m. (answer).

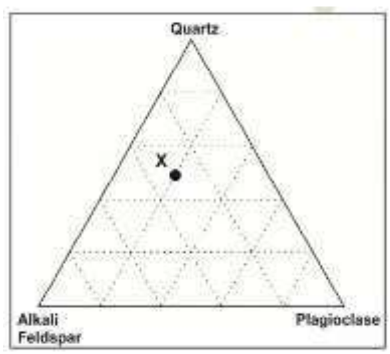
3. **In the given map the true dip (in degree) of the bedding plane X – Y is________.**



➔ Contour interval / vertical distance = (600 – 500) m = 100 m.
Horizontal scale of the map : 1 cm = 20 m
Horizontal distance = 5 cm. = (5 × 20) m = 100 m.

So, True dip (in degree) = $\tan^{-1}\frac{100}{100} = 45^0$. (answer).

4. In the given diagram, the percentage of Plagioclase in a rock of composition 'X' is__________.

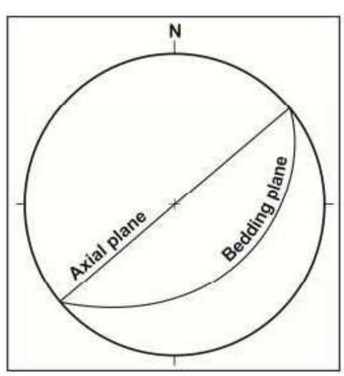


➔ From the given diagram, the percentage of plagioclase in a rock of composition 'X' is 20 %.

5. The birefringence of a uniaxial mineral having refractive indices of 1.658 and 1.486 is___________.

➔ Uniaxial mineral having refractive indices of 1.658 and 1.486 .
So, birefringence of the mineral = (1.658 – 1.486) = 0.172. (answer).

6. In the given stereoplot, the plunge amount of the fold axis is__________.



➔ From the figure it is observed that the bedding plane intersect the axial plane at the periphery.
So, Plunge amount of the fold axis = 0^0 . (answer).

7. A crystal face has the following intercepts for the crystallographic axes : $1a_1$, $1a_2$, $\frac{1}{2}a_3$, ∞c. The Miller – Bravais indices for the face is___________.

➔ Crystal face intersects the crystallographic axes : $1a_1$, $1a_2$, $\frac{1}{2}a_3$, ∞c.

So, Weiss symbol = $1 \; 1 \; \frac{1}{2} \; \infty$.

Reciprocal = $\frac{1}{1} \; \frac{1}{1} \; \frac{2}{1} \; \frac{1}{\infty}$.

So, Miller – Bravais indices = (1 1 2 0) . (answer).

8. Total number of mirror planes in the $\frac{4}{m}3\frac{2}{m}$ point group is _________.

➔ This point group belongs to isometric crystal system.
So, It has 3 mirror planes perpendicular to 3 tetrad and 6 mirror planes perpendicular to 6 diad.
So, Total number of mirror planes in this point group = (6 + 3) = 9. (answer).

9. A radioactive isotope has 1024 atoms. How many atoms will remain after 4 half-lives?

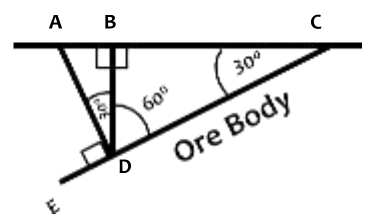
➔ Number of radioactive isotope = 1024 atoms.
So, after 4 half – lives remaining atoms = $\frac{1024}{2^4}$ = 64 atoms. (answer).

10. Waste water discharged from a coal mine has hydrogen ion $[H^+]$ concentration of 10^{-6} moles/liter. The pH of the water is__________.

➔ Concentration of $[H^+]$ ion = 10^{-6} .
So, pH = $-\log_{10}[H^+] = -\log_{10}10^{-6} = 6$. (answer).

11. An ore An ore body is dipping 30° towards west on a flat topography. At what distance (in meters) should a borehole be placed so that it intersects the ore body perpendicularly at a vertical depth of 70 meters?

➔ Dip of the ore body = 30^0.
Borehole intersects the ore body perpendicularly at a vertical depth of 70 m.
In triangle BCD, BD = 70 m, BCD = 30^0 .
So, BC = $\frac{70}{\tan 30^0}$ = 121.24 m.



Again, if, ADE = 90^0 ; BDC = 60^0 ; CDE = 180^0.
So, ADB = CDE – (ADE + BDC) = { 180^0 – (90^0 + 60^0)} = 30^0 .
Now, in triangle ABD, BD = 70 m, ADB = 30^0.
So, AB = 70 × tan 30^0 = 40.41 m.
So, AC = AB + BC = (121.24 + 40.41) m = 161.65 m.
So, The distance at which the borehole should be placed s= 161.65 m. (answer).

12. Using the phase rule, the maximum number of phases in a 3 component geological system having 1 degree of freedom is_______.

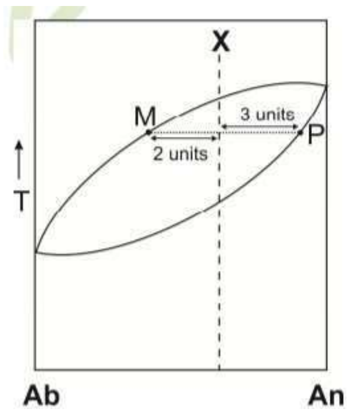
➔ Number of component (C) = 3.
Degree of freedom (F) = 1.
So, Number of phases (P) = C + 2 – F = (3 + 2 – 1) = 4. (answer).

13. The lithostatic pressure in Mega Pascal (MPa) at a depth of 10 km in a granite batholith having density 2700 kg/m³ is_________. (Acceleration due to gravity = 9.8 m/s²)

➔ Depth (h) = 10 Km = 10000 m.
Density (ρ) = 2700 Kg/m^3 .
Acceleration due to gravity (g) = 9.8 m/s^2 .

So, pressure at that depth (P) = (10000 × 2700 × 9.8) Pa = 264600000 Pa = 264.6 MPa. (answer).

14. In the given phase diagram, the weight percent of melt at point 'M' for a crystallizing magma of bulk composition 'X' is__________.



➔ Applying level rule,

The weight % of melt at point 'X' = $\frac{3}{(3+2)} \times 100$ = 60 %. (answer).

15. Calculate the average atomic weight (answer to be given up to 3 decimal places) of Rubidium using the given data.

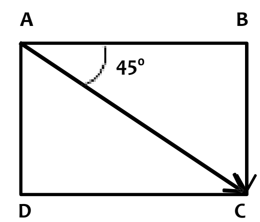
Isotope	Abundance (%)	Atomic weight (a.m.u.)
^{85}Rb	72.17	84.912
^{87}Rb	27.83	86.909

➔ In case of ^{85}Rb : atomic mass = 84.912 ; abundance = 72.17 % .
In case of ^{87}Rb : atomic mass = 86.909 ; abundance = 27.83 %.

So, calculated atomic weight of Rb = $\frac{(84.912 \times 72.17) + (86.909 \times 27.83)}{(72.17 + 27.83)}$ amu .

= 85.467 amu. (answer).

16. In an oblique slip fault having 30° dip, the net slip is 10 meters at an angle of 45° to the strike of the fault plane. The dip slip component of the fault in meters is__________.(Answer to be given up to 2 decimal places).



➔ Net slip of the fault (AC)= 10 meter.
Angle between net slip and strike (CAB) = 45^0 .

So, dip slip component of the fault (BC) = AC Sin 45^0.
= ($10 \times \sin 45^0$) m.
= 7.07 m. (answer).

17. A 10 cm³ sandstone block has a mass of 20 grams. If the average density of sand grains is 2.5 g/cm³, the porosity (in percent) of the sandstone is_________.

➔ Volume of the sandstone block (V_T) = 10 cm^3.
Mass of the sandstone block (M) = 20 grams.
Density of the sand grains (ρ) = 2.5 g/cm^3 .
So, Volume of the grains (V_S) = $\frac{20}{2.5}$ cm^3 = 8 cm^3.
So, Volume of pore spaces (V_V) = (10 – 8) cm^3 = 2 cm^3 .
So, Porosity of the sandstone = ($\frac{2}{10} \times 100$) % = 20 %. (answer).

18. A mineral has a weight of 4.5 grams in air and 3.2 grams in water. Assuming density of water to be 1g/cm³, the specific gravity (up to 2 decimal places) of the mineral is__________.

➔ Weight of the mineral in air (W_1) = 4.5 grams.
Weight of the mineral in water (W_2) = 3.2 grams.
Density of the water (ρ_w) = 1 gm/cm^3 .

So, specific gravity of the mineral = $\frac{4.5}{(4.5-3.2)} \times 1$ = 3.46. (answer).

19. The duration of the Proterozoic Eon in Ma is_________.

➔ End of Archaean = 2500 Ma.
Begin of Paleozoic = 541 Ma.
So, duration of Proterozoic = (2500 – 541) Ma. = 1959 Ma. (answer).

20. From the given equation, calculate how many moles of magnetite will be produced by the reduction of 1 (one) mole of hematite (answer to be given up to 3 decimal places).

$$6Fe_2O_3 \rightarrow 4Fe_3O_4 + O_2$$

➔ From the above equation it is observed that,4 moles of Magnetite (Fe_3O_4) will be produced from 6 moles of Hematite (Fe_2O_3) .
So, $\frac{4}{6}$ = 0.666 moles of Magnetite will be produced by the reduction of 1 mole of Hematite.

IIT – JAM (2016)

Indian Institute of Technology Madras

1. Based on the ideal end member formula of diopside, the mole proportion (%) of CaO for plotting the mineral on a CaO-MgO-SiO_2 triangular diagram is________.

➔ Diopside formula = $(Ca, Mg)Si_2O_6 = CaO + MgO + 2SiO_2$.
So, Diopside = 1 mole CaO + 1 mole MgO + 2 mole SiO_2 .
So, mole proportion of CaO = $(\frac{1}{4} \times 100)$ % = 25 % . (answer).

2. The phi (φ) value of a sediment particle having 4 mm diameter is________.

➔ Diameter of the particle = 4 mm.
So, phi value of the particle = $-\log_2 4 = -2$. (answer).

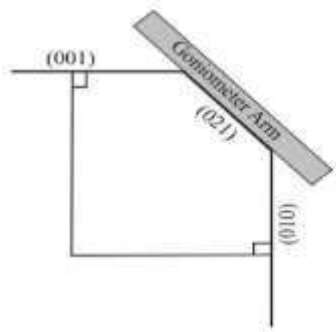
3. Calcite, quartz, wollastonite and CO_2 fluid were present in equilibrium during the formation of a calc-silicate rock. In the chemical system CaO–SiO_2–CO_2 , the degree of freedom of this assemblage is________.

➔ Number of phases = 4.
Number of components = 3.
So, degree of freedom = (3 + 2 – 4) = 1. (answer).

4. Weight of a 10 cm^3 medium grained sandstone block with 20 % (v/v) porosity, in dry state is 26 g. The density of the block when fully saturated with water is____________g/cm^3.

➔ Volume of a medium grained sandstone = 10 cm^3.
Weight in dry state = 26 g.
Porosity = 20 %.
Density of water = 1 g/cm^3 .
So, volume of voids = $(\frac{20}{100} \times 100)$ cm^3 = 2 cm^3 .
This volume is yield by water when fully saturated.
So, weight of water = (2 × 1) g = 2 g.
So, weight of the sandstone when fully saturated = (26 + 2) g = 28 g.
So, density of the sandstone block when fully saturated = $(\frac{28}{10})$ g/cm^3 = 2.8 g/cm^3 . (answer).

5. In the following figure, the exterior angle measured between (001) ∧ (021) with a goniometer in a crystal is 40^0. The interior angle between (010) ∧ (021) in degrees is_______.



➔ Exterior angle between (001) ∧ (021) = 40^0 .
According to law to constancy of interfacial angle,
the interior angle between (010) ∧ (021) = 140^0. (answer).

6. If the elevation of a wave cut platform is 55 m above the sea level and the age of the erosional surface is 120 kilo years, the rate of rock uplift at this coastal location is ________m/kilo years (give answer in two decimal places).

➔ Elevation of the wave cut platform = 55 m.
Age of the erosional surface = 120 kilo years.
So, rate of rock uplift at this coastal location = $(\frac{55}{120})$ m/kilo years = 0.46 m/kilo years. (answer).

7. A foliation plane has strike 025^0 and 60^0 easterly dip. A mineral lineation on this foliation plane has a rake/pitch of 90^0. The plunge direction of the mineral lineation in whole circle bearing is ________________degrees.

➔ Strike of the foliation plane = 025^0; dip = 60^0 easterly.
Pitch of the mineral lineation = 90^0 .
So, plunge direction of the lineation = $(90^0 + 25^0) = 115^0$. (answer).

8. Two outcrops on a 1 : 25000 map are 12 cm apart. The ground distance between the two outcrops is_________km.

➔ Scale of the map = 1 : 25,000.
Distance on map = 12 cm.
So, distance on field = (12 × 25,000) cm = 3,00,000 cm = 3 km. (answer).

9. Fine muds are deposited at a rate of 1 cm per 1000 y. Assuming constant sedimentation rate and absence of compaction, a 1 km thick sequence would be deposited in _______million years.

➔ Rate of deposition = 1 cm/1000 year.
Thickness of the sequence = 1 km = 10^5 cm.
Constant sedimentation rate.
So, time for deposition = (1000 × 10^5) years = 100 million years. (answer).

10. B and B′ are two points on the topographic map shown below. The distance between B and B′ along the linear traverse BB′ is 220m. The angle of the slope along this traverse is _________ degree (give answer in two decimal places).

➔ Linear transverse between B and B′ = 220 m.
Contour interval / vertical distance = (200 – 120) m = 80 m.
So, angle of the slope along the transverse = $\sin^{-1}\frac{80}{220} = 21.32^0$. (answer).

11. The half-life of a radionuclide A is double that of a radionuclide B. The fraction of A remaining when B is reduced to 1/64 is__________. (Give answer in three decimal places).

➔ $T_{1/2}$ of A = 2 * $T_{1/2}$ of B.
B is reduced to 1/64 ; so required half-life = 6.
So, when B is reduced to 1/64, A suffered 3 half-lives.
So, remaining fractions of A = $\frac{1}{2^3}$ = 0.125. (answer).

12. The total metal content of a mineable 40m × 40m × 3m ore block having bulk density 2.75 g/cm^3 and assay value 1.5 wt % Cu is_________metric tonnes.

➔ Dimensions of the ore block = 40m × 40m × 3m.
So, volume of the ore = (40 × 40 × 3) m^3 = 4800 m^3.
Bulk density = 2.75 g/cm^3 = 2750 Kg/m^3.
So, reserve of the ore = (4800 × 2750) Kg = 13200000 Kg.
Assay value = 1.5 wt%.
So, metal content = ($\frac{1.5}{100}$ × 13200000) Kg = 198000 Kg = 198 metric tonne. (answer).

13. The temperature at the Earth's surface is 25^{0}C. The temperature at the base of the Earth's crust (30 Km thick), if the geothermal gradients are 25^{0}C/km up to 15 Km depth and 15^{0}C/Km further down, is _______^{0}C.

➔ Temperature at the surface of the earth = 25^{0}C.
Geothermal gradient = upto 15 Km 25^{0}C and upto rest 15 Km 15^{0}C.
Total thickness = 30 Km.
So, temperature at the base of the earth crust = 25 + (25 × 15) + (15 × 15) ^{0}C = 625^{0}C. (answer).

14. A melt in the binary system $MgO–SiO_2$ contains 89.92 wt% SiO_2. If all the magnesium is consumed to form enstatite ($MgSiO_3$), how many moles of this mineral will crystallize from 100 grams of the melt? Give answer in two decimal places.

(Molecular weight : MgO = 40.3, SiO2 = 60.1)

➔ $MgO + SiO_2 = MgSiO_3$

So, from the equation it is clear that , 1 mole MgO is consumed to form 1 mole $MgSiO_3$.

Now, 1 mole MgO = 40.3 gm MgO.

In the melt, Wt % of SiO_2 = 89.92 %

So, Wt % of MgO = (100 – 89.92) % = 10.08 %.

Now, 40.3 gm of MgO is consumed to form 1 mole $MgSiO_3$.

So, 10.08 gm of MgO is consumed to form = $(\frac{1}{40.3} \times 10.08)$ mole $MgSiO_3$ = 0.25 mole $MgSiO_3$.

So, 0.25 mole of $MgSiO_3$ will crystallize from 100 grams of the melt. (answer).

15. A lherzolite xenolith from the mantle contains 50 volume % olivine, the rest being equal proportions of orthopyroxene and clinopyroxene. If the densities of the minerals are (in g/cc) olivine = 3.42, orthopyroxene = 3.28 and clinopyroxene = 3.46, the bulk density of the xenoliths in g/cc is_______. *(Give answer in two decimal places).*

➔ Xenolith contains 50 % Olivine and 50 % Orthopyroxene & Clinopyroxene.

Density of Olivine = 3.42 g/cc .

Density of Orthopyroxene = 3.28 g/cc .

Density of Clinopyroxene = 3.46 g/cc .

So, bulk density of the xenolith = $[\frac{(50 \times 3.42)}{100} + \frac{(3.28 + 3.46)}{2} \times \frac{50}{100}]$ g/cc = 3.39 g/cc. (answer).

16. The SiO_2 value, recalculated on volatile free basis, of the rock whose major oxide (wt%) composition given below is________. (Give answer in two decimal places).

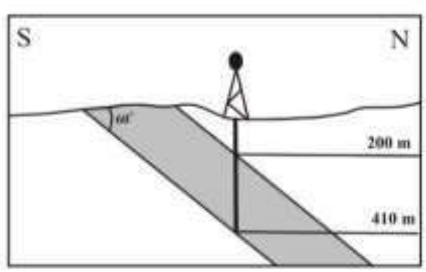
➔ Major oxide composition in the list = SiO_2.

SiO_2 value = 45.58.

Total Value = 95.72.

So, Wt % of SiO_2 recalculated on volatile free basis = $\left(\frac{45.58}{95.72} \times 100\right)$ % = 47.62 %. (answer).

17. As Shown in the following figure, a vertical well intersects the top and bottom of an inclined bed at 200 m and 410 m depths, respectively. If the true dip of the bed is 60^0 to the north, the true thickness of the bed is___________meters.



➔ Vertical wall intersects top and bottom of an inclined bed at 200m and 410m respectively.

So, AC = (410 – 200) m = 210 m.

True thickness of the bed = AB.

True dip of the bed = 60^0.

So, DCE = 60^0 (similar angle) ; ACD = 90^0.

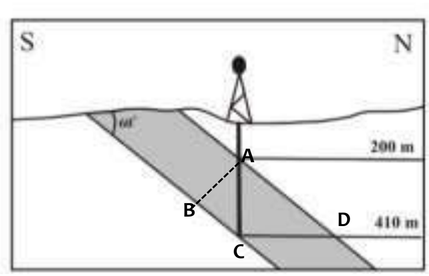
So, ACB = $[180^0 – (90^0 + 60^0)] = 30^0$.

Now, in triangle ABC,

$$\frac{AB}{AC} = \text{Sin } 30^0$$

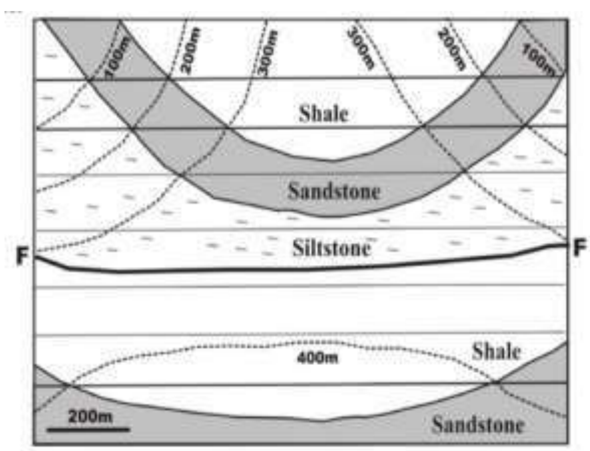
or,

$$AB = (210 \times 0.5) = 105$$



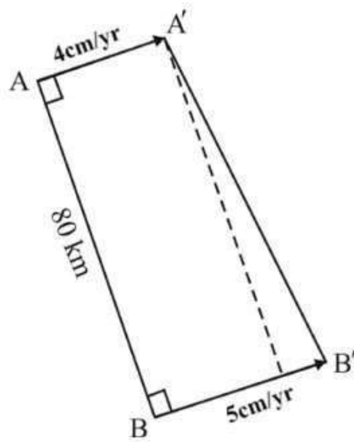
So, true thickness of the bed is 105 m. (answer).

18. In the given geologic map, the horizontal lines are stratum contours. The throw on the fault (F-F) is__________meters.

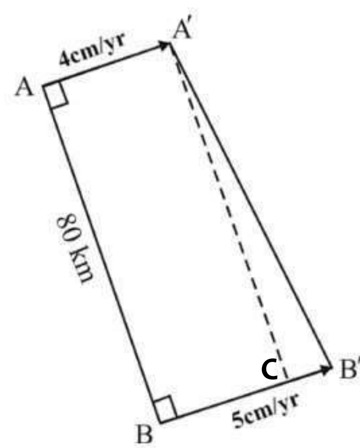


➔ If the fault was not occurred then the sandstone – shale contact was at 800 m contour.
But due to fault it occurs at 400 m.
So, throw of the fault (F – F) = (800 – 400) m = 400 m. (answer).

19. Two localities A and B on a continental plate as shown in the figure below, are separated by a distance of 80 km. The plate velocities measured at A and B are 4 cm/year and 5 cm/year, respectively. Assuming no faulting in the area, the new distance between A and B will be ____________km in one million years. *(Give answer in two decimal places)*.



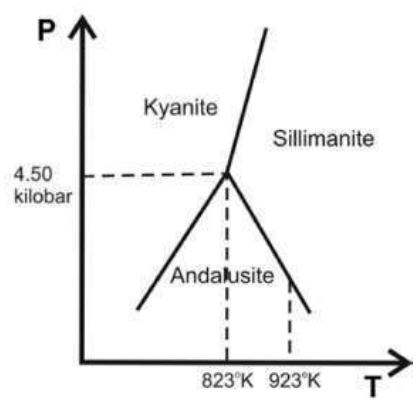
➔ Velocity of plate A = 4 cm/year.
Velocity of plate B = 5 cm/year.
So, after 1 Ma, A – A′ = (4×10^6) cm = 40 Km.
B – B′ = (5×10^6) cm = 50 Km.



Distance between two plates AB = 80 Km.
So, A′C = 80 Km . (AB || A′C).
B′C = (50 – 40) Km = 10 Km.

Now, in triangle A′CB′, A′C = 80 Km ; B′C = 10 Km ; A′CB′ = 90^0.
So, A′B′ = $\sqrt{(802 + 102)}$ = 80.62 .
So, after 1 ma the new distance between A and B is 80.62 Km. (answer).

20. In the following schematic diagram, the aluminosilicate triple point is located at the pressure of 4.50 Kbar and temperature of 823^0K. If the reaction andalusite = sillimanite has negative slope with a value of –18.22 bar/^0K, the pressure of the reaction at 923^0K is _________Kbar. (give answer in two decimal places).



(Figure not to scale)

➔ Pressure at 823^0K = 4.50 Kbar = 450 bar.

Let we consider, Pressure of the reaction at 923^0K = X bar.

Slope = – 18.22 bar/^0K .

So, ΔP = (X – 450) bar ; ΔT = (923 – 823) K = 100 K.

So, from Clapeyron equation,

$$\frac{(X - 450)}{100} = -18.22$$

or,

$$X = 2678 \text{ bar} = 2.678 \text{ Kbar.}$$

So, pressure of the reaction at 923K is 2.678 Kbar. (answer).

IIT - JAM (2017)

Indian Institute of Technology Delhi

JOINT ADMISSION TEST FOR M.SC. – 2017

IIT – Delhi

1. An object is spotted at $S60^0E$ front bearing from the observer. If the position is interchanged, the front bearing value in degree from north (measured clockwise) is_______.

➔ Front bearing = $S60^0E$.
If the position is interchanged then the value of front bearing = $N60^0W$.
So, the front bearing value in degree from north (measured clockwise) is 300^0. (answer).

2. The mole% of forsterite component in olivine with chemical formula $Mg_{1.8}Fe_{0.2}SiO_4$ is_____.

➔ Forsterite = Mg_2SiO_4 .
Given composition of olivine = $Mg_{1.8}Fe_{0.2}SiO_4$.
So, mole% of forsterite = $(\frac{1.8}{2} \times 100)$ % = 90 %. (answer).

3. The Weiss symbol of a crystal face is 4a : 2b : c . The value of h in the corresponding Miller index (hkl) is______.

➔ Weiss symbol = 4a : 2b : c .
So, the face cuts the 'a' axis at 4 units, 'b' axis at 2 units, 'c' axis at 1 unit.
So, reciprocal = $\frac{1}{4}$, $\frac{1}{2}$, 1 .
So, Miller index = (1 2 4).
So, the value of h in the face (hkl) = 1. (answer).

4. In a mineral with chemical formula AT_4O_8, the ionic radii of A and O are 1.12 A^0 and 1.40 A^0, respectively. The co-ordination number of cation A is____________.

➔ Mineral composition = AT_4O_8 .
Ionic radii of A = 1.12 A^0; B = 1.40 A^0.
So, $r_{(cation/anion)} = \frac{1.12}{1.40} = 0.8$.
So, co-ordination number of cation A = 8. (answer).

5. Aluminium (Al) can occur in both tetrahedral and octahedral co-ordination in silicates. The amount of octahedral Al n a pyroxene crystal of composition $Mg_{1.4}Fe_{0.4}Al_{0.4}Si_{1.8}O_6$ is ________. (give answer in one decimal place).

➔ Given pyroxene composition = $Mg_{1.4}Fe_{0.4}Al_{0.4}Si_{1.8}O_6$.
Tetrahedral Si can only be replaced by tetrahedral Al.
Pyroxene is a single chain inosilicate.
So, Si : O = 1 : 3.
So, in the given formula 2 mole Si have to be present, but here it is 1.8.
So, number of tetrahedral Al = (2 – 1.8) = 0.2.
Total number of Al given = 0.4.
So, number of octahedral Al = (0.4 – 0.2) = 0.2 . (answer).

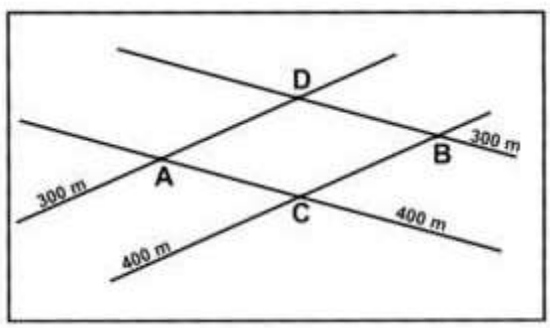
6. The birefringence of a mineral of thickness 30 μm and retardation 0.27 μm is___________. (Give answer in three decimal place).

➔ Thickness = 30 μm.
Retardation = 0.27 μm.
So, Birefringence = $\frac{0.27}{30}$ = 0.009 . (answer).

7. Two limbs of a vertical chevron fold strike S70^{0}E and N55^{0}E . The value of the interlimb angle of the fold is_________^{0}.

➔ Strike of two limbs of a vertical chevron fold = S70^{0}E (110^0) and N55^{0}E (55^0) .
So, interlimb angle of the fold = (110^0 – 55^0) = 55^0. (answer).

8. The schematic map given below shows intersecting strike lines of the same lithological contact. In the map AB and CD are 5 cm and 3.5 cm respectively. The scale of the map is 1 cm = 100 m. The plunge of the fold axis is________degree. (Give answer in one decimal place).

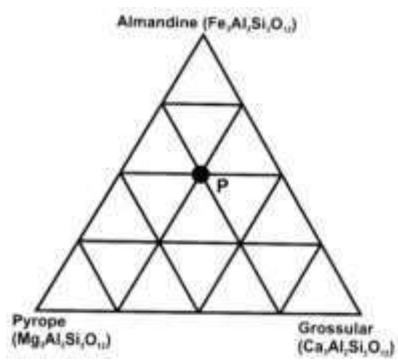


➔ AB = 5 cm.
CD = 3.5 cm.
Scale of the map : 1 cm = 100 m.
So, Horizontal distance (CD) = 350 m.
Vertical drop = 100 m.
So, plunge amount of the fold axis = $\tan^{-1}\frac{100}{350} = 15.9^0$. (answer).

9. The core-rim composition of a normally zoned plagioclase crystal are as follows :
Core : $Ca_{0.6}Na_x Al_{1.6}Si_{2.4}O_8$ Rim : $Ca_{0.4}Na_y Al_{1.4}Si_{2.6}O_8$
The amount of increase of Na atom from core to rim per formula unit of plagioclase is _____(give answer in one decimal place).

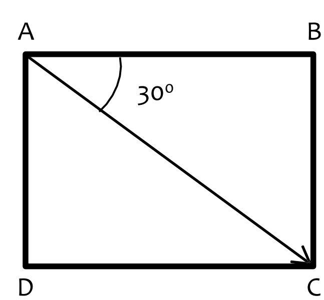
➔ Total number of atoms in core = (0.6 + x + 1.6 + 2.4 + 8) = 12.6 + x.
Total number of atoms in rim = (0.4 + y + 1.4 + 2.6 + 8) = 12.4 + y.
Number of atoms are equal for both core and rim,
So,
$12.6 + x = 12.4 + y$
or,
$y – x = 0.2$
So, The amount of increase of Na atom from core to rim = 0.2. (answer).

10. Considering garnet chemical formula in 12 oxygen basis, the number of Mg cations in a garnet of chemical composition P (as shown in the figure) is______________. (give answer in two decimal places).



➔ Almandine garnet = Fe – garnet.
Pyrope garnet = Mg – garnet.
Grossular garnet = Ca –garnet .
So, from the figure,
P = 25 % pyrope garnet , 25 % grossular garnet and 50 % almandine garnet.
In composition P,
Fe + Ca + Mg = 3.
So, number of Mg cations in composition P = $(\frac{25}{100} \times 3) = 0.75$. (answer).

11. A fault surface in an outcrop has slickenside lineation whose pitch is 30^0 . The horizontal slip on the fault is 1.25 m, as determined from displaced vein. The net slip of the fault is _________ meter. *(give answer in two decimal places).*



➔ Pitch of the lineation (BAC) = 30^0.
Horizontal slip (AB) = 1.25 m.
So, net slip (AC) = $\frac{1.25}{\cos 30^0}$ m = 1.44 m. (answer).

12. In an outcrop, we find a belemnite fossil broken into five rectangular pieces (boudins) of equal size. Long dimension of each boudin is 1.35 cm. Gap between adjacent boudins in all cases is 0.25 cm. Note that the long dimensions of boudins are perfectly aligned. The % of elongation is___________. *(Give answer in one decimal places).*

➔ Total length of the fossil = (1.25 × 5) cm = 6.25 cm.
After elongation, total length of the sample = 6.25 + (0.25 × 4) cm = 7.25 cm.
So, the percentage of elongation = $[\frac{(7.25 - 6.25)}{6.25} \times 100]$ % = 16 %. (answer).

13. A horizontal cylindrical ore body (diameter = 20 m, length = 200 m) has 5 % metal content and density of 3500 kg/m^3 . The reserve of the ore body is___________million tons. (Give answer in two decimal places).

➔ Diameter = 20 m ; radius = 10 m.
Length = 200 m.
So, volume of the cylindrical ore body = $(\pi \times 10^2 \times 200)$ m^3 = 62857.142 m^3.
Density of the ore body = 3500 Kg/m^3 .
So, reserve of the ore body = (62857.142 × 3500) Kg = 2,20,000,000 Kg

= 0.22 million tons. (answer)

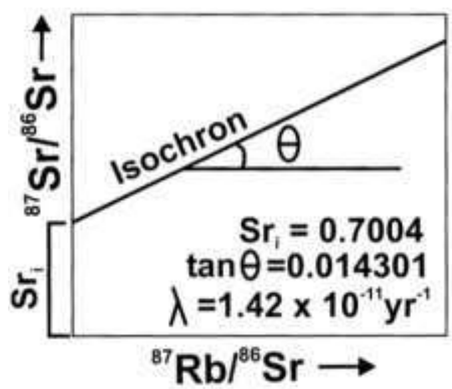
14. A drainage basin of 4^{th} order covers an area of 40 sq. km. Within the basin, total length of 1^{st} order drainage basin is 12.5 km, 2^{nd} order drainage is 8.8 km, 3^{rd} order drainage is 4.7 km and 4^{th} order drainage is 4.0 km . The drainage density of the basin is________km^{-1}. (Give answer in two decimal places).

➔ Total length of drainage = (12.5 + 8.8 + 4.7 + 4.0) km = 30 km.
Total area of the basin = 40 km^2.
So, drainage density of the basin = $\frac{30}{40}$ km^{-1} = 0.75 km^{-1}. (answer).

15. Age of granitic rocks can be determined using Rb – Sr whole rock radioactive dating method and the following age equation,

$(^{87}Sr/^{86}Sr) = (^{87}Sr/^{86}Sr)_i + (^{87}Rb/^{86}Sr)(e^{\lambda t} - 1)$

For a suite of representative co-magmatic granitic rocks, the Rb – Sr whole rock isochron plot and relevant data are shown in the diagram . The age of granite is calculated at _______ Ga . (1 Ga = 10^9 years) (Give answer in one decimal place).



➔ Slope of isochron = tan θ = 0.014301.

Decay constant = $1.42 * 10^{-11}$ $year^{-1}$.

From the given formula slope of the isochron = $(e^{\lambda t} - 1)$

So,

$(e^{\lambda t} - 1) = 0.014301.$

or,

t = 999979246.5 years = 0.9 Ga.

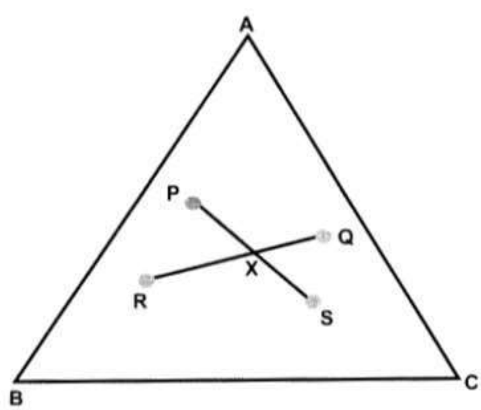
So, the age of the granite calculated is 0.9 Ga. (answer).

16. Consider a granulite facies of metamorphic rock with peak metamorphic condition at 9 kbar, 850^0C. Assume a single layer crust of ρ = 3000 Kg/m^3 and g = 10 m/s^2 during metamorphism. The depth of burial during peak metamorphism is km. (1 Pa = 1 $kg/m/s^2$ and 1 bar = 10^5 Pa).

➔ Pressure = 9 kbar = 9×10^8 Pa.
Density = 3000 kg/m^3.
Acceleration due to gravity = 10 m/s^2.

So, depth of burial during peak metamorphism = $\frac{9 \times 108}{(3000 \times 10)}$ km = 30 km. (answer).

17. Consider four minerals P, Q, R and S in a three component chemical system (A – B – C) as shown in the figure. For aa crossing tie-line relationship, the variance (degree of freedom) of the equilibrium mineral assemblage at X is__________.



➔ Number of phases = 4.
Number of components = 3.
So, degree of freedom at X = (3 + 2 – 4) = 1. (answer).

18. **The refractive indices of four minerals (P, Q, R, S) are as follows :**

P (α = 1.712 , β = 1.721 , γ = 1.727),

Q (ε = 1.553 , ω = 1.544),

R (α = 1.664 , β = 1.672 , γ = 1.694) and

S (ε = 1.486 , ω = 1.658)

The value of maximum birefringence among all the minerals is__________(Give answer in three decimal places).

➔ In case of mineral P,

birefringence = (1.727 – 1.712) = 0.015.

In case of mineral Q ,

birefringence = (1.553 – 1.544) = 0.009.

In case of mineral R,

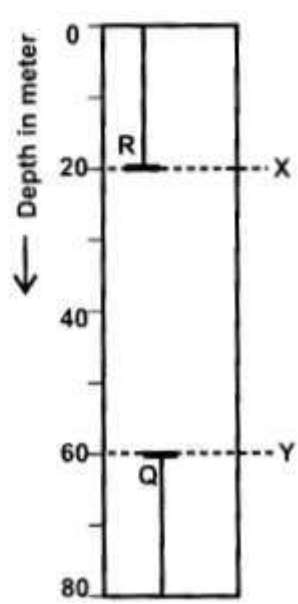
birefringence = (1.694 – 1.664) = 0.030.

In case of mineral S,

birefringence = (1.658 – 1.486) = 0.172.

So, the value of maximum birefringence among all the minerals is 0.172. (answer).

19. **In a sedimentary succession shown in the figure, the last occurrence of fossil species Q (dated 50 Ma) and the first occurrence of the fossil species R (dated 30 Ma) are recorder at Y and X, respectively. The estimated rate of sedimentation is___________m/million years. (assume constant rate of sedimentation).**



➔ Last occurrence of fossil species, Q = 50 Ma.
First occurrence of fossil species, P = 30 Ma.
So, age difference = (50 – 30) Ma = 20 Ma.
From the figure, difference in depth of sedimentation, (Y – X) = (60 – 20) m = 40 m.
So, rate of sedimentation = $\frac{40}{20}$ m/million years = 2 m/million years. (answer).

20. The top surface of a coal seam is exposed at 150 m contour level on a hilltop at location A. The same surface of the seam is also exposed on a river bed at location B at the 50 m contour level. The aerial distance A – B is 1 km. The amount of dip of the coal seam along A – B is _________(degree). (Give answer in one decimal place).

➔ Vertical drop / contour distance = (150 – 50) m = 100 m.

Horizontal distance = 1 km = 1000 m.

So, dip of the coal seam = $\tan^{-1}\frac{100}{1000} = 5.7^0$.

IIT - JAM (2018)

Indian Institute of Technology Bombay

1. When plotted on a map of 1:50000 scale, a 2 km long dyke exposed on a horizontal surface has a length of_________cm. (answer in one decimal place).

➔ Scale of the map = 1 : 50000.
Length of the dyke of the field = 2 km = 2×10^5 cm.
So, Length of the dyke on map = $\frac{2 \times 105}{50000}$ cm = 4 cm. (answer).

2. The valency of iron in hematite is______.

➔ Chemical formula of hematite = Fe_2O_3.
So, valency of iron in hematite = 3. (answer).

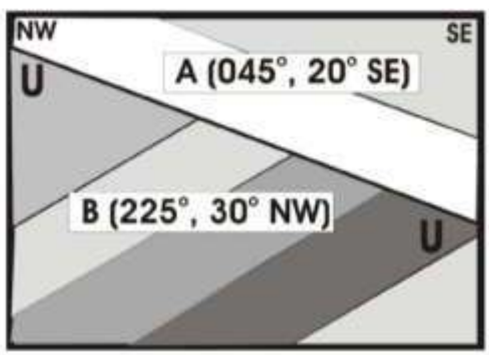
3. A crustal rock is at a lithostatic pressure of 3 kbar and a temperature of 275ºC. If the lithostatic pressure increases at a uniform rate of 0.3 kbar/km, and the surface temperature is 25ºC, the geothermal gradient (in ºC/km) is . (answer in one decimal place).

➔ Lithostatic pressure increases at a uniform rate of 0.3 kbar/km.
So, the depth at which the pressure is 3 kbar = $\frac{0.3}{3}$ km = 10 km.
Temperature at 10 km = 275^0C.
Surface temperature = 25^0C.
So, geothermal gradient = $\frac{(275 - 25)}{10}$ ^{0}C/km = 25^0C/km. (answer).

4. The absolute difference in the Moh's hardness values of the two silicates among the minerals listed below is______.
Apatite, Corundum, Gypsum, Talc, Topaz

➔ Silicate mineral with lowest hardness in the list = Talc (Hardness = 1).
Silicate mineral with highest hardness in the list = Topaz (Hardness = 8).
So, The absolute difference in the Moh's hardness values of the two silicates among the minerals listed = (8 – 1) = 7. (answer).

5. **Attitudes of beds in sequences A (younger) and B (older), separated by an unconformity UU, are given in the following sectional view. If UU was horizontal when sequence A was deposited, the dip amount of beds in sequence B at that time was (answer in one decimal place).**

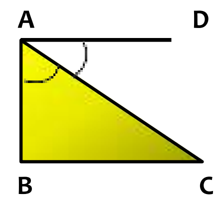


➔ Current dip of Bed A = 20^0 ; B = 30^0 .
Now, If the unconformity is horizontal, the A bed is also horizontal.
So, Dip of the B bed when the unconformity is horizontal = ($30^0 + 20^0$) = 50^0. (answer).

6. **The number of alpha (α) particles emitted to produce a daughter isotope of ^{206}Pb from a parent isotope of ^{238}U by radioactive decay is____________.**

➔ $^{238}U \rightarrow {}^{206}Pb$.
Emission of 1 alpha particles reduces Mass number by 4.
Here, the reduction of Mass number = (238 – 206) = 32.
So, number of alpha particles emitted is $= \frac{32}{4} = 8$. (answer).

7. The dip slip on a fault 000º, 30ºE is 10 m. Assuming slip equals separation here, the throw on the fault is______m (answer in one decimal place).



➔ Dip of the fault (DAC) = 30^0.
So, Hade of the fault (BAC) = $(90^0 – 30^0) = 60^0$.
Dip slip of the fault (AC) = 10 m.
So, throw of the fault (AB) = $(10 * \text{Cos } 60^0)$ m = 5 m. (answer).

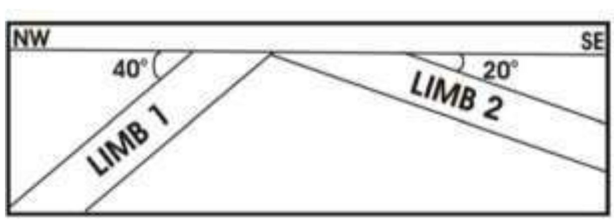
8. A continuous 10 m thick sequence of shale was deposited in 10,000 years at uniform rate of sedimentation. The number of samples that must be collected at equal stratigraphic intervals to sample the succession every 500 years is_______.

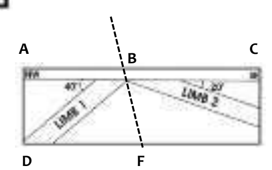
➔ Thickness of the deposit = 10 m.
Time span = 10,000 years.
Sedimentation rate uniform.
So, in 500 years interval the thickness of the sequence that deposited = $(\frac{10}{10,000} \times 500)$ m

= 0.5 m.

So, the number of samples that must be collected at equal stratigraphic intervals to sample the succession every 500 years = $\frac{10}{0.5} = 20$. (answer).

9. Attitudes of the two limbs of a non-plunging kink fold shown below are 045º, 20ºSE and 045º, 40ºNW. The dip amount (in degrees) of the axial plane of the kink fold is (answer in one decimal place).





→ ABC = 180^0 .
ABD = 40^0 ; CBE = 20^0 .
DBE = $180^0 - (40^0 + 20^0) = 120^0$.
So, dip amount of the axial plane will be = (FBE + EBC) = $(60^0 + 20^0) = 80^0$. (answer).

10. In the garnet formula $(Fe_{2.5}Mg_{0.3}Ca_x)Al_2Si_3O_{12}$, x represents the number of atoms of Ca. The mole % of grossular in the garnet is______(answer in one decimal place).

→ Garnet formula = $(Fe_{2.5}Mg_{0.3}Ca_x)Al_2Si_3O_{12}$.
In garnet, Fe + Mg + Ca = 3.
So, x = 3 – (2.5 + 0.3) = 0.2.
So, mole % of grossular garnet = $(\frac{0.2}{3} \times 100)$ % = 6.6 %. (answer).

11. Assuming the Earth to be an ideal sphere, the volume % of the core relative to the total volume of the Earth is______(answer in one decimal place).

→ Radius of earth = 6378 km ; radius of the core = 3478 km.
Assuming earth as a sphere,
Volume of the earth = $\frac{4}{3}\pi (6378)^3$ km^3.
Volume of the core = $\frac{4}{3}\pi (3478)^3$ km^3.
So, volume % of core relative to the earth = $(\frac{\frac{4}{3}\pi (6378)^3}{\frac{4}{3}\pi (3478)^3} \times 100)$ % = 16.2 %. (answer).

12. Based on 8 oxygen atoms, the number of silicon atoms in a plagioclase of composition $Ab_{20}An_{80}$ is_____(answer in one decimal place).

➔ Chemical composition of Albite = $NaAlSi_3O_8$.

Chemical composition of Anorthite = $CaAlSi_2O_8$.

So, number of Si atoms in a plagioclase of composition $Ab_{20}An_{80}$ = $(\frac{20}{100} * 3) + (\frac{80}{100} * 2)$

= 2.2 (answer).

13. 600 tons of low grade iron ore (40% Fe) are blended with 400 tons of high grade iron ore (65% Fe). The grade of the blended ore is___________% Fe (answer in one decimal place).

➔ Low grade iron ore,

Grade = 40 %.

Amount of ore = 600 tons.

So, Fe content = $\frac{40}{100} \times$ 600 tons = 240 tons.

High grade iron ore,

Grade = 65 %.

Amount of ore = 400 tons.

So, Fe content = $\frac{65}{100} \times$ 400 tons = 260 tons.

After blending,

Total amount of ore = (600 + 400) tons = 1000 tons.

Total amount of Fe = (240 + 260) tons = 500 tons.

So, grade of the blended ore = $(\frac{500}{1000} \times 100)$ % = 50 %. (answer).

14. The mass of a fully dried rock sample of volume 100 cm^3 is 300 g. The mass of the sample, when fully saturated with water of density 1.00 g/cm^3, is 325 g. Assuming no volume change, the computed porosity of the rock is % (answer in one decimal place).

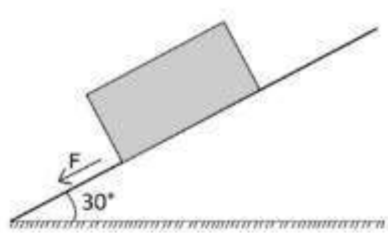
➔ Volume of the rock sample = 100 cm^3 .
Mass of fully dried sample = 300 g.
Mass of fully saturated sample = 325 g.
Density of water = 1 g/cm^3 .
Mass of water = (325 – 300) g = 25 g.
So, volume of water = $\frac{25}{1}$ cm^3 = 25 cm^3 .
This water occupies all the pore spaces when the sample is fully saturated.
So, Volume of pore spaces = 25 cm^3.
So, Porosity of the rock sample = ($\frac{25}{100}$ × 100) % = 25 %. (answer).

15. When a dunite comprising pure forsterite undergoes melting, the weight % of MgO in the melt is (answer in one decimal place; given molecular weights of SiO2 = 60.08; MgO = 40.30).

➔ $2MgO + SiO_2 \rightarrow Mg_2SiO_4$
So, total weight of Mg_2SiO_4 = 60.08 + (2 × 40.30) gm = 140.68 gm.

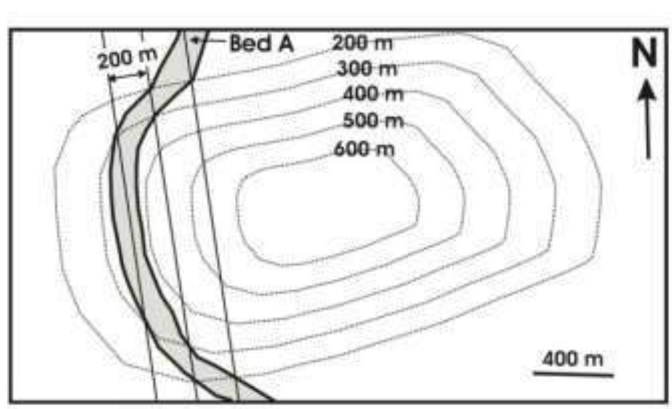
So, weight % of MgO in forsterite melt = ($\frac{80.60}{140.68}$ × 100) % = 57.3 %. (answer)

16. A block of rock with a mass of 72 kg slides on a surface inclined at an angle of 30º as shown in the figure. Assuming no cohesion and friction, the force 'F' is Newton (answer in one decimal place; acceleration due to gravity = 9.8 m/s².).



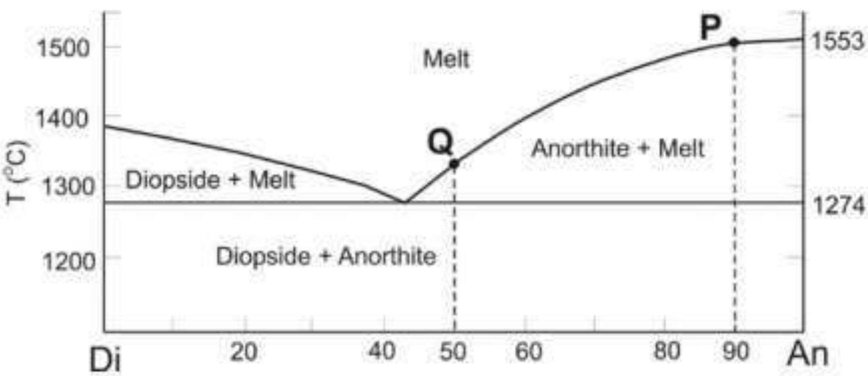
➔ Mass = 72 kg.
Acceleration due to gravity = 9.8 m/s^2.
Slope of the inclined surface = 30^0.
No cohesion and no friction.
So, Force = $(72 \times 9.8 \times \sin 30^0)$ N = 352.8 N. (answer).

17. The true thickness of Bed A in the map given below is______m (answer in one decimal place).



➔ Horizontal distance / Outcrop width = 200 m.
Vertical drop / Contour difference = 100 m.
So, true dip = $\tan^{-1}\frac{100}{200}$ = 26.56^0. (answer).

18. A melt containing 900 moles of anorthite and 100 moles of diopside undergoes crystallization. The number of moles of anorthite that crystallizes as the melt composition moves from P to Q is .



➔ Total melt = (900 + 100) mole = 1000 mole.

Let we consider, number of moles of anorthite crystallizes = x.

Now, applying lever rule,

$$x = \frac{(50 - 10)}{50} \times 1000 \text{ mole} = 800 \text{ mole. (answer).}$$

19. A confined sandstone aquifer with a uniform cross-sectional area of 7 m^2 and a hydraulic conductivity of 2 m/s, transmits water across a hydraulic gradient of 3.2. Assuming steady state Darcian flow, the volumetric flow rate through the aquifer is m^3/s (answer in one decimal place).

➔ Cross – sectional area = 7 m^2.

Hydraulic conductivity = 2 m/s.

Hydraulic gradient = 3.2.

So, Volumetric flow rate through the aquifer = (7 × 2 × 3.2) m^3/s = 44.8 m^3/s. (answer)

20. A diamondiferous lamproite is ultrapotassic and has a molar K_2O/Na_2O ratio of 11. If the Na_2O content of the rock is 0.62 wt%, the K_2O content is wt% (answer in one decimal place; molecular weight of Na_2O = 61.98, and K_2O = 94.20).

➔ Molar K_2O / Na_2O ratio = 11.

Wt % of Na_2O = 0.62 %.

Molecular weight of Na_2O = 61.98.

So, number of moles of Na_2O present in the rock $= \frac{0.62}{61.98}$

Let we consider, Wt% of K_2O = x.

Molecular weight of K_2O = 94.20.

So, number of moles of K_2O present in the rock $= \frac{x}{94.20}$.

Now,

$$\frac{\frac{x}{94.20}}{\frac{0.62}{61.98}} = 11$$

or,

$$x = 10.36.$$

So, the K_2O content is 10.36 wt%. (answer).

IIT - JAM (2019)

Indian Institute of Technology Kharagpur

1. **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.**

➔ As Richter scale is a logarithmic scale, the intensity of an earthquake of magnitude 8 is greater than the intensity of an earthquake of magnitude 5 by 10^3 = 1000 times. (answer).

2. **Assume: (i) geothermal gradient = 25°C/km in the crust, (ii) density of the crustal rocks = 3000 kg/m³, and (iii) acceleration due to gravity = 10 m/s². Based on these values, the lithostatic pressure at a point where temperature is 400°C will be___________MPa.**

➔ Geothermal gradient = 25^0C/km.

So, the depth of the point where temperature is 400^0C = $\frac{400}{25}$ km = 16 km = 16000 m.

Density of crustal blocks = 3000 kg/m³.

Acceleration due to gravity = 10 m/s².

So, the lithostatic pressure at that point = (16000 × 3000 × 10) Pa = 480 × 10^6 Pa = 480 MPa. (answer).

3. **The radii of A^{+2} and B^- ions are 1.12Å and 1.31Å, respectively. The coordination number of A^{+2} in mineral AB_2 is_____________.**

➔ Radii of A^{+2} = 1.12 Å.

Radii of B^- = 1.31Å.

So, $r_{cation/anion} = \frac{1.12}{1.31} = 0.85$.

So, co-ordination number of A^{+2} = 8. (answer)

4. **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).**

➔ Diameter of A = 1ϕ.

So, diameter of A = 2^{-1} mm = 0.5 mm.

Diameter of B = 3ϕ.

So, diameter of B = 2^{-3} mm = 0.125 mm.

So, difference in diameters between A and B = (0.5 – 0.125) mm = 0.375 mm. (answer).

5. **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 place).**

➔ Refractive index of A = 1.750

Refractive index of B = 1.430.

Let we consider, the limiting value of angle of incidence = θ.

Now, for total internal reflection,

$$1.750 \text{ Sin } \theta = 1.430 \text{ Sin } 90^0$$

or,

$$\theta = 54.8^0$$

So, the limiting value of angle of incidence above which the light ray undergoes total internal reflection is 54.8^0. (answer).

6. **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).**

➔ Throw of the normal fault (AB) = 100 m.

Heave of the fault (BC) = 200 m.

Let we consider. Hade of the fault (BAC)= θ.

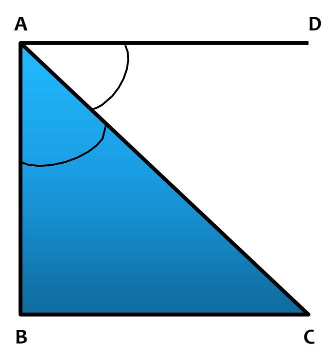
So, $\tan \theta = \frac{200}{100}$

or,

$\theta = \tan^{-1} 2 = 63.4^0$

So, hade of the fault = 63.4^0.

So, dip of the fault (CAD) = $(90^0 – 63.4^0) = 26.6^0$.



7. The difference between Si/O ratios of K-feldspar and olivine is__________(answer in two decimal places).

➔ K-feldspar = $KAlSi_3O_8$.
Olivine = $(Mg, Fe)SiO_4$.
So, according to chemical composition,
Si/O ratio in K-feldspar = $\frac{3}{8}$= 0.375.
Si/O ratio in Olivine = $\frac{1}{4}$= 0.250.
So, difference in Si/O ratio = (0.375 – 0.250) = 0.125.
Again, according to Silicate structure,
K-feldspar is a tectosilicate, so Si/O ratio = $\frac{1}{2}$= 0.50.
Olivine is a nesosilicate, so Si/O ratio = $\frac{1}{4}$= 0.250.
So, difference in Si/O ratio = (0.500 – 0.250) = 0.250.
So, the difference between Si/O ratios of K-feldspar and olivine is 0.125 or 0.250. (answer).

8. If a crystal contains 5 faces and 8 edges, the number of vertices in the crystal is__________.

➔ Number of faces = 5.
Number of edges = 8.
So, number of vertices = (8 + 2 – 5) = 10.

9. 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).

➔ Temperature = 298.15 Kelvin.

Gibbs free energy = 19.737 kCal/mole.

Universal gas constant = 1.98717 Calorie/degree/mole.

Equlibrium constant = K.

So, from the formula of Gibbs free energy,

$$19.737 = -2.303 \times 298.15 \times 1.98717 \times \log_{10} K$$

or,

$$\log_{10} K = -14.47$$

So, the $\log_{10}$ of the equilibrium constant = – 14.47. (answer).

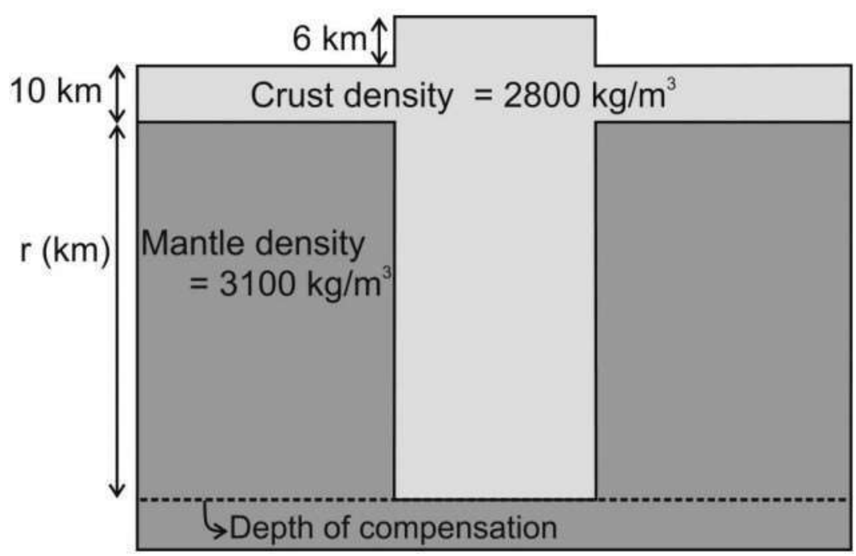
10. A normal fault displaces a sandstone bed such that the dip-slip and the strike-slip components are 3 m and 4 m, respectively. The net-slip of the displacement is___________m.

➔ Dip slip fault = 3 m.

Strike slip fault = 4 m.

So, net slip of the fault = $\sqrt{(32 + 42)}$ m = 5 m.

11. 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/m³ and 3100 kg/m³, respectively. Assuming the acceleration due to gravity to be same throughout the region, the thickness of the root (r) is_______________km.



➔ Height of the plateau = 6 km.
Crustal thickness = 10 km.
Root = r km.
Density of the crust = 2800 kg/m³.
Density of the mantle = 3100 kg/m³.
Now, applying Airy's theory of Isostasy,

$$r = \frac{(2800 \times 6)}{(3100 - 2800)} \text{ km} = 56 \text{ km}.$$

So, the thickness of the root = 56 km. (answer).

12. 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/s², the boulder will hit the ground with a velocity of______________m/s.

➔ Mass of the boulder = 50 kg.
Height = 20 m.
Acceleration due to gravity = 10 m/s^2 .
So, potential energy of the boulder = (50 × 20 × 10) Joule = 10,000 Joule.
Let we consider, the boulder hits the ground with a velocity of v m/s.
So, kinetic energy of the boulder = $\frac{1}{2}$ × 50 × v^2 Joule = 25 v^2 Joule.
The potential energy will convert into kinetic energy, So,

$$10,000 = 25\, v^2$$

or,

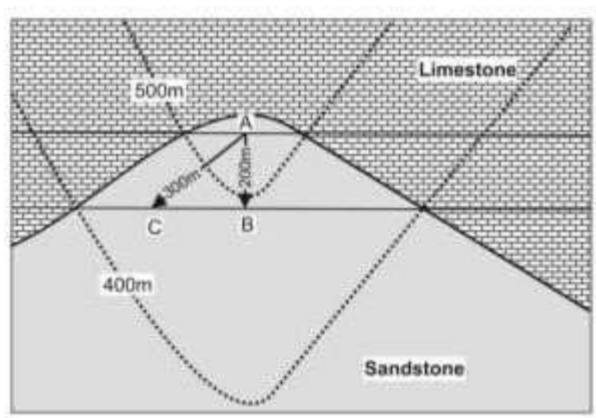
$$v = 20$$

So, the boulder will hit the ground with a velocity of 20 m/s. (answer).

13. Mass and volume of a fully dried soil sample are 500 g and 250 cm³, respectively. The average density of the particles in the soil sample is 2.5 g/cm³. The void ratio of the soil sample is __________%.

➔ Mass of the fully dried soil sample = 500 g.
Volume of the soil sample = 250 cm^3 .
Average density of the soil particles = 2.5 g/cm^3 .
So, volume of the soil particles = $\frac{500}{2.5}$ cm^3 = 200 cm^3 .
So, volume of the voids = (250 – 200) cm^3 = 50 cm^3.
So, void ratio of the soil sample = ($\frac{50}{200}$ × 100) % = 25 %. (answer).

14. 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).



➔ Towards AB direction,

Horizontal distance = 200 m.

Vertical drop = 100 m.

So, dip of the bed = $\tan^{-1}\frac{100}{200} = 26.56^0$.

Towards AC direction,

Horizontal distance = 300 m.

Vertical drop = 100 m.

So, dip of the bed = $\tan^{-1}\frac{100}{300} = 18.43^0$.

So, difference in the dip angle towards AB and AC direction = $(26.56^0 - 18.43^0) = 8.13^0$.(answer).

15. A tabular ore body of 9 km² area and an average thickness of 9 m has a density of 3000 kg/m³. The tonnage (in million tonnes) of the ore body is___________.

➔ Area of the tabular ore body = $9\ km^2 = 9 \times 10^6\ m^2$.

Thickness of the ore body = 9 m.

Density of the ore body = $3000\ kg/m^3$.

So, tonnage of the ore body = $(9 \times 10^6 \times 9 \times 3000)$ kg = 243×10^9 kg = 243 million tonnes.

16. Assume that the orbit of the earth is a circle of radius 150 × 10^6 km. The gravitational constant and the earth's orbital velocity are given as 6.7 × 10^{-11} Nm^2/kg^2 and 30 × 10^3 m/s, respectively. The calculated mass of the sun is________________________×10^{30} kg (rounded off to two decimal places).

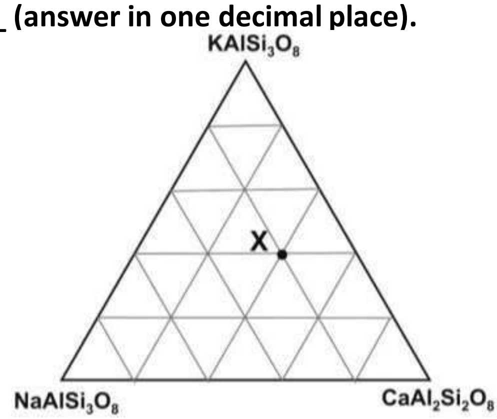
➔ Radius of the circular orbit = 150 × 10^6 km = 150 × 10^9 m.

Gravitational constant = 6.7 × 10^{-11} Nm^2/kg^2.

Earth's orbital velocity = 30 × 10^3 m/s.

So, calculated mass of the sun = $\frac{(30 \times 10^3)^2 \times (150 \times 10^9)}{6.7 \times 10^{-11}}$ kg = 2 × 10^{30} kg. (answer).

17. 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).



➔ X_{Ab} = 20 % = 0.2 mole.

X_{An} = 40 % = 0.4 mole.

So, difference in X_{An} and X_{Ab} = (0.4 – 0.2) = 0.2. (answer).

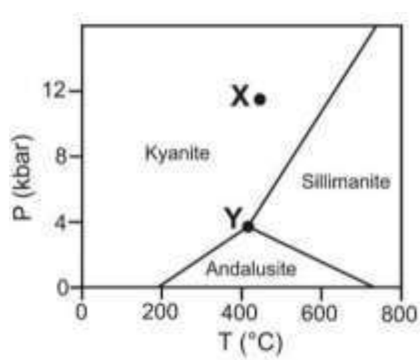
18. Two vertical wells penetrating a confined aquifer are 200 m apart. The water surface elevations in these wells are 35 m and 40 m above a common reference datum. The discharge per unit area through the aquifer is 0.05 m/day. Using Darcy's law, the coefficient of permeability is_____________m/day.

➔ Distance between two vertical wells (dl) = 200 m.
Difference in elevation (dh) = (40 – 35) m = 5 m.
Discharge per unit area / Darcy velocity (v) = 0.05 m/day.
Let we consider, coefficient of permeability = K m/day.
So, Using Darcy's law,

$$K = \left(\frac{200}{5} \times 0.05\right) \text{ m/day} = 2 \text{ m/day.}$$ So,

the coefficient of permeability = 2 m/day. (answer).

19. 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_____________.



➔ At X,
Number of phases = 1.
Number of component = 1.
So, degree of freedom = (2 + 1 – 1) = 2.
At Y,
Number of phases = 3.
Number of components = 1.
So, degree of freedom = (2 + 1 – 3) = 0.
So, the difference in the degree of freedom at points X and Y = (2 – 0) = 2. (answer).

20. The core and rim compositions of garnet are $(Fe_{0.75}Ca_{0.90}Mn_{1.35})Al_2Si_3O_{12}$ and $(Fe_{0.90}Ca_{1.35}Mn_{0.75})Al_2Si_3O_{12}$, respectively. The difference in mole fractions of spessertine between the core and the rim is______________(answer in one decimal place).

➔ Spessertine garnet = $Mn_3Al_2Si_3O_{12}$.

So, mole fraction of spessertine garnet at core = $\frac{1.35}{3}$ = 0.45.

So, mole fraction of spessertine garnet at rim = $\frac{0.75}{3}$ = 0.25.

So, difference in mole fractions of spessertine between the core and the rim = (0.45 – 0.25)

= 0.25. (answer).