SESSION - 1

GATE 2022 General Aptitude (GA)

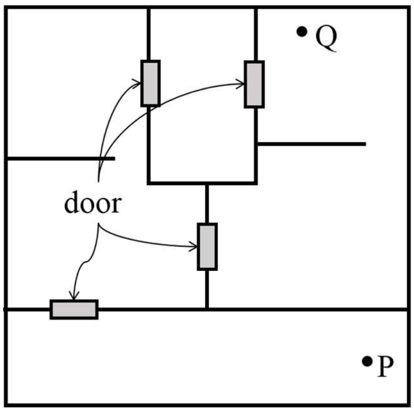
Q.1 – Q.5 Carry ONE mark each.

Q.1	Inhaling the smoke from a burning __________ could __________ you quickly.
(A)	tire / tier
(B)	tire / tyre
(C)	tyre / tire
(D)	tyre / tier

Q.2	A sphere of radius r cm is packed in a box of cubical shape. What should be the minimum volume (in cm^3) of the box that can enclose the sphere?
(A)	$\frac{r^3}{8}$
(B)	r^3
(C)	$2r^3$
(D)	$8r^3$

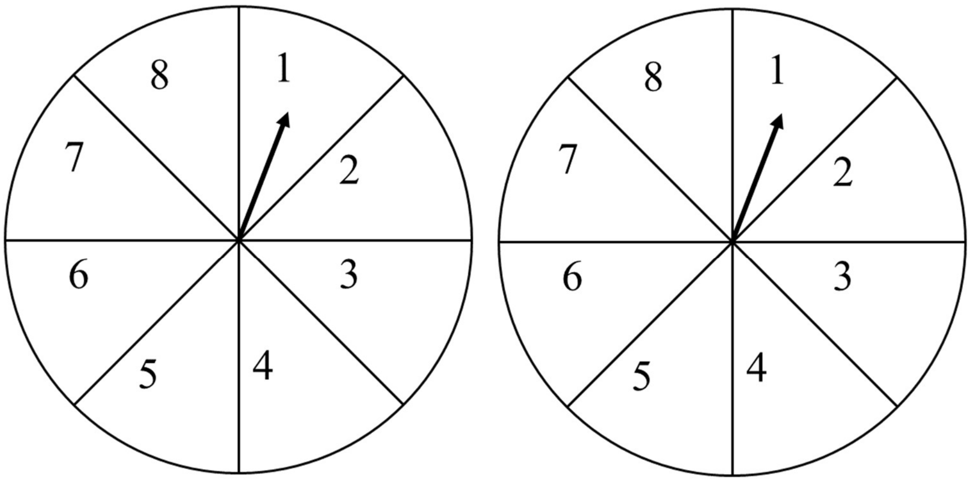
Q.3	Pipes P and Q can fill a storage tank in full with water in 10 and 6 minutes, respectively. Pipe R draws the water out from the storage tank at a rate of 34 litres per minute. P, Q and R operate at a constant rate. If it takes one hour to completely empty a full storage tank with all the pipes operating simultaneously, what is the capacity of the storage tank (in litres)?
(A)	26.8
(B)	60.0
(C)	120.0
(D)	127.5

Q.4	Six persons P, Q, R, S, T and U are sitting around a circular table facing the center not necessarily in the same order. Consider the following statements: • P sits next to S and T. • Q sits diametrically opposite to P. • The shortest distance between S and R is equal to the shortest distance between T and U. Based on the above statements, Q is a neighbor of
(A)	U and S
(B)	R and T
(C)	R and U
(D)	P and S

Q.5	A building has several rooms and doors as shown in the top view of the building given below. The doors are closed initially. What is the minimum number of doors that need to be opened in order to go from the point P to the point Q? 
(A)	4
(B)	3
(C)	2
(D)	1

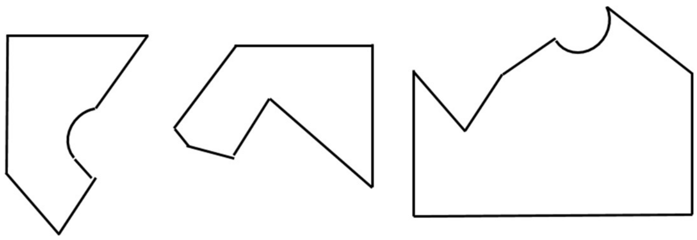
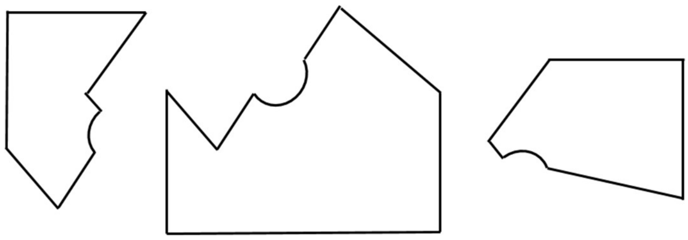
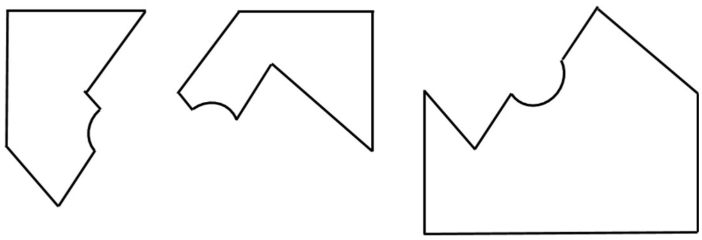
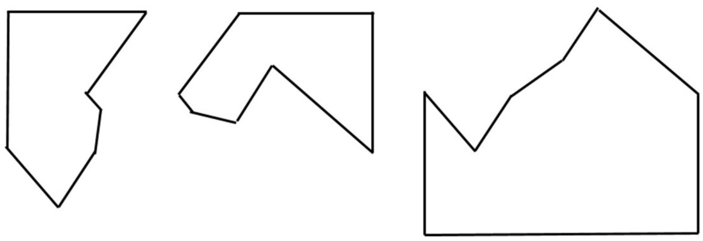
Q. 6 – Q. 10 Carry TWO marks each.

Q.6	Rice, a versatile and inexpensive source of carbohydrate, is a critical component of diet worldwide. Climate change, causing extreme weather, poses a threat to sustained availability of rice. Scientists are working on developing Green Super Rice (GSR), which is resilient under extreme weather conditions yet gives higher yields sustainably. Which one of the following is the CORRECT logical inference based on the information given in the above passage?
(A)	GSR is an alternative to regular rice, but it grows only in an extreme weather
(B)	GSR may be used in future in response to adverse effects of climate change
(C)	GSR grows in an extreme weather, but the quantity of produce is lesser than regular rice
(D)	Regular rice will continue to provide good yields even in extreme weather

Q.7	A game consists of spinning an arrow around a stationary disk as shown below. When the arrow comes to rest, there are eight equally likely outcomes. It could come to rest in any one of the sectors numbered 1, 2, 3, 4, 5, 6, 7 or 8 as shown. Two such disks are used in a game where their arrows are independently spun. What is the probability that the sum of the numbers on the resulting sectors upon spinning the two disks is equal to 8 after the arrows come to rest? 
(A)	$\frac{1}{16}$
(B)	$\frac{5}{64}$
(C)	$\frac{3}{32}$
(D)	$\frac{7}{64}$

Q.8	Consider the following inequalities. (i) $3p - q < 4$ (ii) $3q - p < 12$ Which one of the following expressions below satisfies the above two inequalities?
(A)	$p + q < 8$
(B)	$p + q = 8$
(C)	$8 \leq p + q < 16$
(D)	$p + q \geq 16$

Q.9	Given below are three statements and four conclusions drawn based on the statements. Statement 1: Some engineers are writers. Statement 2: No writer is an actor. Statement 3: All actors are engineers. Conclusion I: Some writers are engineers. Conclusion II: All engineers are actors. Conclusion III: No actor is a writer. Conclusion IV: Some actors are writers. Which one of the following options can be logically inferred?
(A)	Only conclusion I is correct
(B)	Only conclusion II and conclusion III are correct
(C)	Only conclusion I and conclusion III are correct
(D)	Either conclusion III or conclusion IV is correct

Q.10	Which one of the following sets of pieces can be assembled to form a square with a single round hole near the center? Pieces cannot overlap.
(A)	
(B)	
(C)	
(D)	

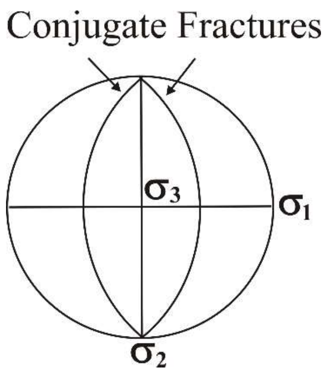
PART A: COMPULSORY SECTION FOR ALL CANDIDATES
Q.11 – Q .17 Carry ONE mark each

Q.11	Which one of the following is the typical product of ductile deformation?
(A)	Gouge
(B)	Breccia
(C)	Cataclasite
(D)	Mylonite
Q.12	Which one among the following coastal erosional landforms is caused by the action of sea waves?
(A)	Ventifact
(B)	Kettle
(C)	Cirque
(D)	Cliff

Q.13	In which one of the following regions of the electromagnetic spectrum does the maximum atmospheric scattering occur?
(A)	UV
(B)	IR
(C)	Radiowave
(D)	Microwave
Q.14	Which one of the following is the Poisson's ratio for an incompressible fluid?
(A)	0
(B)	0.25
(C)	1
(D)	0.5
Q.15	Which among the following Period(s) belong(s) to the Paleozoic Era?
(A)	Carboniferous
(B)	Paleogene
(C)	Silurian
(D)	Cretaceous

Q.16	The average bulk density of a fully saturated sandstone reservoir with a fractional porosity of 0.23 is ______ g/cc. [*round off to 2 decimal places*] [Assume matrix density for sandstone = 2.63 g/cc and fluid density = 1.05 g/cc]
Q.17	For a productive alluvial aquifer with hydraulic conductivity = 105 m/day and hydraulic gradient = 0.01, the flow rate is _________ m/day. [*round off to 2 decimal places*]

Q.18 – Q .26 Carry TWO marks each

Q.18	The relationship between conjugate shear fractures and the principal stresses in a homogenous, isotropic, deformed body is shown in the stereoplot given below (σ_1, σ_2 and σ_3 are compressive stresses). Which one of the given fault regimes is indicated according to the Anderson's theory of faulting for the formation of conjugate shear fractures under plane strain? 
(A)	Dextral strike-slip
(B)	Sinistral strike-slip
(C)	Reverse
(D)	Normal

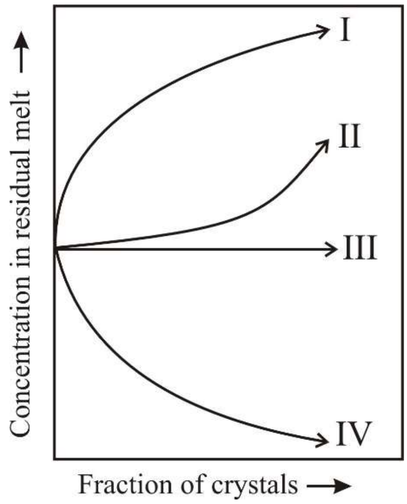
Q.19	How many independent elastic parameters are needed to describe a homogenous isotropic material?
(A)	21
(B)	2
(C)	36
(D)	3
Q.20	Which one of the following is a mafic volcanic rock?
(A)	Dacite
(B)	Trachyte
(C)	Rhyolite
(D)	Basalt
Q.21	The intercepts of a crystal face on the crystallographic axes are ∞a, 2b, 3c. Which one of the following is its Miller Index?
(A)	(032)
(B)	(023)
(C)	(203)
(D)	(320)

Q.22	Match the locations in Group I with the corresponding economic deposits in Group II. **Group I** P. Wajrakarur Q. Sukinda R. Malanjkhand S. Mangampeta **Group II** 1. Chromite 2. Diamond 3. Barite 4. Copper
(A)	P-3; Q-4; R-1; S-2
(B)	P-3; Q-1; R-4; S-2
(C)	P-2; Q-1; R-4; S-3
(D)	P-2; Q-4; R-1; S-3
Q.23	Choose the CORRECT statement(s) on seismic wave propagation in an elastic isotropic medium.
(A)	P-waves are polarized in the direction of propagation.
(B)	S-waves are polarized in the direction of propagation.
(C)	Rayleigh waves are elliptically polarized.
(D)	Love waves are elliptically polarized.

Q.24	The difference in arrival times of P- and S-waves generated by an earthquake and recorded at a seismological station is one second. Assuming a homogeneous and isotropic Earth, a P-wave velocity (V_P) of 3 km/s, the ratio of P- to S-wave velocities (V_P/V_S) of 2.0, the distance between the station and the hypocenter is __________km. [*round off to 1 decimal place*]
Q.25	Assuming the rate of rotation of the Earth is 7.27×10^{-5} radians/s and the radius of Earth is 6371 km, the centrifugal acceleration at 60° latitude for a spherically rotating Earth is ______ $\times 10^{-3}$ m/s^2. [*round off to 1 decimal place*]
Q.26	The angle of inclination of the remanent magnetization of a volcanic rock measured at a location is 45°. The magnetic latitude of the location of the volcanic rock at the time of its magnetization is _________ °N. [*round off to 1 decimal place*]

PART B (SECTION 1): FOR GEOLOGY CANDIDATES ONLY
Q.27 – Q.44 Carry ONE mark Each

Q.27	A coarse-grained igneous rock consists of 55% olivine, 25% augite and 20% enstatite. According to the IUGS classification, the rock is
(A)	websterite
(B)	lherzolite
(C)	wehrlite
(D)	harzburgite
Q.28	The rock-type used to build the walls of the Red Fort in Delhi is
(A)	sandstone
(B)	marble
(C)	granite
(D)	basalt

Q.29	During crystallization of a magma, which one of the following schematic paths (I, II, III and IV) describes the behavior of compatible elements in the residual melt? 
(A)	II
(B)	IV
(C)	I
(D)	III
Q.30	In the geological map of India, which one of the following geological units has the largest area?
(A)	Vindhyan Supergroup
(B)	Deccan Volcanic Province
(C)	Singhbhum Granite
(D)	Mesozoic rocks of Kutch

Q.31	Which one of the following cross-stratifications provides the paleocurrent direction on the truncated bedding surface of an undeformed cross-stratified sedimentary strata?
(A)	Tabular
(B)	Hummocky
(C)	Trough
(D)	Herringbone
Q.32	Which one of the following is a dinosaur?
(A)	*Stegodon*
(B)	*Stegosaurus*
(C)	*Equus*
(D)	*Otoceras*
Q.33	The Hoek-Brown failure envelope is typically the segment of which one of the following?
(A)	Straight line
(B)	Ellipse
(C)	Parabola
(D)	Hyperbola

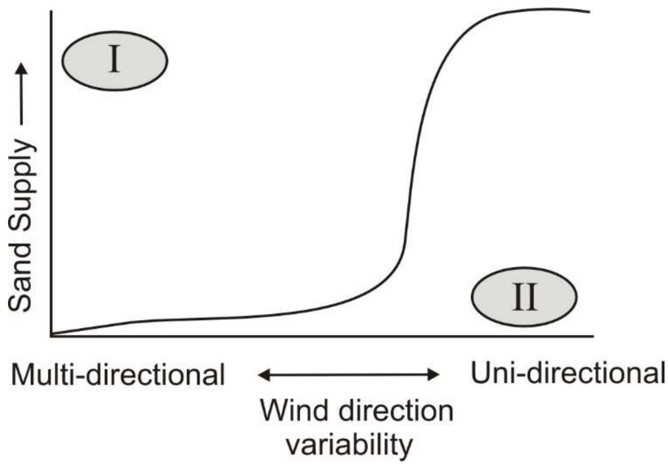
Q.34	Which one of the following is the optical spectral window suitable for remote sensing?
(A)	0.02 – 0.2 µm
(B)	0.4 – 14 µm
(C)	0.8 – 2.0 µm
(D)	0.01 – 1 m
Q.35	A radioactive nucleus $^{290}_{92}X$ decays to $^{278}_{87}Y$. The number of α and β particles emitted during this decay are
(A)	12α and $1\beta^{+}$
(B)	6α and $1\beta^{-}$
(C)	3α and $1\beta^{+}$
(D)	3α and $1\beta^{-}$

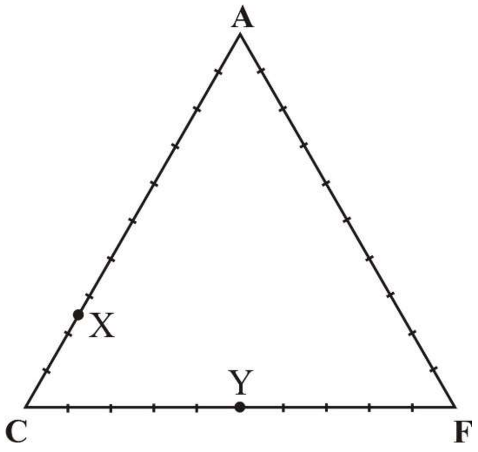
Q.36	The silicate mineral(s) that commonly occur(s) in regionally metamorphosed siliceous dolomitic limestone is/are
(A)	diopside
(B)	cordierite
(C)	tremolite
(D)	wollastonite
Q.37	Which of the natural hazard(s) listed below can be caused by Earthquakes?
(A)	Tsunamis
(B)	Landslides
(C)	Cyclones
(D)	Lightning
Q.38	Which of the following is/are the driving force(s) behind plate motion?
(A)	Slab-Pull
(B)	Ridge-Push
(C)	Mantle Convection
(D)	Advection

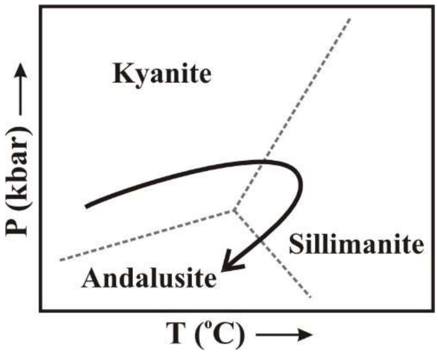
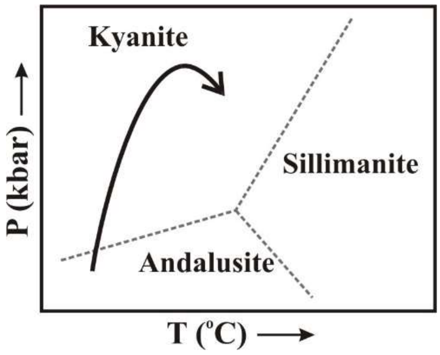
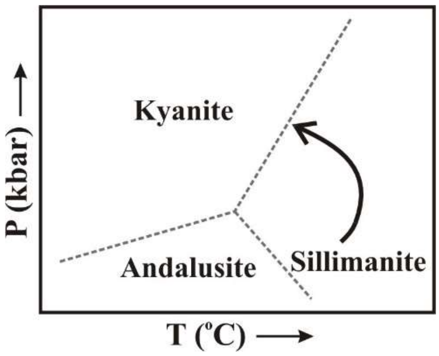
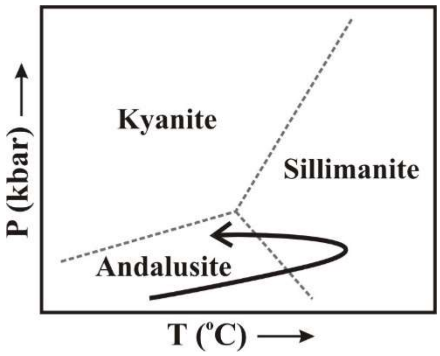
Q.39	Which of the following is/are copper ore mineral(s)?
(A)	Bornite
(B)	Pentlandite
(C)	Gahnite
(D)	Covellite
Q.40	Which of the following stratigraphic unit(s) of the Vindhyan Supergroup contain(s) commercially significant limestone deposit(s)?
(A)	Bhander Formation
(B)	Rewa Formation
(C)	Kaimur Formation
(D)	Rohtas Formation
Q.41	The strike and dip of the axial plane of a reclined fold is 022° and 28° SE, respectively. The plunge direction (in whole circle bearing) of the axis of the reclined fold is _______ degrees. [*in integer*]
Q.42	If the shrinkage factor of a crude oil is 0.7, its formation volume factor is ______. [*round off to 1 decimal place*]

Q.43	The cross section of a river channel is approximated by a trapezium. The river has an average channel width of 40 m and average depth of 3 m. If the average flow speed is 2 m/s, the discharge rate is _________ m^3/s. [*in integer*]
Q.44	A mineral of uniform composition is cut into a wedge shape. The birefringence of the wedge section is 0.012. The retardation at 40 µm thickness of the wedge is _______ nm. [*in integer*]

Q.45 – Q.65 Carry TWO marks Each

Q.45	The sand supply and the variability of wind direction results in different dune types. In the options below, choose the CORRECT pair of dune types marked I and II in the figure. 
(A)	I – Transverse dune; II – Barchan dune
(B)	I – Star dune; II – Barchan dune
(C)	I – Barchan dune; II – Linear dune
(D)	I – Barchan dune; II – Star dune
Q.46	Which one of the following statements is CORRECT?
(A)	Salt dome traps are abundant in the Upper Assam Basin
(B)	Fold and thrust related traps are common in the Mumbai Offshore Basin
(C)	Limestone is the predominant reservoir rock in the Cambay Basin
(D)	Sandstone is the reservoir rock in the Krishna-Godavari Basin

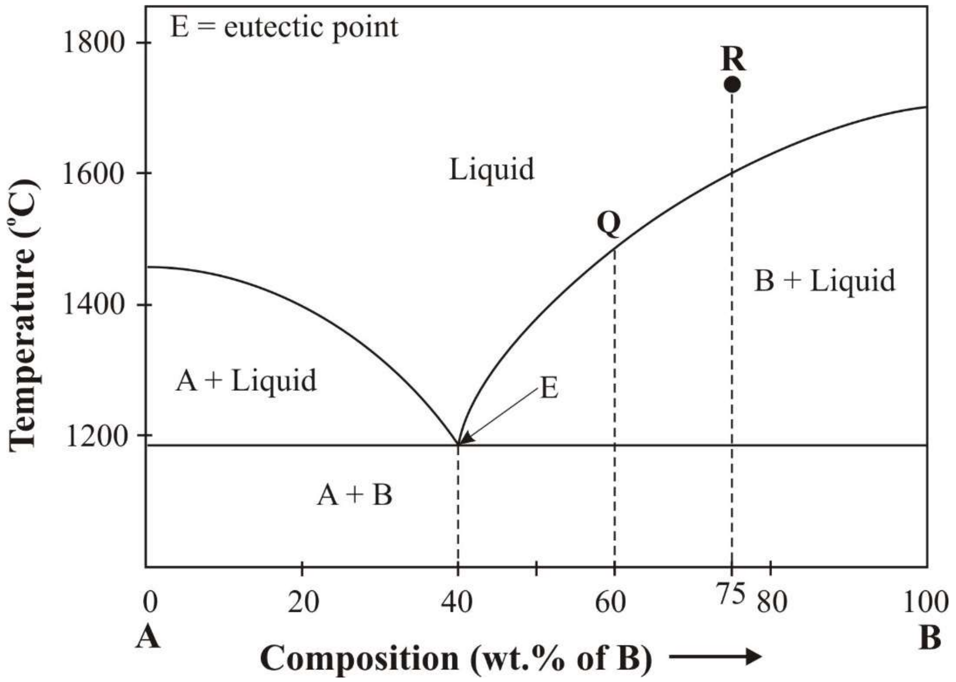
Q.47	Identify the common metamorphic minerals labelled X and Y in the ACF diagram. 
(A)	X – Anorthite; Y – Actinolite
(B)	X – Grossular; Y – Diopside
(C)	X – Wollastonite; Y – Almandine
(D)	X – Ferrosilite; Y – Andradite

Q.48	Which one of the following schematic P-T paths is characteristic for a rock metamorphosed in a subduction zone?
(A)	
(B)	
(C)	
(D)	
Q.49	Which one of the following is the CORRECT statement regarding the ecology of bivalves?
(A)	*Pholas* is a swimming form
(B)	*Venus* is a shallow burrower
(C)	*Pecten* is a stone borer
(D)	*Spondylus* is a deep burrower

Q.50	On a fault surface with strike and dip 320° and 55° NE, respectively, four sets of slickenlines were measured by a geologist. Given that the fault surface was measured correctly, the plunge and plunge direction of the lineation on the fault surface is
(A)	55° → 050°
(B)	20° → 320°
(C)	50° → 325°
(D)	60° → 090°
Q.51	Match the following tectonic settings in Group-I with the corresponding examples in Group-II. **Group-I** / **Group-II** P Rift Basin — 1 Pacific Ocean Q Passive Margin — 2 Gulf of Suez R Subducting Ocean — 3 West coast of India S Collision — 4 Mediterranean Sea
(A)	P-2; Q-3; R-1; S-4
(B)	P-3; Q-2; R-4; S-1
(C)	P-2; Q-1; R-3; S-4
(D)	P-4; Q-3; R-1; S-2

Q.52	Match the following igneous textures in Group-I with their definitions in Group-II. **Group-I** / **Group-II** P Vitrophyre — 1 Alkali feldspar rimmed by plagioclase Q Rapakivi — 2 Aggregate of radially arrayed, needle-like crystals of plagioclase with or without clinopyroxene R Ocelli — 3 Sub-parallel skeletal, platy olivine and/or pyroxene S Spinifex — 4 Large phenocrysts within a glassy matrix
(A)	P-2; Q-3; R-4; S-1
(B)	P-3; Q-4; R-2; S-1
(C)	P-4; Q-1; R-2; S-3
(D)	P-4; Q-1; R-3; S-2

Q.53	Match the Volcanogenic Massive Sulfide (VMS)-type deposits in Group-I with the dominant mineralized host rocks in Group-II. **Group-I** / **Group-II** P Besshi — 1 Felsic volcanics Q Bathurst — 2 Mafic volcanics + siliciclastics R Kuroko — 3 Mafic volcanics S Cyprus — 4 Felsic volcanics + siliciclastics
(A)	P-2; Q-1; R-3; S-4
(B)	P-2; Q-4; R-1; S-3
(C)	P-4; Q-3; R-1; S-2
(D)	P-1; Q-4; R-2; S-3

Q.54	The following diagram shows phase relations in a system consisting of components A and B at 1 bar pressure. If the initial composition of liquid is **R**, during cooling and crystallization of magma, which of the following statement(s) is/are CORRECT? 
(A)	On complete crystallization of magma, the final composition (in wt.%) of rock consists of 25 of mineral **A** and 75 of mineral **B**.
(B)	On cooling of magma, mineral **A** is the first mineral to crystallize.
(C)	At point **Q**, the weight percentages of crystal and liquid are 37.5 and 62.5, respectively.
(D)	The composition (in wt.%) of liquid at point E is 40 **A** and 60 **B**.

Q.55	Which of the following systems tract(s) indicate regression?
(A)	Transgressive systems tract
(B)	Falling stage systems tract
(C)	Highstand systems tract
(D)	Lowstand systems tract
Q.56	Which of the following sedimentary feature(s) indicate(s) sub-aerial exposure of the depositional surface?
(A)	Groove cast
(B)	Double mud drape
(C)	Rain print
(D)	Adhesion ripple
Q.57	Which of the following statement(s) is/are correct?
(A)	Diatoms are algal forms.
(B)	Dinoflagellates are unicellular algae.
(C)	Petropods are planktic gastropods.
(D)	Radiolarians are organic-walled microfossils.

Q.58	Which among the following space groups is/are non-compatible with glide plane?
(A)	$Pab2_1$
(B)	Pnma
(C)	$P6_3/c$
(D)	$P\overline{3}c1$
Q.59	Which type of porphyroclast(s) listed below is/are suitable as kinematic indicators in ductile shear zones?
(A)	σ - type
(B)	Θ - type
(C)	δ - type
(D)	φ - type
Q.60	Which of the following parameter(s) is/are Rock Mass Rating (RMR) based on?
(A)	Rock Quality Designation
(B)	Uniaxial compressive strength of intact rock
(C)	Groundwater conditions
(D)	Rock composition

Q.61	A sample of 10 g coal yields 1 g of moisture, 2 g of ash and 5.6 g of volatile matter. The percentage of volatile matter content of the coal on dry ash-free basis is ________. [*round off to 1 decimal place*]
Q.62	A soil sample shows an average beta count of 6.8 counts per minute (cpm) per gram of organic carbon. The ^{14}C count rate from organic carbon of present day vegetation is 15.26 cpm/g. The age of the sample is _________ years. [*round off to 1 decimal place*] (Half-life of ^{14}C = 5370 years)
Q. 63	A digital camera with a focal length of 150 mm is flown at a height of 3000 m over a flat terrain for taking aerial photographs. The scale of the aerial photograph is 1: ________. [*in integer*]
Q. 64	The following reaction occurs at 1 bar and 823 K.

Grossular + Quartz = Anorthite + 2 Wollastonite

Mineral	**Entropy ($S^{1, 823}$)**	**Volume ($V^{1, 823}$)**
	kJ K^{-1}	**J bar^{-1}**
Grossular	0.255	12.535
Quartz	0.042	2.269
Anorthite	0.200	10.079
Wollastonite	0.082	3.993

Using the above molar thermodynamic data, the calculated slope of the above reaction is ________bar K^{-1}. [*round off to 2 decimal places*]

Q.65	Operating costs of an open cast gold mine are Rs. 4000/tonne. The recovery at the mill is 90%. At a gold price of Rs. 4550/g, the cutoff grade of gold calculated on the basis of operating cost is _________ g/tonne. [*round off to 2 decimal places*]

Q. No.	Session	Question Type	Subject Name	Key/Range	Mark
1	4	MCQ	GA	C	1
2	4	MCQ	GA	D	1
3	4	MCQ	GA	C	1
4	4	MCQ	GA	C	1
5	4	MCQ	GA	C	1
6	4	MCQ	GA	B	2
7	4	MCQ	GA	D	2
8	4	MCQ	GA	A	2
9	4	MCQ	GA	C	2
10	4	MCQ	GA	C	2
11	4	MCQ	GG	D	1
12	4	MCQ	GG	D	1
13	4	MCQ	GG	A	1
14	4	MCQ	GG	D	1
15	4	MSQ	GG	A, C	1
16	4	NAT	GG	2.24 to 2.30	1
17	4	NAT	GG	1.00 to 1.10	1
18	4	MCQ	GG	C	2
19	4	MCQ	GG	B	2
20	4	MCQ	GG	D	2
21	4	MCQ	GG	A	2
22	4	MCQ	GG	C	2
23	4	MSQ	GG	A, C	2
24	4	NAT	GG	3.0 to 3.0	2
25	4	NAT	GG	16.3 to 17.3	2
26	4	NAT	GG	26.2 to 27.0	2
27	4	MCQ	GG	B	1
28	4	MCQ	GG	A	1
29	4	MCQ	GG	B	1
30	4	MCQ	GG	B	1
31	4	MCQ	GG	C	1
32	4	MCQ	GG	B	1
33	4	MCQ	GG	C	1
34	4	MCQ	GG	B	1
35	4	MCQ	GG	D	1
36	4	MSQ	GG	A, C, D OR A, C	1
37	4	MSQ	GG	A, B	1
38	4	MSQ	GG	A, B, C	1
39	4	MSQ	GG	A, D	1
40	4	MSQ	GG	A, D	1
41	4	NAT	GG	112 to 112	1
42	4	NAT	GG	1.4 to 1.5	1
43	4	NAT	GG	240 to 240	1
44	4	NAT	GG	480 to 480	1

45	4	MCQ	GG	B	2
46	4	MCQ	GG	D	2
47	4	MCQ	GG	B	2
48	4	MCQ	GG	B	2
49	4	MCQ	GG	B	2
50	4	MCQ	GG	A	2
51	4	MCQ	GG	A	2
52	4	MCQ	GG	C	2
53	4	MCQ	GG	B	2
54	4	MSQ	GG	A, C	2
55	4	MSQ	GG	B, C, D	2
56	4	MSQ	GG	C, D	2
57	4	MSQ	GG	A, B, C OR A,B	2
58	4	MSQ	GG	A, C	2
59	4	MSQ	GG	A, C	2
60	4	MSQ	GG	A, B, C	2
61	4	NAT	GG	80.0 to 80.0	2
62	4	NAT	GG	6261.0 to 6266.0	2
63	4	NAT	GG	20000 to 20000	2
64	4	NAT	GG	20.00 to 21.00	2
65	4	NAT	GG	0.96 to 1.00	2

SESSION - 2

GATE 2022 General Aptitude (GA)

Q.1 – Q.5 Carry ONE mark each.

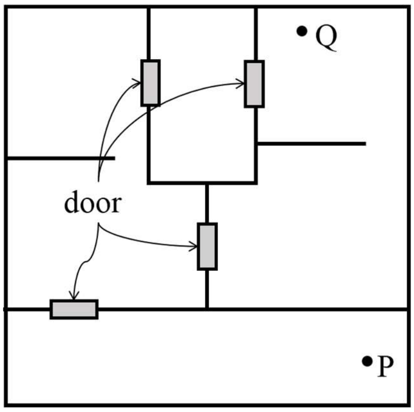
Q.1	Inhaling the smoke from a burning __________ could __________ you quickly.
(A)	tire / tier
(B)	tire / tyre
(C)	tyre / tire
(D)	tyre / tier

Q.2	A sphere of radius r cm is packed in a box of cubical shape. What should be the minimum volume (in cm^3) of the box that can enclose the sphere?
(A)	$\frac{r^3}{8}$
(B)	r^3
(C)	$2r^3$
(D)	$8r^3$

Q.3	Pipes P and Q can fill a storage tank in full with water in 10 and 6 minutes, respectively. Pipe R draws the water out from the storage tank at a rate of 34 litres per minute. P, Q and R operate at a constant rate. If it takes one hour to completely empty a full storage tank with all the pipes operating simultaneously, what is the capacity of the storage tank (in litres)?
(A)	26.8
(B)	60.0
(C)	120.0
(D)	127.5

Q.4	Six persons P, Q, R, S, T and U are sitting around a circular table facing the center not necessarily in the same order. Consider the following statements: • P sits next to S and T. • Q sits diametrically opposite to P. • The shortest distance between S and R is equal to the shortest distance between T and U. Based on the above statements, Q is a neighbor of
(A)	U and S
(B)	R and T
(C)	R and U
(D)	P and S

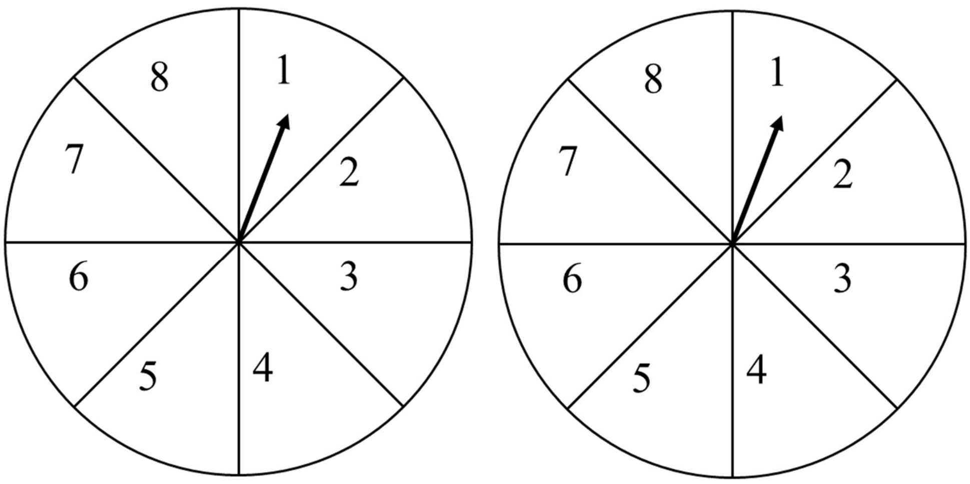
Q.5	A building has several rooms and doors as shown in the top view of the building given below. The doors are closed initially. What is the minimum number of doors that need to be opened in order to go from the point P to the point Q?



(A)	4
(B)	3
(C)	2
(D)	1

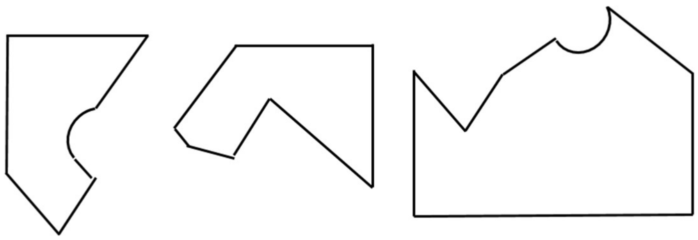
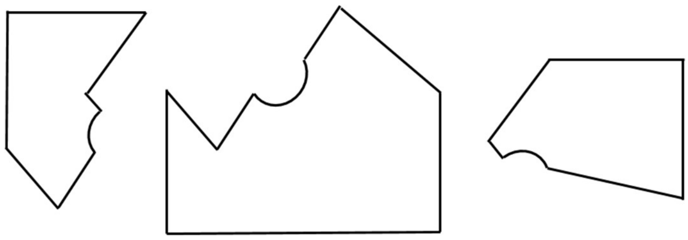
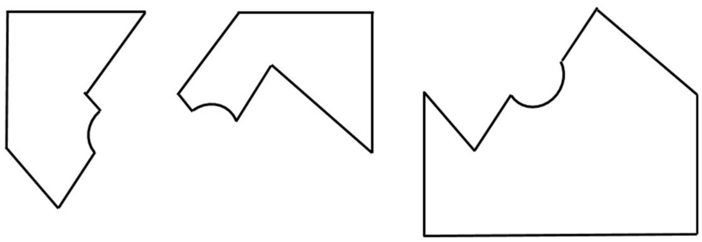
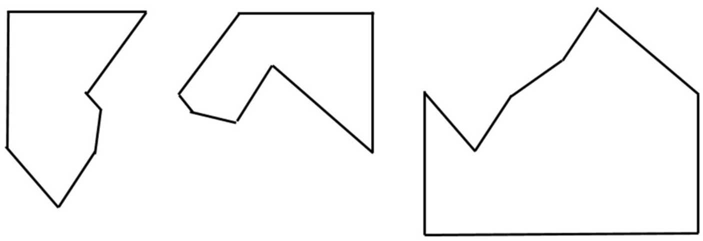
Q. 6 – Q. 10 Carry TWO marks each.

Q.6	Rice, a versatile and inexpensive source of carbohydrate, is a critical component of diet worldwide. Climate change, causing extreme weather, poses a threat to sustained availability of rice. Scientists are working on developing Green Super Rice (GSR), which is resilient under extreme weather conditions yet gives higher yields sustainably. Which one of the following is the CORRECT logical inference based on the information given in the above passage?
(A)	GSR is an alternative to regular rice, but it grows only in an extreme weather
(B)	GSR may be used in future in response to adverse effects of climate change
(C)	GSR grows in an extreme weather, but the quantity of produce is lesser than regular rice
(D)	Regular rice will continue to provide good yields even in extreme weather

Q.7	A game consists of spinning an arrow around a stationary disk as shown below. When the arrow comes to rest, there are eight equally likely outcomes. It could come to rest in any one of the sectors numbered 1, 2, 3, 4, 5, 6, 7 or 8 as shown. Two such disks are used in a game where their arrows are independently spun. What is the probability that the sum of the numbers on the resulting sectors upon spinning the two disks is equal to 8 after the arrows come to rest? 
(A)	$\frac{1}{16}$
(B)	$\frac{5}{64}$
(C)	$\frac{3}{32}$
(D)	$\frac{7}{64}$

Q.8	Consider the following inequalities. (i) $3p - q < 4$ (ii) $3q - p < 12$ Which one of the following expressions below satisfies the above two inequalities?
(A)	$p + q < 8$
(B)	$p + q = 8$
(C)	$8 \leq p + q < 16$
(D)	$p + q \geq 16$

Q.9	Given below are three statements and four conclusions drawn based on the statements. Statement 1: Some engineers are writers. Statement 2: No writer is an actor. Statement 3: All actors are engineers. Conclusion I: Some writers are engineers. Conclusion II: All engineers are actors. Conclusion III: No actor is a writer. Conclusion IV: Some actors are writers. Which one of the following options can be logically inferred?
(A)	Only conclusion I is correct
(B)	Only conclusion II and conclusion III are correct
(C)	Only conclusion I and conclusion III are correct
(D)	Either conclusion III or conclusion IV is correct

Q.10	Which one of the following sets of pieces can be assembled to form a square with a single round hole near the center? Pieces cannot overlap.
(A)	
(B)	
(C)	
(D)	

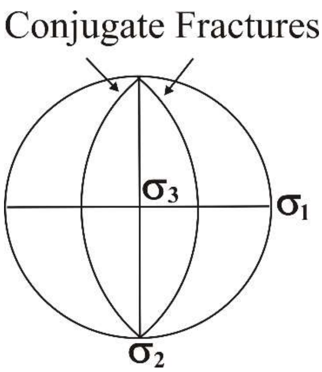
PART A: COMPULSORY SECTION FOR ALL CANDIDATES
Q.11 – Q .17 Carry ONE mark each

Q.11	Which one of the following is the typical product of ductile deformation?
(A)	Gouge
(B)	Breccia
(C)	Cataclasite
(D)	Mylonite
Q.12	Which one among the following coastal erosional landforms is caused by the action of sea waves?
(A)	Ventifact
(B)	Kettle
(C)	Cirque
(D)	Cliff

Q.13	In which one of the following regions of the electromagnetic spectrum does the maximum atmospheric scattering occur?
(A)	UV
(B)	IR
(C)	Radiowave
(D)	Microwave
Q.14	Which one of the following is the Poisson's ratio for an incompressible fluid?
(A)	0
(B)	0.25
(C)	1
(D)	0.5
Q.15	Which among the following Period(s) belong(s) to the Paleozoic Era?
(A)	Carboniferous
(B)	Paleogene
(C)	Silurian
(D)	Cretaceous

Q.16	The average bulk density of a fully saturated sandstone reservoir with a fractional porosity of 0.23 is ______ g/cc. [*round off to 2 decimal places*] [Assume matrix density for sandstone = 2.63 g/cc and fluid density = 1.05 g/cc]
Q.17	For a productive alluvial aquifer with hydraulic conductivity = 105 m/day and hydraulic gradient = 0.01, the flow rate is _________ m/day. [*round off to 2 decimal places*]

Q.18 – Q .26 Carry TWO marks each

Q.18	The relationship between conjugate shear fractures and the principal stresses in a homogenous, isotropic, deformed body is shown in the stereoplot given below (σ_1, σ_2 and σ_3 are compressive stresses). Which one of the given fault regimes is indicated according to the Anderson's theory of faulting for the formation of conjugate shear fractures under plane strain? 
(A)	Dextral strike-slip
(B)	Sinistral strike-slip
(C)	Reverse
(D)	Normal

Q.19	How many independent elastic parameters are needed to describe a homogenous isotropic material?
(A)	21
(B)	2
(C)	36
(D)	3
Q.20	Which one of the following is a mafic volcanic rock?
(A)	Dacite
(B)	Trachyte
(C)	Rhyolite
(D)	Basalt
Q.21	The intercepts of a crystal face on the crystallographic axes are ∞a, 2b, 3c. Which one of the following is its Miller Index?
(A)	(032)
(B)	(023)
(C)	(203)
(D)	(320)

Q.22	Match the locations in Group I with the corresponding economic deposits in Group II. **Group I** P. Wajrakarur Q. Sukinda R. Malanjkhand S. Mangampeta **Group II** 1. Chromite 2. Diamond 3. Barite 4. Copper
(A)	P-3; Q-4; R-1; S-2
(B)	P-3; Q-1; R-4; S-2
(C)	P-2; Q-1; R-4; S-3
(D)	P-2; Q-4; R-1; S-3
Q.23	Choose the CORRECT statement(s) on seismic wave propagation in an elastic isotropic medium.
(A)	P-waves are polarized in the direction of propagation.
(B)	S-waves are polarized in the direction of propagation.
(C)	Rayleigh waves are elliptically polarized.
(D)	Love waves are elliptically polarized.

Q.24	The difference in arrival times of P- and S-waves generated by an earthquake and recorded at a seismological station is one second. Assuming a homogeneous and isotropic Earth, a P-wave velocity (V_P) of 3 km/s, the ratio of P- to S-wave velocities (V_P/V_S) of 2.0, the distance between the station and the hypocenter is __________km. [*round off to 1 decimal place*]
Q.25	Assuming the rate of rotation of the Earth is 7.27×10^{-5} radians/s and the radius of Earth is 6371 km, the centrifugal acceleration at 60° latitude for a spherically rotating Earth is ______$\times 10^{-3}$ m/s^2. [*round off to 1 decimal place*]
Q.26	The angle of inclination of the remanent magnetization of a volcanic rock measured at a location is 45°. The magnetic latitude of the location of the volcanic rock at the time of its magnetization is _________ °N. [*round off to 1 decimal place*]

PART B (SECTION 2): FOR GEOPHYSICS CANDIDATES ONLY
Q.27 – Q.47 Carry ONE mark Each

Q.27	In 2D stacked seismic sections, the vertical axis corresponds to two-way travel time and the horizontal axis corresponds to __________.
(A)	receiver locations
(B)	source locations
(C)	Offsets
(D)	common midpoint (CMP) locations
Q.28	In a 2D seismic survey acquired on land, head waves were recorded at the surface. Assuming that the subsurface consisted of horizontal, isotropic and homogeneous layers, the moveout of the head wave event(s) would be _________.
(A)	linear
(B)	parabolic
(C)	hyperbolic
(D)	elliptical

Q.29	An accurate depth migration of seismic data requires the knowledge of ________.
(A)	interval velocities
(B)	root mean squared (RMS) velocities
(C)	stacking velocities
(D)	normal moveout (NMO) velocities
Q.30	The dimension of bulk modulus is _________.
(A)	$[ML^{-1}T^{-2}]$
(B)	$[MLT^{-1}]$
(C)	$[ML^{-2}T^{-1}]$
(D)	$[ML^{2}T^{-2}]$

Q.31	A current flows from a medium with resistivity ρ_1 to a medium with resistivity ρ_2. A planar interface separates the two media. The angle of incidence and refraction with respect to the normal to the interface are θ_1 and θ_2, respectively. If the components of the current density perpendicular to the interface and the components of the electric field horizontal to the interface are continuous, the electrical law of refraction can be expressed as ____________.
(A)	$\rho_1 \tan \theta_1 = \rho_2 \tan \theta_2$
(B)	$\rho_1 \sin \theta_1 = \rho_2 \sin \theta_2$
(C)	$\rho_2 \cos \theta_1 = \rho_1 \cos \theta_2$
(D)	$\rho_1 \tan \theta_2 = \rho_2 \tan \theta_1$
Q.32	The convolution of two box-car pulses of positive amplitudes, with unequal and finite durations yields a _________ pulse.
(A)	triangular
(B)	trapezoidal
(C)	rectangular
(D)	sinusoidal

Q.33	Which ONE of the following P-phases represents a reflection from the Moho?
(A)	Pn
(B)	Pg
(C)	P*
(D)	PmP
Q.34	The remanent, induced and total magnetizations of a rock sample are denoted by $\overrightarrow{M_R}$, $\overrightarrow{M_I}$ and $\overrightarrow{M_T}$, respectively. The Königsberger ratio is
(A)	$\lvert\overrightarrow{M_I}\rvert / \lvert\overrightarrow{M_R}\rvert$
(B)	$\lvert\overrightarrow{M_R}\rvert / \lvert\overrightarrow{M_T}\rvert$
(C)	$\lvert\overrightarrow{M_R}\rvert / \lvert\overrightarrow{M_I}\rvert$
(D)	$\lvert\overrightarrow{M_I}\rvert / \lvert\overrightarrow{M_T}\rvert$

Q.35	Which among the following is/are CORRECT statement(s) about the Van Allen radiation belts?
(A)	The inner belt consists mainly of protons and the belt extends to about 1000-3000 km from the Earth's surface.
(B)	The belts are doughnut-shaped regions coaxial with the geomagnetic field lines of the Earth.
(C)	The pitch of the helical motion of the charged particles increases as the particles approach the surface of the Earth.
(D)	The outer belt occupies regions between 3 to 4 Earth radii and consists primarily of electrons.
Q.36	Which of the following logging methods can be used to measure the resistivity of the flushed zone?
(A)	Lateral log
(B)	Long normal log
(C)	Microlaterolog
(D)	Microspherically focused log

Q.37	Which of the following statement(s) is/are CORRECT about the continuation of the gravity field?
(A)	Continuation of the gravity field from one surface to another is permissible only when there are no masses present between the two surfaces.
(B)	In upward continuation, the longer wavelength anomalies are attenuated more than the shorter wavelength anomalies.
(C)	Downward continuation may enhance noise and uncertainties.
(D)	Upward continuation is a smoothing process.

Q.38	An oceanic plate formed at a mid-oceanic ridge 27 million years ago. The plate has been moving with a uniform half-spreading rate of 4 cm/year ever since its formation. The current distance between the edge of this plate and the centre of the ridge is __________ km. [*round off to 1 decimal place*]
Q.39	An artificial neural network (ANN) is trained to classify between shale and sand formations. The final layer of the ANN consists of a single neuron with a sigmoid activation function given by $\sigma(x) = \frac{1}{1+e^{-x}}$. If the input to the final neuron is 0, then the output is __________. [*round off to 1 decimal place*]
Q.40	A current electrode introduces a 2 Ampere current at a point (P) on the surface of a uniform half space. If the resistivity of the half space is 5 Ω-m, the magnitude of the electric field (due to the current) in the half space at a distance of 1 m from P is ________ V/m. [*round off to 2 decimal places*]

Q.41	The relative dielectric permittivity of a homogeneous isotropic medium is 10 and the relative magnetic permeability of the same medium is 1. If the velocity of the electromagnetic wave propagating through this medium is v and the velocity of light in vacuum is c, then the ratio v/c is ________. [*round off to 2 decimal places*]
Q.42	A mountain of height 8 km above mean sea level is in isostatic equilibrium with a 42 km thick continental crust. As predicted by Airy's hypothesis, the root beneath this mountain is ________ km. [*round off to 1 decimal place*] [Assume, density of mantle = 3.7×10^3 kg m^{-3} and density of crust = 2.7×10^3 kg m^{-3}]
Q.43	In wet soil of resistivity 100 Ωm, the skin depth of a GPR signal of 100 MHz is _________ m. [*round off to 2 decimal places*] [Assume: $\mu_0 = 4\pi \times 10^{-7} H/m$]
Q.44	A Wadati diagram was prepared for a local earthquake occurring in a homogeneous crust. If the crust is assumed to be a Poisson solid, the slope of the straight line in the Wadati diagram is ________. *[round off to 2 decimal places]*

Q.45 – Q.65 Carry TWO marks Each

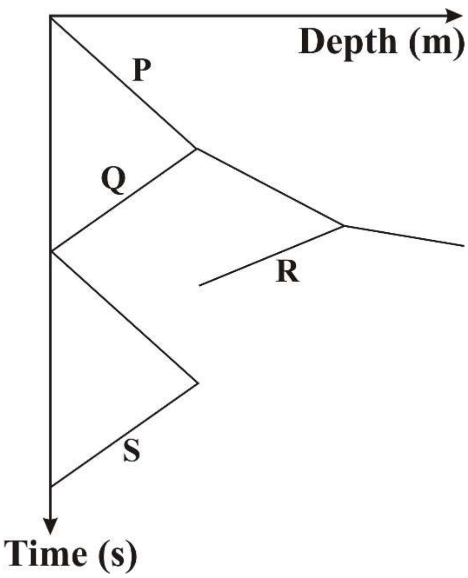
Q.45	The gravitational potential of the spheroidal Earth can be expressed as $U_G = -G\frac{E}{r}\left[1 - \sum_{n=2}^{n=\infty}\left(\frac{R}{r}\right)^2 J_n P_n(\cos\theta)\right]$, where G is the gravitation constant, E is the mass of the Earth, r is the radial distance from the centre of the Earth, R is the radius of Earth, J_n are the coefficients obtained from satellite geodesy, P_n represents the Legendre polynomial of order n, and θ is the colatitude. Which among the following is described by the term corresponding to $n = 2$? [Given: $P_2(\cos\theta) = \frac{1}{2}(3\cos^2\theta - 1)$]
(A)	Gravitational potential due to a spherical Earth
(B)	Deviations from the ellipsoid that correspond to a pear-shaped Earth
(C)	The effect of the polar flattening on the Earth's gravitational potential
(D)	The gravitational potential of the Earth-Moon system
Q.46	The magnetic potential of a dipole at any external point (P) can be expressed as $V = C_m\frac{\vec{m}\cdot\hat{r}}{r^2},\ \ r \neq 0$, where $\vec{m}$ is the dipole moment, $\hat{r}$ is a unit normal along the vector directed from the centre of the dipole to the external point (P) and C_m is a constant. If θ is the angle between $\vec{m}$ and $\hat{r}$, the radial component of $\vec{B}$ is:
(A)	$B_r = 2C_m\frac{m\cos\theta}{r^3}$
(B)	$B_r = C_m\frac{m\cos\theta}{r^3}$
(C)	$B_r = C_m\frac{m\sin\theta}{r^3}$
(D)	$B_r = 2C_m\frac{m\sin\theta}{r^3}$

Q.47	The functions $g(t)$ and $G(\omega)$ constitute a Fourier Transform pair $[g(t) \leftrightarrow G(\omega)]$ as per the convention: $g(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} G(\omega)e^{j\omega t}d\omega$ and $G(\omega) = \int_{-\infty}^{+\infty} g(t)e^{-j\omega t}dt$ Which ONE among the following is the correct Fourier transform pair?
(A)	$\frac{dg(t)}{dt} \leftrightarrow G(\omega)$
(B)	$\frac{dg(t)}{dt} \leftrightarrow j\omega G(\omega)$
(C)	$\frac{dg(t)}{dt} \leftrightarrow -j\omega G(\omega)$
(D)	$\frac{dg(t)}{dt} \leftrightarrow \omega G(\omega)$
Q.48	Gauss' divergence theorem is given by $\int_V \vec{\nabla} \cdot \vec{a}\ dV = \int_S \vec{a} \cdot \vec{dS}$ where $\vec{a}$ is a vector field and V is the volume enclosed by the surface S. If $\vec{a} = \nabla\phi + \vec{\nabla} \times \vec{\psi}$, then the application of divergence theorem to $\vec{a}$ yields:
(A)	$\int_V \nabla^2\phi\ dV = \int_S \nabla\phi \cdot \vec{dS}$
(B)	$\int_V \vec{\nabla} \cdot \vec{\psi}\ dV = \int_S \vec{\psi} \cdot \vec{dS}$
(C)	$\int_V \nabla^2\phi\, dV = \int_S (\vec{\nabla} \times \vec{\psi}) \cdot \vec{dS}$
(D)	$\int_V \phi\ dV = \int_S \vec{\psi} \cdot \vec{dS}$

Q.49	The angular frequency (ω) and wavenumber (k) for an electromagnetic wave is related by the expression $\omega^2 = \alpha k + \beta k^3$, where α and β are constants. The wavenumber k_0 for which the group velocity equals the phase velocity is _______.
(A)	$3\sqrt{\frac{\alpha}{\beta}}$
(B)	$\frac{1}{3}\sqrt{\frac{\alpha}{\beta}}$
(C)	$\sqrt{\frac{\alpha}{\beta}}$
(D)	$\frac{1}{2}\sqrt{\frac{\alpha}{\beta}}$

Q.50	The schematic represents P-wave arrivals from a zero-offset Vertical Seismic Profiling (VSP) experiment conducted over a horizontally layered and isotropic Earth. Match the four events labelled in the schematic and their listed descriptions.

Schematic



Description

1. Primary reflection from the first reflector
2. Direct arrival
3. First order multiple
4. Primary reflection from the second reflector

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

Q.51	The transfer function of a linear system is given as $(s) = \frac{2s+1}{s^2+5s+6}$. The poles of this function are ___________.
(A)	–3 and –2
(B)	–3 and 2
(C)	3 and –2
(D)	3 and 2
Q.52	The eigenvalues of the given matrix ***A*** are __________. $\boldsymbol{A} = \begin{bmatrix} 2 & -1 & 1 \\ -1 & 0 & 1 \\ 1 & 1 & 2 \end{bmatrix}$
(A)	–1, 2 and 3
(B)	1, 2 and 3
(C)	0, 2 and 3
(D)	0, 2 and 2

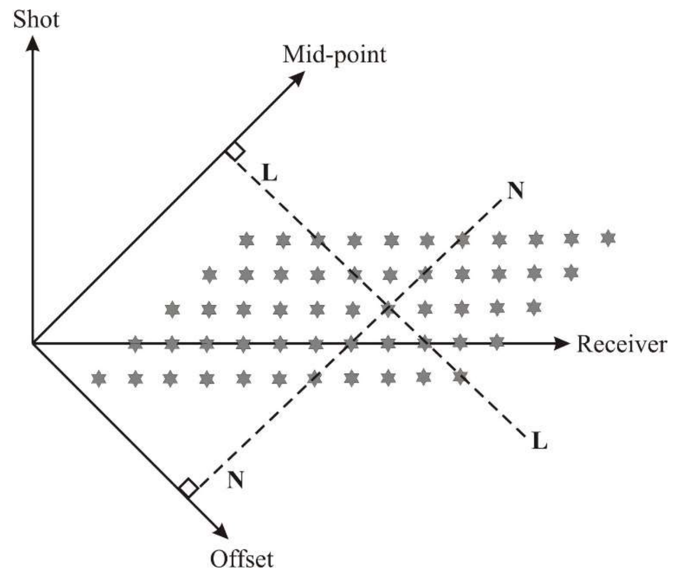
Q.53	The apparent resistivity values obtained from a vertical electrical sounding (VES) survey over a horizontally layered 1-D Earth are indicated by ρ_1, ρ_2, ρ_3, ρ_4, where the subscript refers to the n^{th} layer from the surface. Match the VES curve types listed in Group-I with the corresponding ordering of resistivity values listed in Group-II.

Group-I	Group-II
P. QH	1. $\rho_1 < \rho_2 > \rho_3 < \rho_4$
Q. HK	2. $\rho_1 > \rho_2 > \rho_3 < \rho_4$
R. HA	3. $\rho_1 > \rho_2 < \rho_3 > \rho_4$
S. KH	4. $\rho_1 > \rho_2 < \rho_3 < \rho_4$

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

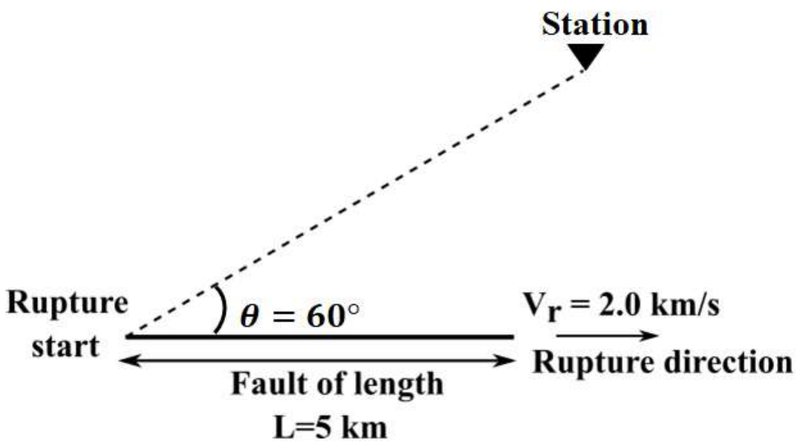
Q.54	Choose the CORRECT statement(s) from the following on the solution of systems of linear equations without the application of regularization.
(A)	An under-determined system of linearly independent equations has either a trivial solution or an infinite number of solutions.
(B)	An ill-conditioned system of linear equations can yield stable solutions in the presence of noise.
(C)	An over-determined system of linearly independent equations does not have an exact solution.
(D)	A system of linearly independent equations with the number of equations equal to the number of unknowns is a mixed-determined system.
Q.55	In seismic spiking deconvolution with an **unknown** source wavelet, the wavelet can be deconvolved most effectively under which of the following condition(s)?
(A)	The source wavelet is minimum phase.
(B)	The source wavelet is zero phase.
(C)	The autocorrelation of the reflectivity series in time domain can be approximated by a delta function.
(D)	The autocorrelation of the reflectivity series in time domain can be approximated to be identically zero.

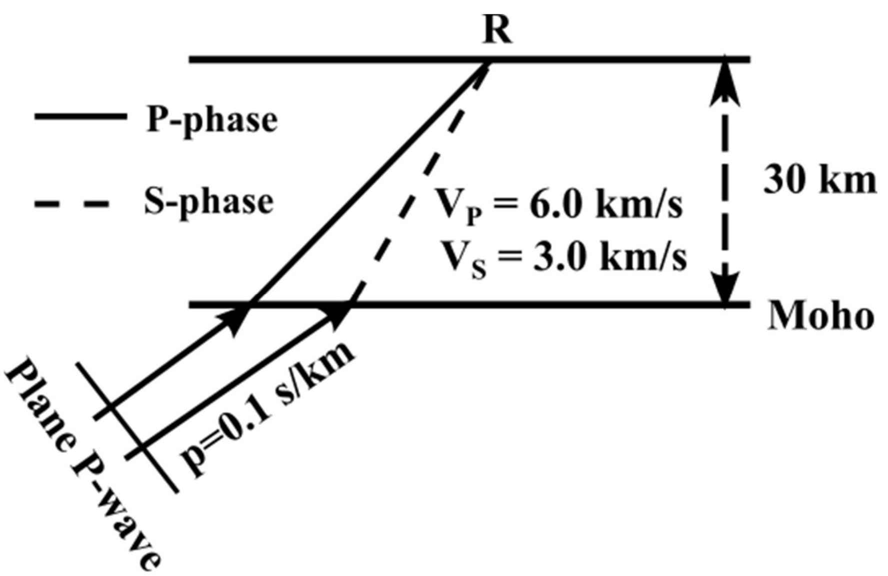
Q.56	The stacking chart for an end-on 2D seismic survey is shown in the figure. The shot, receiver, mid-point and offset coordinate axes are as indicated in the figure, while each star represents a unique seismic trace. With reference to the stacking chart, which of the following is/are CORRECT statement(s)?



(A)	The traces along LL constitute a common mid-point (CMP) gather.
(B)	The traces along LL constitute a common shot gather.
(C)	The traces along NN constitute a common offset gather.
(D)	The traces along NN constitute a common receiver gather.
Q.57	Suppose $x_{1/5}$ defines the half-width at 1/5th of the maximum gravity value measured over a buried sphere of uniform density. If d is the distance from the surface to the centre of the sphere, the value of $\frac{x_{1/5}}{d}$ is ________. [*round off to 2 decimal places*]

Q.58	In a reservoir zone, the deep induction log reads 3 Ωm for a formation whose porosity is 19%. The hydrocarbon saturation of that formation as estimated from Archie's equation is ______%. [*round off to 1 decimal place*] [Assume: a=1, n=2, m=1.5, formation water resistivity = 0.04 Ωm]
Q.59	The heat flow q (mW/m^2) is related to the age t (My) of the ocean floor as $t = (510/q)^2$. Assuming the temperature gradient and the thermal conductivity at a site in the Indian ocean to be 55 °C/km and 2.3 W/m °C, respectively, the age of the site is_______ My. [*round off to 2 decimal places*] [Use the magnitude of the calculated value of q]
Q.60	The radioactive isotopes ^{A}X and ^{B}X of an element X at the time of formation of a rock sample were in equal proportions. Subsequently, in a closed system, it was found that the abundances of the isotopes were in the ratio ^{B}X / ^{A}X = 128.55. The elapsed time since the formation of the sample is ______ years. [*round off to 1 decimal place*] [Assume: decay rate of $\lambda_A = 9.85 \times 10^{-3}$ y^{-1}, $\lambda_B = 1.55 \times 10^{-3}$ y^{-1}].
Q.61	A two-layered planet consists of a core and a mantle of uniform but unequal densities. The density of the core is 7150 kg m^{-3} and the mean density of the planet is 5620 kg m^{-3}. If the mantle enclosing the core occupies 2/3rd of the radius of the planet from the surface, then the density of the mantle is ______ kg m^{-3}. [*round off to 1 decimal place*]

Q.62	A reflection seismic survey is conducted over a two-layered medium with a single horizontal, homogeneous, isotropic layer underlain by a homogenous, isotropic half-space. The Shuey two-term approximation for the P-wave reflection coefficient for the interface separating the media is given by: $R(\theta) = 0.025 - 0.1\ \sin^2\theta$, where θ is the angle of incidence of the P-wave with respect to the normal to the interface. Assuming the validity of the approximation, the offset-to-depth ratio (offset/depth) at which a polarity reversal can be observed in a CMP gather from the survey is _________. *[round off to two decimal places]* [Hint: A change in the sign of the reflection coefficient leads to polarity reversal]
Q.63	The given figure shows the rupture of a unilateral fault with the rupture velocity (V_r) of 2 km/s. According to the simple Haskell source model, the rupture time associated with the entire length of the fault as estimated at the station is ________ sec. [*round off to 2 decimal places*] [Assume: Shear wave speed = 3.5 km/s] 

Q.64	The given figure shows ray paths for direct P and P-to-S converted phases recorded at a station on the surface (R) for a teleseismic event. Given that the ray parameter (p) is 0.1 s/km, the arrival time difference between the P-to-S converted phase and the direct P-phase at the receiver R is _____sec. [*round off to 2 decimal places*] 
Q.65	A land seismic survey is conducted over a horizontally layered and isotropic Earth. The thickness and the P-wave velocity of the homogeneous weathered layer are 5 m and 800 m/s, respectively. The shots are fired at a depth of 5 m below the surface and the receivers are placed on the surface at mean sea level (MSL). If the datum plane is defined to be 5 m below the MSL, the magnitude of the P-wave static correction to be applied to the data is ________ milliseconds. [*round off to 2 decimal places*]

Q. No.	Session	Question Type	Subject Name	Key/Range	Mark
1	4	MCQ	GA	C	1
2	4	MCQ	GA	D	1
3	4	MCQ	GA	C	1
4	4	MCQ	GA	C	1
5	4	MCQ	GA	C	1
6	4	MCQ	GA	B	2
7	4	MCQ	GA	D	2
8	4	MCQ	GA	A	2
9	4	MCQ	GA	C	2
10	4	MCQ	GA	C	2
11	4	MCQ	GG	D	1
12	4	MCQ	GG	D	1
13	4	MCQ	GG	A	1
14	4	MCQ	GG	D	1
15	4	MSQ	GG	A, C	1
16	4	NAT	GG	2.24 to 2.30	1
17	4	NAT	GG	1.00 to 1.10	1
18	4	MCQ	GG	C	2
19	4	MCQ	GG	B	2
20	4	MCQ	GG	D	2
21	4	MCQ	GG	A	2
22	4	MCQ	GG	C	2
23	4	MSQ	GG	A, C	2
24	4	NAT	GG	3.0 to 3.0	2
25	4	NAT	GG	16.3 to 17.3	2
26	4	NAT	GG	26.2 to 27.0	2
27	4	MCQ	GG	D	1
28	4	MCQ	GG	A	1
29	4	MCQ	GG	A	1
30	4	MCQ	GG	A	1
31	4	MCQ	GG	A	1
32	4	MCQ	GG	B	1
33	4	MCQ	GG	D	1
34	4	MCQ	GG	C	1
35	4	MSQ	GG	A, B, D	1
36	4	MSQ	GG	C, D	1
37	4	MSQ	GG	A,C, D	1
38	4	NAT	GG	1080.0 to 1080.0	1
39	4	NAT	GG	0.5 to 0.5	1
40	4	NAT	GG	1.55 to 1.65	1
41	4	NAT	GG	0.29 to 0.35	1
42	4	NAT	GG	21.0 to 22.0	1
43	4	NAT	GG	0.46 to 0.54	1
44	4	NAT	GG	0.71 to 0.75	1

45	4	MCQ	GG	C	2
46	4	MCQ	GG	A	2
47	4	MCQ	GG	B	2
48	4	MCQ	GG	A	2
49	4	MCQ	GG	C	2
50	4	MCQ	GG	A	2
51	4	MCQ	GG	A	2
52	4	MCQ	GG	A	2
53	4	MCQ	GG	B	2
54	4	MSQ	GG	A, C	2
55	4	MSQ	GG	A, C	2
56	4	MSQ	GG	A, C	2
57	4	NAT	GG	1.34 to 1.44	2
58	4	NAT	GG	57.0 to 63.0	2
59	4	NAT	GG	16.00 to 16.50	2
60	4	NAT	GG	580.0 to 590.0	2
61	4	NAT	GG	5556.1 to 5566.1	2
62	4	NAT	GG	1.10 to 1.20	2
63	4	NAT	GG	1.69 to 1.89	2
64	4	NAT	GG	4.00 to 4.50	2
65	4	NAT	GG	6.20 to 6.30	2