Question Paper Name: GATE 2019 Paper

Duration: 180

Total Marks: 100

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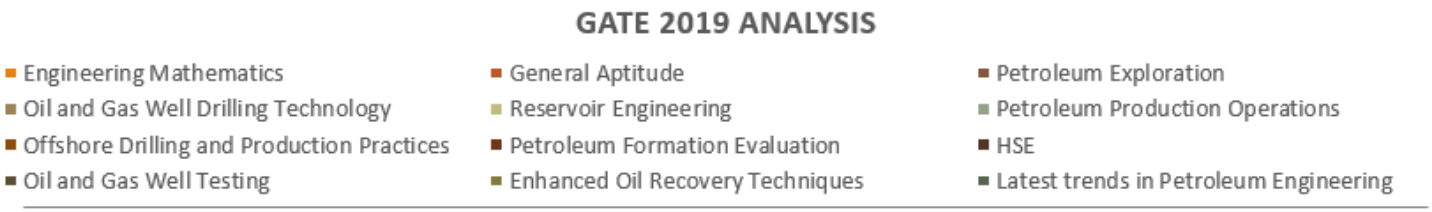
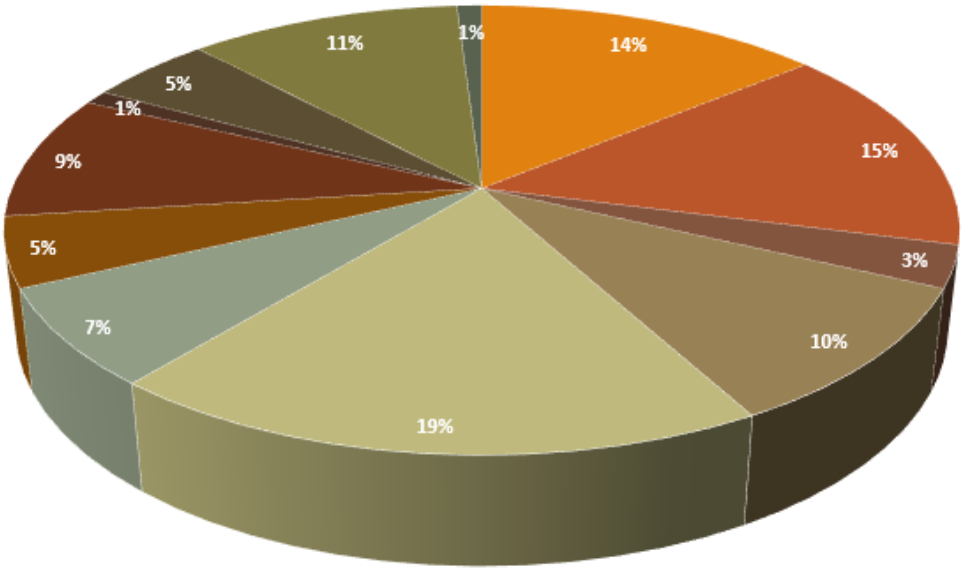
Gate 2019

The Gate 2019 is conducted by Indian Institute of Technology (IIT) Madras. In this Paper the maximum marks is from Reservoir Engineering.

Organizing Institute	IIT Madras
Number of Candidates Registered	2428
Number of Candidates Appeared	2035
Air 1st Rank Marks (out of 100)	84.67
General/EWS Qualifying Marks (out of 100)	49.9
OBC Qualifying Marks (out of 100)	44.9
SC/ST Qualifying Marks (out of 100)	33.3





SUBJECT	Number of Questions		Total Marks
	1 Mark	2 Mark	
Engineering Mathematics	6	4	14
General Aptitude	5	5	15
Petroleum Exploration	1	1	3
Oil and Gas Well Drilling Technology	2	4	10
Reservoir Engineering	5	7	19
Petroleum Production Operations	1	3	7
Offshore Drilling and Production Practices	3	1	5
Petroleum Formation Evaluation	3	3	9
HSE	1	0	1
Oil and Gas Well Testing	1	2	5
Enhanced Oil Recovery Techniques	1	5	11
Latest trends in Petroleum Engineering	1	0	1
TOTAL	30	35	100

Gate 2019 Question Paper

Q.1 The fishermen, _____the flood victims owed their lives, were rewarded by the government.
(A) whom
(B) to which
(C) to whom
(D) that

Q.2 Some students were not involved in the strike.
If the above statement is true, which of the following conclusions is/are logically necessary?
1. Some who were involved in the strike were students.
2. No student was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.
(A) 1 and 2
(B) 3
(C) 4
(D) 2 and 3

Q.3 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is .
(A) 17.1
(B) 21.0
(C) 33.1
(D) 72.8

Q.4 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:
1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.
Which is the second number from the right?
(A) 2
(B) 4
(C) 7
(D) 10

Q.5 Until Iran came along, India had never been_in kabaddi.
(A) defeated
(B) defeating

(C) defeat
(D) defeatist

Q.6 Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates.
Which one of the following statements can be inferred from the given passage?
(A) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced
(B) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates
(C) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes
(D) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

Q.7 In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?
(A) 10.50
(B) 14.70
(C) 15.00
(D) 50.00

Q.8 The nomenclature of Hindustani music has changed over the centuries. Since the medieval period dhrupad styles were identified as baanis. Terms like gayaki and baaj were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term gharana became acceptable. Gharana originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?
(A) dhrupad, baani
(B) gayaki, vocal
(C) baaj, institution
(D) gharana, lineage

Q.9 Two trains started at 7AM from the same point. The first train travelled north at a speed of 80km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is ____AM.

(A) 9
(B) 10
(C) 11
(D) 11.30

Q.10 "I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community."
Based on the paragraph above, the prestige of a head-hunter depended upon

(A) The prestige of the kingdom
(B) The prestige of the heads
(C) the number of taxes he could levy
(D) The number of heads he could gather

Q.11 Let r and θ be the modulus and argument of the complex number $z = 1 + i$, respectively. Then (r, θ) equals

(A) $(\sqrt{2}, \pi/4)$
(B) $(2, \pi/2)$
(C) $(2, \pi/3)$
(D) $(\sqrt{2}, \pi)$

Q.12 Let $\lambda 1$ and $\lambda 2$ be the two eigenvalues of the matrix $A = \begin{bmatrix} 0 & -1 \\ 1 & 1 \end{bmatrix}$
Then, $\lambda 1 + \lambda 2$ and $\lambda 1,2$ are respectively

(A) 1 and 1
(B) 1 and −1
(C) −1 and 1
(D) −1 and −1

Q.13 The Laplace transform of the function $(t) = e^{-t}$ is given by

(A) $\frac{1}{(s+1)^2}$
(B) $\frac{1}{s-1}$
(C) $\frac{1}{s+1}$
(D) $\frac{1}{(s-1)^2}$

Q.14 The relative decline rate of oil is given by $\frac{1}{q}\frac{dq}{dt} = -a\, q^b$, where q is the oil production rate, a (> 0) is the decline rate and b is a constant.
The equation gives harmonic decline curve when b is

(A) 1.5
(B) 1
(C) 0.5
(D) 0

Q.15 Which one of the following provides a vertical stab for the flow lines and annulus access lines from multiple wells in offshore subsea completion?
(A) Moon pool deck
(B) Spider beams
(C) Telescopic joints
(D) Manifold

Q.16 In a faulted reservoir, the principle of superposition for the pressure drop using diffusivity equation is applicable. This is due to
(A) High Reynolds number flow in the well.
(B) constant permeability.
(C) pressure dependent viscosity.
(D) linearity of the diffusivity equation.

Q.17 Which one of the following parameters is measured using routine core analysis (RCA)?
(A) Porosity
(B) Relative permeability
(C) Capillary pressure
(D) Wettability

Q.18 Match the following
P. Induction Log I. Equivalent water resistivity
Q. Dielectric Log II. Resistivity
R. Self-Potential Log III. Conductivity
S. Electrical Log IV. Permittivity

(A) P-II, Q-IV, R-III, S-I
(B) P-III, Q-I, R-IV, S-II
(C) P-II, Q-III, R-IV, S-I
(D) P-III, Q-IV, R-I, S-II

Q.19 Which one of the following rocks and reservoir fluids are arranged in the decreasing order of their electrical resistivity? Assume that rocks have equal porosity and are filled

with brine.

(A) Shale > Brine > Sandstone > Limestone > Gas
(B) Gas > Shale > Sandstone > Limestone > Brine
(C) Gas > Limestone > Sandstone > Shale > Brine
(D) Shale > Brine > Limestone > Sandstone > Gas

Q.20 Which one of the following is the correct sequence of events for hydrocarbon generation in the subsurface?

(A) Catagenesis→ Metagenesis → Diagenesis
(B) Catagenesis → Diagenesis → Metagenesis
(C) Diagenesis → Catagenesis → Metagenesis
(D) Diagenesis → Metagenesis→ Catagenesis

Q.21 Match the following:

P. Bingham plastic I. $\tau = k\gamma n$
Q. Power law II. $\tau = \tau y + k\gamma n$
R. Power law with yield stress III. $= \tau y + \mu p\gamma$

Here
τ : shear stress
τy: yield value or yield stress
μp: shear viscosity
n: power law index
k: consistency index
γ: shear rate

(A) P-II, Q-I, R-III
(B) P-I, Q-III, R-II
(C) P-III, Q-II, R-I
(D) P-III, Q-I, R-II

Q.22 Match the following

P. Twist off	I. due to excessive tension
Q. Parting	II. due to excessive torque
R. Collapse	III. due to cyclic loading
S. Fatigue for drill pipe failure:	IV. due to extensive external pressure

(A) P-III, Q-IV, R-I, S-II
(B) P-II, Q-I, R-IV, S-III
(C) P-I, Q-II, R-III, S-IV

(D) P-IV, Q-III, R-II, S-I

Q.23 Which one of the following flow regimes is more favorable for gas lift operation?
(A) Bubbly flow
(B) Annular flow
(C) Churn flow
(D) Stratified flow

Q.24 H2S gas is
(A) acidic.
(B) non-corrosive.
(C) lighter than air.
(D) non-flammable.

Q.25 Which one of the following offshore platforms DOES NOT use buoyant columns or pontoons?
(A) Tension leg platforms
(B) Jack up platforms
(C) Spar platforms
(D) Semi-submersible platforms

Q.26 In which one of the following offshore platforms, the condition of the sea floor is a vital consideration?
(A) Drill ship platforms
(B) Tension leg platforms
(C) Concrete gravity platforms
(D) Floating, production, storage and offloading (FPSO) platforms

Q.27 The 'Klinkenberg effect' is related to
(A) viscous fingering during water flooding in oil reservoirs.
(B) hysteresis effect in relative permeability during drainage and imbibition process.
(C) oil viscosity dependence on temperature.
(D) slippage of gas phase at the sand grain surface.

Q.28 Favourable conditions for formation of gas hydrates are
(A) high temperature and high pressure.
(B) high temperature and low pressure.

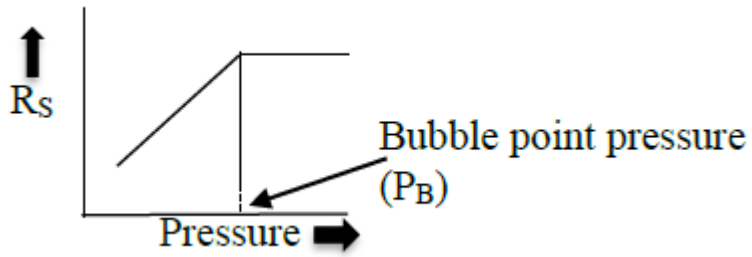
(C) low temperatureand high pressure.
(D) low temperature and low pressure.

Q.29 Match the fo llowing quantities with their dimensions:
P. Viscosity
Q. Permeability
R. Compressibility
S. Pressure

I. $M^1 L^{-1} T^{-2}$
II. $M^0 L^2 T^0$
III. $M^1 L^{-1} T^{-1}$
IV. $M^{-1} L^1 T^2$

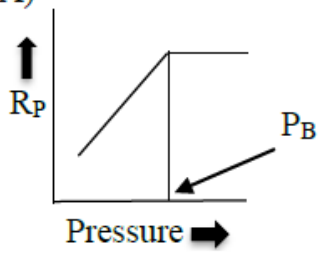
(A) P-III, Q-II, R-IV, S-I
(B) P-II, Q-I, R-IV, S-III
(C) P-III, Q-I, R-IV, S-II
(D) P-I, Q-II, R-III, S-IV

Q.30. The plot of dissolved gas oil ratio (RS), defined as the "ratio of STP volume of gas dissolved in the oil at pressure P, to the volume of the oil at STP" is given below.

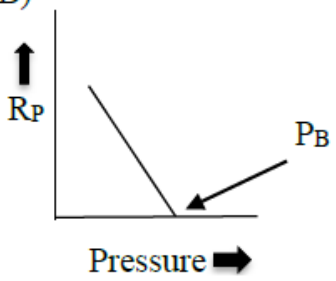


For the same oil, the plot of produced gas oil ratio (RP) defined as the "ratio of STP volume of the gas liberated from the oil at pressure P, to the volume of the oil at STP" is

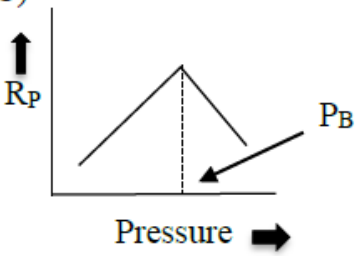
(A)



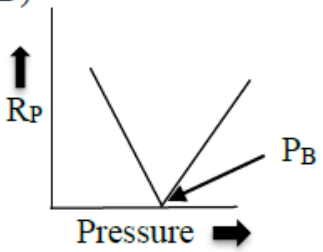
(B)



(C)



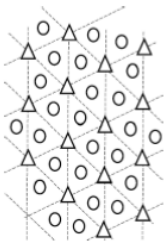
(D)



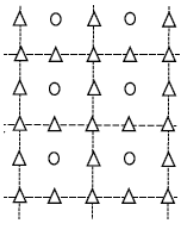
Q.31. which one of the following denotes a regular four-spot flood Pattern?

△ represents injection well
o represents production well

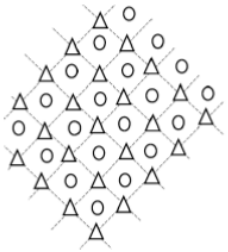
(A)



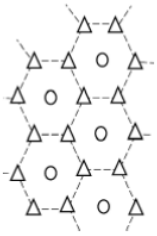
(B)



(C)



(D)



Q.32 The value of is $\lim_{x \to 0} \frac{(x+1)sinx}{x^2+2x}$ (round off to 2 decimal places).

Q.33 Let A = $\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$, X = $\begin{bmatrix} 1 & a \\ b & 0 \end{bmatrix}$ and Y = $\begin{bmatrix} 3 & 1 \\ 3 & 2 \end{bmatrix}$ If $AX = Y$, then $a + b$ equals __.

Q.34 Let $\vec{u} = i + j + ak$ and $v = a^2 i + 4j - 4k$, where i, j and k are cartesian unit vectors. If
$\vec{u}$ is perpendicular to v, then a equals _____ .

Q.35 If the neutron log porosity (ϕN) is 0.09 and density log porosity (ϕD) is 0.24 in the cross- over region, then the average porosity of the gas bearing region is ____(round off to 2 decimal places).

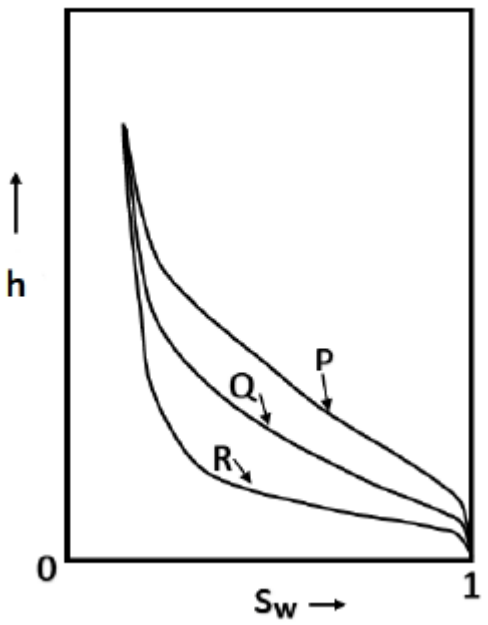
Q.36 .The general solution of the differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = 0$ is (here C1 and C2 are arbitrary constants)
(A) y = C1 e^x + C2 e^{-x}
(B) y = C1 xe^x + C2 xe^{2x}
(C) y = C1 e^x + C2 xe^{-x}
(D) y = C1 e^x + C2 xe^x

Q.37 Consider the following system of linear equations (where p and q are constants)

$x_1 + {}_2 + x_3 = 1$
$x_1 - x_2 + 2x_3 = p$
$3x_1 - x_2 + 5x_3 = q$

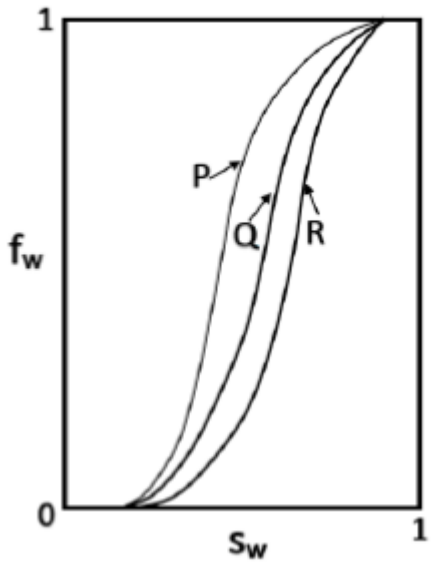
This system has at least one solution for any p and q satisfying
(A) $2p - q + 1 = 0$.
(B) $2q + p + 1 = 0$.
(C) $2p + q - 1 = 0$.
(D) $2q + p - 1 = 0$.

Q.38 Three reservoirs P, Q and R have identical geometry and rock properties. The plot of the height of the transition zone (h) above the free water level (FWL) against the water saturation (Sw) is given in the figure. Assume $\sigma \cos \theta$ for all the three fluid combinations remains the same. Which one of the following is the correct match of the reservoir fluids with the reservoir (σ is the interfacial tension between the respective fluid phases and θ is the contact angle).



(A) P: low density oil – water, Q: gas – water, R: high density oil – water
(B) P: gas – water , Q: low density oil – water, R: high density oil – water
(C) P: high density oil – water, Q: low density oil – water, R: gas – water
(D) P: gas – water, Q: high density oil – water, R: low density oil – water

Q.39 The fractional flow (fw) versus water saturation (Sw) curve for an imbibition process (neglecting the capillary forces) in a given core for three different inclinations is shown in the figure.



Which one of the following is the correct representation of the fractional flow curves?

(A) P: Down-dip, Q: No-dip, R: Up-dip
(B) P: Down-dip, Q: Up-dip, R: No-dip
(C) P: No-dip, Q: Down-dip, R: Up-dip
(D) P:Up-dip, Q: No-dip, R: Down-dip

Q.40 Match the following:

P. Dynamic positioning	I. Self-contained drilling rig on a floating barge, fitted with long support legs that can be raised or lowered independently of each other.
Q. Mooring	II. A system which automatically controls a vessel's position and heading exclusively by means of active thrust.
R. Jack-up	III. Remains afloat by weight and buoyancy balance.
S. Semi-submersible platform	IV. A system that is used for station keeping of a floating platform or ship at any depth.

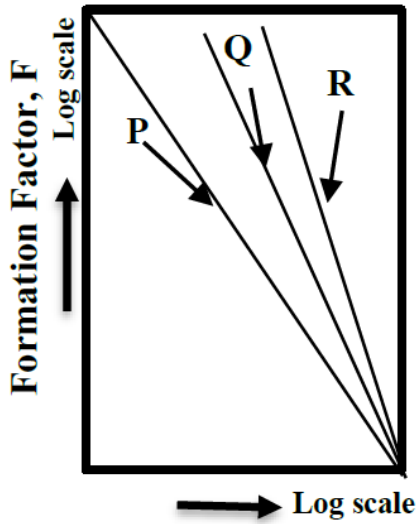
(A) P-IV, Q-II, R-I, S-III
(B) P-III, Q-I, R-IV, S-II
(C) P-II, Q-IV, R-I, S-III
(D) P-II, Q-IV, R-III, S-I

Q.41 Match the following:

P. Increase in sweep efficiency at the macroscopic-level by increasing water viscosity	I. LPG injection
Q. Increase in sweep efficiency at the macroscopic-level by decreasing oil viscosity	II. Surfactant flooding
R. Increase in displacement efficiency at the pore-scale by using a miscible displacing fluid	III. In-situ combustion
S. Increase in displacement efficiency at the pore-scale by reducing interfacial tension	IV. Polymer flooding

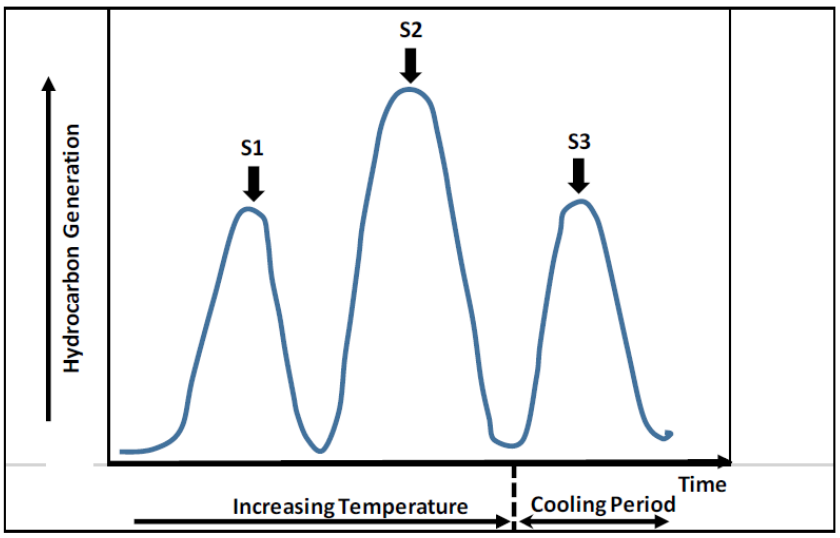
(A) P-I, Q-IV, R-III, S-II
(B) P-I, Q-II, R-IV, S-III
(C) P- IV, Q-III, R-I, S-II
(D) P-IV, Q-I, R-II, S-III

Q.42 An exploratory well encountered three reservoir formations S1 (perfectly cemented), S2 (poorly cemented) and S3 (fractured). The Formation Factor (F) is governed by the equation $F = a\phi^{-m}$, where 'ϕ' is the porosity and 'm' is the cementation factor. The constant 'a', linked to tortuosity is assumed to be 1 for all the formations. The log-log plot between Formation Factor (F) and porosity (ϕ) is shown.



Which one of the following represents the correct match of the formations with their respective plots?
(A) S1-P, S2-Q, S3-R
(B) S1-R, S2-P, S3-Q
(C) S1-P, S2-R, S3-Q
(D) S1-R, S2-Q, S3-P

Q.43 Typical parameters obtained in the pyrolysis experiment of the source rock materials are shown in the Figure. Which one of the following is NOT true about pyrolysis in source rock analysis?



(A) Peak S1 represents volatilization of existing hydrocarbons.
(B) Peak S2 represents breakdown of kerogen and generation of hydrocarbons.
(C) Peak S3 represents Tmax, the temperature at which most hydrocarbons are generated.
(D) S1/(S1+S2) represents the production index.

Q.44 A single well encounters multiple clean sands of exactly the same thickness, porosity and permeability. Rw is the formation fluid resistivity and Rmf is the mud filtrate resistivity

P. Rmf > Rw	I. No deflection
Q. Rmf = Rw	II. Positive deflection
R. Rmf < Rw	III. Negative deflection

Which one of the following match the relation between Rw and Rmf to that of Self Potential (SP) log deflection?
(A) P-I,Q-III,R-II
(B) P-III,Q-I,R-II
(C) P-II,Q-I,R-III
(D) P-I,Q-II,R-III

Q.45 Which one of the following options is **NOT** a part of the mud logs prepared by the drill-site geologist?
(A) Rate of Penetration (ROP)
(B) Chromatograph showing presence of C1 to C5 concentration
(C) Lithology from drill cutting and its interpretation
(D) Reservoir unit delineation based on volume of shale (Vsh)

Q.46 Match the following:

P. Location of storing the kelly on the trip	I. Mousehole
Q. Location of storing the next drill pipe	II. Rathole
R. Location of storing pump pressure gauges	III. Top driv
S. Rotational system that controls a drill string without a kelly	IV. Standpipe

(A) P-II, Q-I, R-IV, S-III
(B) P-IV, Q-II, R-III, S-I
(C) P-II, Q-I, R-III, S-IV
(D) P-IV, Q-III, R-II, S-I

Q.47 A box contains 2 red and 3 black balls. Three balls are randomly chosen from the box and are placed in a bag. Then the probability that there are 1 red and 2 black balls in the bag, is _____ .

Q.48 The values of a function (x) over the interval [0,4] are given in the table below:

x	0	1	2	3	4
$f(x)$	1	0.5	0.2	0.1	0.06

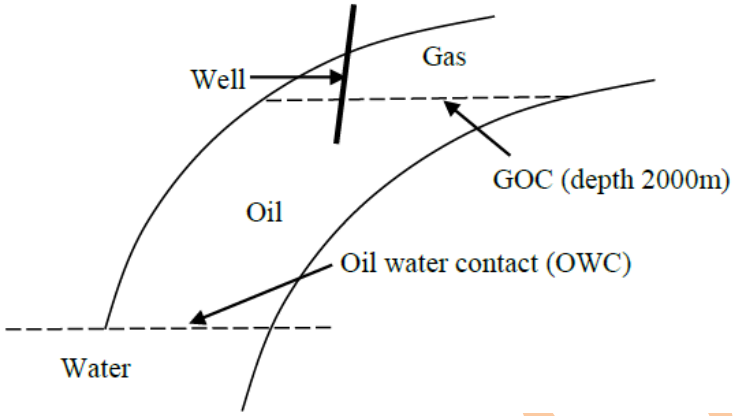
Then, according to the trapezoidal rule, the value of the integral $\int_0^4 f(x)dx$ is_____(round off to 2 decimal places).

Q.49 Oil is produced at a constant rate from a well in a bounded reservoir. The variation of the bottom-hole pressure with time is shown in the given Table. The magnitude of the slope of the pressure vs time curve that you would use to find the drainage area is _____ psi/day (round off to 1 decimal place).

Time (days)	**Flowing bottom- hole pressure (psi)**	**Time (days)**	**Flowing bottom- hole pressure (psi)**
0	3500	6	2512
1	2864	7	2482
2	2725	8	2452
3	2644	9	2422
4	2587	10	2392
5	2542	11	2362

Q.50 In a core flood experiment of immiscible and incompressible displacement of oil (μo = 1 cP) with water (μw = 1 cP), only axial flow is observed. The relative permeability of water is given by $krw = Sw^2$, where Sw is water saturation. The relative permeability of oil is given by $kro = (1 - Sw)^2$. The gravity and capillary pressure are neglected. From the fractional flow and water saturation relationship, the saturation of water at the flood front is ____ % (round off to 1 decimal place).

Q.51 In an oil well, the pressure at the gas oil contact (GOC) at a depth of 2000 m is 205 bar (gauge), as shown in the figure.



The static oil pressure gradient is 0.08 bar/m in the pay zone. If a constant hydrostatic pressure gradient of 0.1 bar/m prevails throughout the subsurface, then the thickness of the oil column is _____m (round off to 1 decimal place).

Q.52 Oil is produced at a constant rate of 10 m3/day from a reservoir for 500 days. The producing gas oil ratio (GOR) is constant at 10 $\frac{\text{m3 gas}}{\text{m3 oil}}$ for the first 100 days. Then, the producing gas oil ratio increases linearly and on the 500th day the measured GOR is 50 $\frac{\text{m3 gas}}{\text{m3 oil}}$.The cumulative produced gas oil ratio after 500 days of production is_____ $\frac{\text{m3 gas}}{\text{m3 oil}}$ (round off to 1 decimal place). Assume that all volumes are measured at STP.

Q.53 A pressure build-up test was conducted in a well after 1000 days of producing oil at a constant rate of 0.01 reservoir-m3/s. The two shut-in bottom-hole pressure readings taken at 0.5 day and 1 day after shut-in are 150×10^5 Pa and 151×10^5 Pa, respectively. These pressure points correspond to the linear region of the Horner's plot. The reservoir thickness is 100 m and oil viscosity is 0.001 Pa.s. The permeability of the reservoir is _____mD (round off to 1 decimal place). [1 mD = 10^{-15} m2].

Q.54 In an oil reservoir, the residual oil saturation in the volume flooded with polymer solution is 20%. The initial water saturation is 20%. The volumetric sweep efficiency is 50%. The maximum possible recovery factor for the reservoir is _____% (round off to 1 decimal place).

Q.55 An electrical submersible pump (ESP) delivers well fluid with 100% watercut. In the ESP, the impeller diameter is 0.1 m and speed is 3600 rpm. The total head developed by the ESP is 300 m (water column height). If the stage efficiency of the ESP is 60%, then the minimum number of stages required is _____ (round off to nearest integer). [g = 9.81 m/s2]

Q.56 In a counter flow heat exchanger, hot fluid enters at 100°C and leaves at 50°C. Cold fluid enters at 30°C and leaves at 40°C. If heat losses are ignored, then the logarithmic mean temperature difference (LMTD) is ___°C (round off to 1 decimal place).

Q.57 A model porous block of cross sectional area (A) and length (L) is made up of N independent capillaries of equal radii (r) and length (L). The porosity of the block is 10%, and the permeability for a laminar, incompressible and steady state flow is 0.02 mD. If the flow is only through the capillaries, then the value of r is _____x 10^{-6} cm (round off to 1 decimal place). [1 mD = 10^{-15} m2].

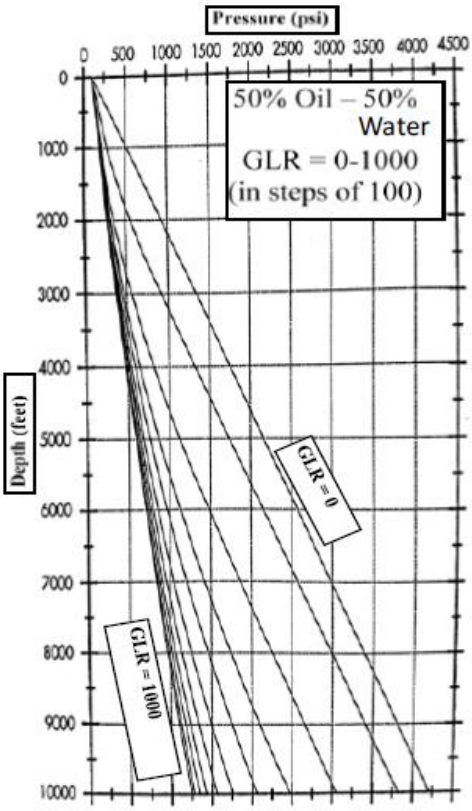
Q.58 A model porous medium of 5 cylindrical capillaries of radii varying from 60 to 100 micrometers (refer Table) is subjected to Mercury Injection Capillary Pressure (MICP) treatment. The capillaries are being filled in an increasing order of their entry pressure. The magnitude of $(\sigma \cos \theta)_{r-Hg}$ is 367 dyne/cm
,where σ is the interfacial tension and θ is the contact angle. The minimum applied mercury pressure to achieve 50% mercury saturation in the sample is _ ____× 10 dyne/cm2 (round off to 1 decimal place).

Radius (µm)	**Cross-sectional area (µm2)**	**Cross sectional area (fraction)**	**Cumulative area (fraction)**
60	11304	0.11	1.00
70	15386	0.15	0.89
80	20096	0.19	0.74
90	25434	0.25	0.55
100	31400	0.30	0.30
Total Area =	103620		

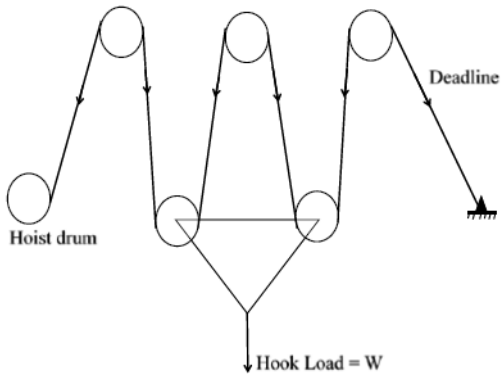
Q.59 The sonic log parameters from an exploratory well in a reservoir are as follows:
Measured P-wave transit time ($\Delta tlog$) = 85 µs/ft
True resistivity (Rt) = 10 ohm-m
Matrix transit time (Δtma) = 45 µs/ft
Fluid transit time (Δtfl) = 205 µs/ft
Formation water resistivity at reservoir temperature (Rw) = 0.1 ohm-m
The hydrocarbon saturation (in percentage) in the reservoir is _____(round off to 1 decimal place).

[Hint: Wyllie time average equation is Δtlog = (1-ϕ)Δtma + ϕ Δtfl and formation water resistivity has the correlation Rw = $\frac{1}{a}\emptyset^2\ Rt\ \ Sw^2$, where Sw is water saturation, ϕ is porosity and a = 1]

Q.60 A vertical well of 8000 ft is producing below bubble point pressure. Oil and water each is produced at the rate of 500 bbl/day. The indicated bottom hole pressure is 3000 psi. If the same gas to liquid ratio (GLR) is maintained, using the given figure, the new bottom hole pressure at 5000 ft is _____psi.



Q.61 In a drilling rig, the crown block and the traveling block have three and two sheaves, respectively. A single wireline connects the hoisting drum to the deadline anchor as shown in the figure. Neglect the weight of the pulleys and the wireline, and friction between the sheaves and wireline. The ratio of the deadline load to static crown load is _(round off to 2 decimal places).



Q.62 Cement weighing 100 kg is mixed with 50 liters of water. The specific gravity of cement is 3.14 and the density of water is 1000 kg/m3. Neglecting volume changes, the resulting density of the slurry is_____kg/m3 (round off to 1 decimal place).

Q.63 In an active water drive during a certain period, the rate of production and reservoir pressure remain constant. The water influx into the reservoir from the aquifer is 6000 bbl/day. The surface oil and water production rates are 3000 STB/day and 1500 STB/day, respectively. The current production gas to oil ratio is 825 SCF/STB, and the formation volume factors at the current pressure for oil, water and gas are 1.375 bbl/STB, 1.04 bbl/STB and 0.007 bbl/STB, respectively. The solution gas to oil ratio at the current pressure is _SCF/STB (round off to 1 decimal place).

Q.64 In a water flooding experiment, the pressure gradients in the displacing and displaced phases are 400 psi/ft and 350 psi/ft, respectively. Assume that the displacement front is stable in the absence of capillary and gravity forces. Consider that only water flows upstream and only oil flows downstream of the displacement front. Then the mobility ratio for this immiscible displacement process is _(round off to 2 decimal places).

Q.65 In a pressure draw-down testing, the well bore flowing pressure (Pwf) is given by

$$P_{wf} = P_i - \frac{162.6\, q\, \mu\, B}{kh}\left[log\left(\frac{kt}{\emptyset \mu c r_w^2}\right) - 3.23 + 0.87\, S\right].$$

The following data is given in the oil field units,
Initial reservoir pressure (Pi) = 5000 psia
Pressure after 1 hr of production (P1hr) = 4000 psia
Oil flow rate (q) = 500 STB/day
Porosity (Ø) = 0.25
Viscosity of oil (μ) = 2 cP
Formation volume factor of oil (B) = 1.2 bbl/STB
Formation thickness (h) = 20 ft
Total compressibility (c) = 30 × 10^{-6} psi-1
Well bore radius (rw) = 0.3 ft

The slope of Pwf versus log t is −100 psi/cycle. Then, the skin factor (S) for this well is __ (round off to 1 decimal place).

Q.1 The fishermen,_____the flood victims owed their lives, were rewarded by the government.
(A) whom
(B) to which
(C) to whom
(D) that
Ans:C

Q.2 Some students were not involved in the strike.
If the above statement is true, which of the following conclusions is/are logically necessary?
1. Some who were involved in the strike were students.
2. No student was involved in the strike.
3. At least one student was involved in the strike.
4. Some who were not involved in the strike were students.
(A) 1 and 2
(B) 3
(C) 4
(D) 2 and 3
Ans:C

Q.3 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is .
(A) 17.1
(B) 21.0
(C) 33.1
(D) 72.8
Ans:C
Exp:
Volume of the circular cone is given by
Vo = $\frac{1}{3}\pi r^2 h$
Given radius and height is increased by 10%
r1 = 1.1r
h1 = 1.1h
V1 = $\frac{1}{3}\pi r1^2 h1$ = $(1.1)^3\frac{1}{3}\pi r^2 h$ = 1.331 Vo
Volume increase in % = $\frac{V1-Vo}{Vo}$ = $\frac{0.331Vo}{Vo}$ = 0.331 = 33.1%

Q.4 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:

1. No two odd or even numbers are next to each other.
2. The second number from the left is exactly half of the left-most number.
3. The middle number is exactly twice the right-most number.

Which is the second number from the right?

(A) 2
(B) 4
(C) 7
(D) 10

Ans:C

Exp:

The sequence of the above data is

10 5 4 7 2

Q.5 Until Iran came along, India had never been_in kabaddi.

(A) defeated
(B) defeating
(C) defeat
(D) defeatist

Ans:A

Q.6 Since the last one year, after a 125 basis point reduction in repo rate by the Reserve Bank of India, banking institutions have been making a demand to reduce interest rates on small saving schemes. Finally, the government announced yesterday a reduction in interest rates on small saving schemes to bring them on par with fixed deposit interest rates.

Which one of the following statements can be inferred from the given passage?

(A) Whenever the Reserve Bank of India reduces the repo rate, the interest rates on small saving schemes are also reduced

(B) Interest rates on small saving schemes are always maintained on par with fixed deposit interest rates

(C) The government sometimes takes into consideration the demands of banking institutions before reducing the interest rates on small saving schemes

(D) A reduction in interest rates on small saving schemes follow only after a reduction in repo rate by the Reserve Bank of India

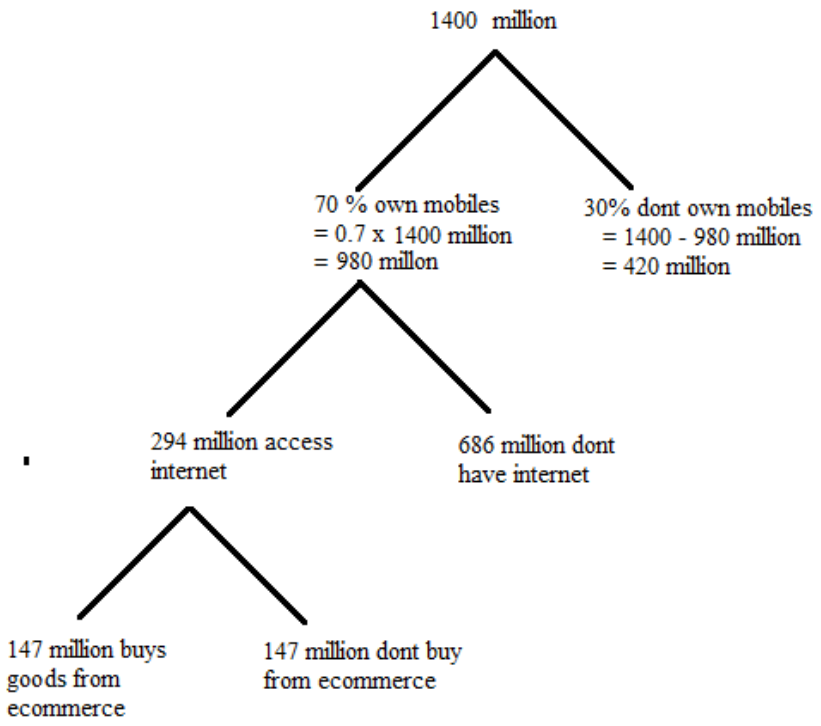
Ans:C

Q.7 In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?

(A) 10.50
(B) 14.70
(C) 15.00
(D) 50.00

Ans:A

Exp:



Percentage of buyers in the country = $\frac{147\ million}{1400\ million}$ x 100 = 10.5%

Q.8 The nomenclature of Hindustani music has changed over the centuries. Since the medieval period dhrupad styles were identified as baanis. Terms like gayaki and baaj were used to refer to vocal and instrumental styles, respectively. With the institutionalization of music education the term gharana became acceptable. Gharana originally referred to hereditary musicians from a particular lineage, including disciples and grand disciples.

Which one of the following pairings is NOT correct?

(A) dhrupad, baani
(B) gayaki, vocal
(C) baaj, institution
(D) gharana, lineage

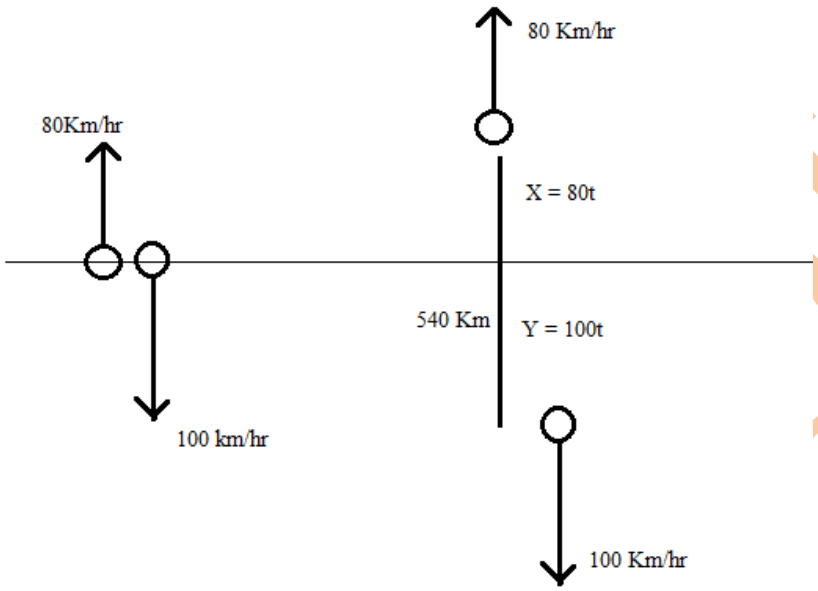
Ans:C

Q.9 Two trains started at 7AM from the same point. The first train travelled north at a speed of 80km/h and the second train travelled south at a speed of 100 km/h. The time at which they were 540 km apart is AM.

(A) 9
(B) 10
(C) 11
(D) 11.30

Ans:B

Exp:



X+Y = 540 Km
80t + 100t = 540
180t = 540
t = 540/180 = 3hr
Then The time at which the trains are 540 KM APART is 7 Am + 3 = 10Am

Q.10 "I read somewhere that in ancient times the prestige of a kingdom depended upon the number of taxes that it was able to levy on its people. It was very much like the prestige of a head-hunter in his own community."
Based on the paragraph above, the prestige of a head-hunter depended upon

(A) the prestige of the kingdom
(B) the prestige of the heads
(C) the number of taxes he could levy
(D) the number of heads he could gather

Ans:D

Q.11 Let r and θ be the modulus and argument of the complex number $z = 1 + i$, respectively. Then (r, θ) equals

(A) $(\sqrt{2}, \pi/4)$
(B) $(2, \pi/2)$
(C) $(2, \pi/3)$
(D) $(\sqrt{2}, \pi)$

Ans:A

Exp:

Given Complex number z = 1 + i

Modulus of Z = $\sqrt{1^2 + 1^2} = \sqrt{2}$

Argument of Z is tan θ = 1

$\theta = \frac{\pi}{4}$

Q.12 Let $\lambda 1$ and $\lambda 2$ be the two eigenvalues of the matrix $A = \begin{bmatrix} 0 & -1 \\ 1 & 1 \end{bmatrix}$

Then, $\lambda 1 + \lambda 2$ and $\lambda 1, \lambda 2$ are respectively

(A) 1 and 1
(B) 1 and −1
(C) −1 and 1
(D) −1 and −1

Ans:A

Exp:

Sum of eigen values is given by the trace of the matrix

i.e $1 + \lambda 2 = 0 + 1 = 1$

Product of eigen values is given by determinant of the matrix

Det of A = 0 -(-1) = 1

Q.13 The Laplace transform of the function $(t) = e^{-t}$ is given by

(A) $\frac{1}{(s+1)^2}$
(B) $\frac{1}{s-1}$
(C) $\frac{1}{s+1}$
(D) $\frac{1}{(s-1)^2}$

Ans:C

Exp:

WE know that Laplace of L(1) = $\frac{1}{s}$

L $(e^{-t}) = \frac{1}{s+1}$

Q.14 The relative decline rate of oil is given by $\frac{1}{q}\frac{dq}{dt} = -a\,q^b$, where q is the oil production rate, a (> 0) is the decline rate and b is a constant.
The equation gives harmonic decline curve when b is

(A) 1.5
(B) 1
(C) 0.5
(D) 0

Ans:B
Exp:
$\frac{1}{q}\frac{dq}{dt} = -a\,q^b$
Taking b = 1
$\frac{1}{q}\frac{dq}{dt} = -aq$
$\frac{dq}{q^2} = -a\,dt$
on integrating from 0 to t we get
$\frac{1}{q} - \frac{1}{qi} = at$
This is harmonic decline equation so b = 1

Q.15 Which one of the following provides a vertical stab for the flow lines and annulus access lines from multiple wells in offshore subsea completion?
(A) Moon pool deck
(B) Spider beams
(C) Telescopic joints
(D) Manifold
Ans:D

Q.16 In a faulted reservoir, the principle of superposition for the pressure drop using diffusivity equation is applicable. This is due to

(A) High Reynolds number flow in the well.
(B) constant permeability.
(C) pressure dependent viscosity.
(D) linearity of the diffusivity equation.

Ans:D

Q.17 Which one of the following parameters is measured using routine core analysis (RCA)?
(A) Porosity
(B) Relative permeability
(C) Capillary pressure
(D) Wettability
Ans:A

Q.18 Match the following

P. Induction Log	I. Equivalent water resistivity
Q. Dielectric Log	II. Resistivity
R. Self-Potential Log	III. Conductivity
S. Electrical Log	IV. Permittivity

(A) P-II, Q-IV, R-III, S-I
(B) P-III, Q-I, R-IV, S-II
(C) P-II, Q-III, R-IV, S-I
(D) P-III, Q-IV, R-I, S-II
Ans:D

Q.19 Which one of the following rocks and reservoir fluids are arranged in the decreasing order of their electrical resistivity? Assume that rocks have equal porosity and are filled with brine.

(A) Shale > Brine > Sandstone > Limestone > Gas
(B) Gas > Shale > Sandstone > Limestone > Brine
(C) Gas > Limestone > Sandstone > Shale > Brine
(D) Shale > Brine > Limestone > Sandstone > Gas

Ans:C

Q.20 Which one of the following is the correct sequence of events for hydrocarbon generation in the subsurface?

(A) Catagenesis→ Metagenesis → Diagenesis
(B) Catagenesis → Diagenesis → Metagenesis
(C) Diagenesis → Catagenesis → Metagenesis
(D) Diagenesis → Metagenesis→ Catagenesis

Ans:C

Q.21 Match the following:

P. Bingham plastic	I. $\tau = k\gamma^n$
Q. Power law	II. $\tau = \tau y + k\gamma^n$
R. Power law with yield stress	III. $= \tau y + \mu p\gamma$

Here
τ : shear stress
τy: yield value or yield stress
μp: shear viscosity
n: power law index
k: consistency index
γ: shear rate

(A) P-II, Q-I, R-III
(B) P-I, Q-III, R-II
(C) P-III, Q-II, R-I
(D) P-III, Q-I, R-II
Ans:D

Q.22 Match the following

P. Twist off
Q. Parting
R. Collapse
S. Fatiguefor drill pipe failure:

I. due to excessive tension
II. due to excessive torque
III. due to cyclic loading
IV. due to extensive external pressure

(A) P-III, Q-IV, R-I, S-II
(B) P-II, Q-I, R-IV, S-III
(C) P-I, Q-II, R-III, S-IV
(D) P-IV, Q-III, R-II, S-I
Ans:B

Q.23 Which one of the following flow regimes is more favorable for gas lift operation?
(A) Bubbly flow
(B) Annular flow
(C) Churn flow
(D) Stratified flow
Ans:A

Q.24 H2S gas is
(A) acidic.
(B) non-corrosive.
(C) lighter than air.
(D) non-flammable.
Ans:A

Q.25 Which one of the following offshore platforms DOES NOT use buoyant columns or pontoons?
(A) Tension leg platforms
(B) Jack up platforms
(C) Spar platforms
(D) Semi-submersible platforms
Ans:B

Q.26 In which one of the following offshore platforms, the condition of the sea floor is a vital consideration?
(A) Drill ship platforms
(B) Tension leg platforms
(C) Concrete gravity platforms
(D) Floating, production, storage and offloading (FPSO) platforms
Ans:C

Q.27 The 'Klinkenberg effect' is related to
(A) viscous fingering during water flooding in oil reservoirs.
(B) hysteresis effect in relative permeability during drainage and imbibition process.
(C) oil viscosity dependence on temperature.
(D) slippage of gas phase at the sand grain surface.
Ans:D

Q.28 Favourable conditions for formation of gas hydrates are
(A) high temperature and high pressure.
(B) high temperature and low pressure.
(C) low temperatureand high pressure.
(D) low temperature and low pressure.
Ans:C

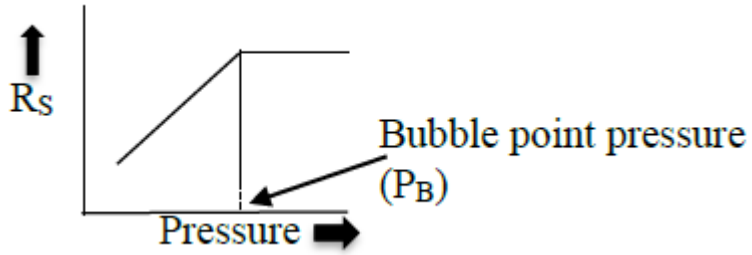
Q.29 Match the fo llowing quantities with their dimensions:

P. Viscosity
Q. Permeability
R. Compressibility
S. Pressure

I. $M^1 L^{-1} T^{-2}$
II. $M^0 L^2 T^0$
III. $M^1 L^{-1} T^{-1}$
IV. $M^{-1} L^1 T^2$

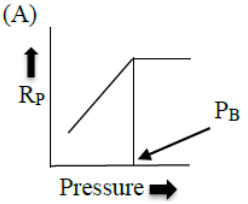
(A) P-III, Q-II, R-IV, S-I
(B) P-II, Q-I, R-IV, S-III
(C) P-III, Q-I, R-IV, S-II
(D) P-I, Q-II, R-III, S-IV
Ans:A

Q.30. The plot of dissolved gas oil ratio (RS), defined as the "ratio of STP volume of gas dissolved in the oil at pressure P, to the volume of the oil at STP" is given below.

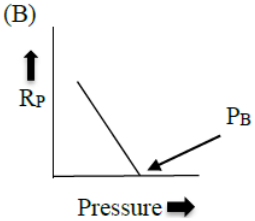


For the same oil, the plot of produced gas oil ratio (RP) defined as the "ratio of STP volume of the gas liberated from the oil at pressure P, to the volume of the oil at STP" is

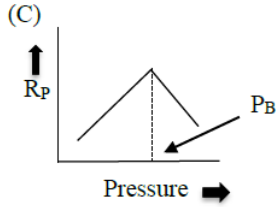
(A)



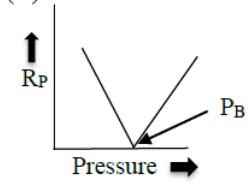
(B)



(C)



(D)

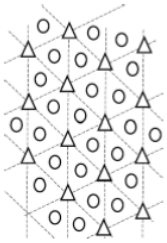


Ans:B

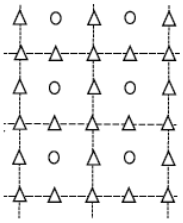
Q.31. which one of the following denotes a regular four-spot flood Pattern?

△ represents injection well
o represents production well

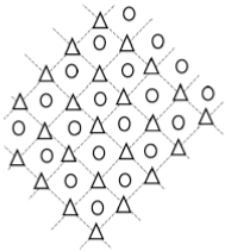
(A)



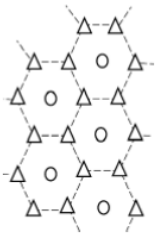
(B)



(C)



(D)



Ans:A

Q.32 The value of is $\lim_{x\to 0} \frac{(x+1)sinx}{x^2+2x}$ (round off to 2 decimal places).

Ans:0.49 – 0.51

Exp:

$\lim_{x\to 0}\frac{(x+1)sinx}{x^2+2x} = \frac{0}{0}\ (Indeterminate\ form)$

Applying L hospital rule

$\lim_{x\to 0}\frac{(x+1)cosx+sinx}{2x+2} = \frac{1}{2} = 0.50$

Q.33 Let A = $\begin{bmatrix}1 & 2\\2 & 1\end{bmatrix}$, X = $\begin{bmatrix}1 & a\\b & 0\end{bmatrix}$ and Y = $\begin{bmatrix}3 & 1\\3 & 2\end{bmatrix}$ If $AX = Y$, then $a + b$ equals __.

Ans:2

Exp:

A X = $\begin{bmatrix}1 & 2\\2 & 1\end{bmatrix}\begin{bmatrix}1 & a\\b & 0\end{bmatrix}$ = $\begin{bmatrix}1+2b & a+0\\2+b & 2a+0\end{bmatrix}$ = $\begin{bmatrix}1+2b & a\\2+b & 2a\end{bmatrix}$

Given AX=Y

$\begin{bmatrix}1+2b & a\\2+b & 2a\end{bmatrix}$ = $\begin{bmatrix}3 & 1\\3 & 2\end{bmatrix}$

a =1

b =1

therefore a+b = 1+1 = 2

Q.34 Let $\vec{u} = i + j + ak$ and $v = a^2i + 4j - 4k$, where i, j and k are cartesian unit vectors. If

$\vec{u}$ is perpendicular to v, then a equals _____ .

Ans:2

Exp:

For them to be perpendicular there Dot product should be zero

$\vec{u} \cdot v = (i + j + ak) \cdot (a^2i + 4j - 4k) = a^2 + 4 - 4a = 0$

$a^2 + 4 - 4a = 0$

$(a-2)^2 = 0$

a =2

Q.35 If the neutron log porosity (ϕN) is 0.09 and density log porosity (ϕD) is 0.24 in the cross-

over region, then the average porosity of the gas bearing region is ____(round off to 2 decimal places).

Ans:0.17 – 0.20

Exp:

The porosity of the crossover region is given by

$\phi = \sqrt{\frac{\emptyset N^2 + \emptyset D^2}{2}} = \sqrt{\frac{0.09^2 + 0.24^2}{2}} = 0.18124$

Q.36 .The general solution of the differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = 0$ is (here C1 and C2 are arbitrary constants)

(A) y = C1 e^x + C2 e^{-x}

(B) y = C1 xe^x + C2 xe^{2x}

(C) y = C1 e^x + C2 xe^{-x}

(D) y = C1 e^x + C2 xe^x

Ans:D

Exp:

Let D = $\frac{d}{dx}$

$(D^2 - 2D + 1)y = 0$

D = 1,1

Then

$y = (C1+C2x)e^x$

Q.37 Consider the following system of linear equations (where p and q are constants)

$x_1 + x_2 + {}_3 = 1$

$x_1 - x_2 + 2x_3 = p$

$3x_1 - x_2 + 5x_3 = q$

This system has at least one solution for any p and q satisfying

(A) $2p - q + 1 = 0$.

(B) $2q + p + 1 = 0$.

(C) $2p + q - 1 = 0$.

(D) $2q + p - 1 = 0$.

Ans:A

Exp:

Changing the above equations into augmented format we get

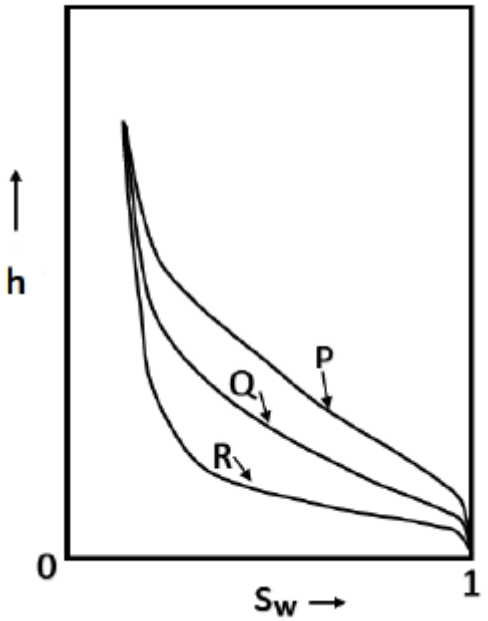
$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 2 & p \\ 3 & -1 & 5 & q \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & -2 & 1 & p-1 \\ 0 & -4 & 2 & q-3 \end{bmatrix} \rightarrow \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & -2 & 1 & p-1 \\ 0 & 0 & 0 & q-2p-1 \end{bmatrix}$$

For atleast one solution to exist

q-2p-1 = 0

2p-q+1 = 0

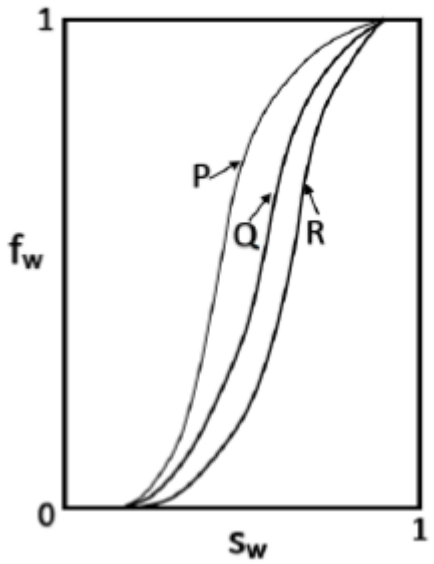
Q.38 Three reservoirs P, Q and R have identical geometry and rock properties. The plot of the height of the transition zone (h) above the free water level (FWL) against the water saturation (Sw) is given in the figure. Assume $\sigma \cos \theta$ for all the three fluid combinations remains the same. Which one of the following is the correct match of the reservoir fluids with the reservoir (σ is the interfacial tension between the respective fluid phases and θ is the contact angle).



(A) P: low density oil – water, Q: gas – water, R: high density oil – water
(B) P: gas – water , Q: low density oil – water, R: high density oil – water
(C) P: high density oil – water, Q: low density oil – water, R: gas – water
(D) P: gas – water, Q: high density oil – water, R: low density oil – water

Ans:C

Q.39 The fractional flow (fw) versus water saturation (Sw) curve for an imbibition process (neglecting the capillary forces) in a given core for three different inclinations is shown in the figure.



Which one of the following is the correct representation of the fractional flow curves?

(A) P: Down-dip, Q: No-dip, R: Up-dip
(B) P: Down-dip, Q: Up-dip, R: No-dip
(C) P: No-dip, Q: Down-dip, R: Up-dip
(D) P:Up-dip, Q: No-dip, R: Down-dip

Ans:A

Q.40 Match the following:

P. Dynamic positioning	I. Self-contained drilling rig on a floating barge, fitted with long support legs that can be raised or lowered independently of each other.
Q. Mooring	II. A system which automatically controls a vessel's position and heading exclusively by means of active thrust.
R. Jack-up	III. Remains afloat by weight and buoyancy balance.
S. Semi-submersible platform	IV. A system that is used for station keeping of a floating platform or ship at any depth.

(A) P-IV, Q-II, R-I, S-III
(B) P-III, Q-I, R-IV, S-II
(C) P-II, Q-IV, R-I, S-III
(D) P-II, Q-IV, R-III, S-I

Ans:C

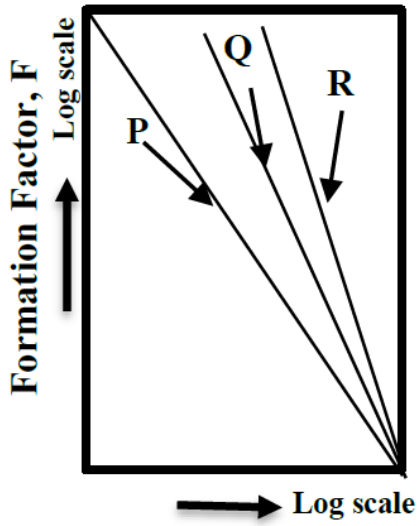
Q.41 Match the following:

P. Increase in sweep efficiency at the macroscopic-level by increasing water viscosity	I. LPG injection
Q. Increase in sweep efficiency at the macroscopic-level by decreasing oil viscosity	II. Surfactant flooding
R. Increase in displacement efficiency at the pore-scale by using a miscible displacing fluid	III. In-situ combustion
S. Increase in displacement efficiency at the pore-scale by reducing interfacial tension	IV. Polymer flooding

(A) P-I, Q-IV, R-III, S-II
(B) P-I, Q-II, R-IV, S-III
(C) P- IV, Q-III, R-I, S-II
(D) P-IV, Q-I, R-II, S-III

Ans:C

Q.42 An exploratory well encountered three reservoir formations S1 (perfectly cemented), S2 (poorly cemented) and S3 (fractured). The Formation Factor (F) is governed by the equation $F = a\phi^{-m}$, where 'ϕ' is the porosity and 'm' is the cementation factor. The constant 'a', linked to tortuosity is assumed to be 1 for all the formations. The log-log plot between Formation Factor (F) and porosity (ϕ) is shown.



Which one of the following represents the correct match of the formations with their respective plots?

(A) S1-P, S2-Q, S3-R
(B) S1-R, S2-P, S3-Q
(C) S1-P, S2-R, S3-Q
(D) S1-R, S2-Q, S3-P

Ans:D

Exp:

$F = a\phi^{-m}$

Applying log on both sides

log F = log a – m log ϕ

mR > mQ > mP

m represents cementation factor

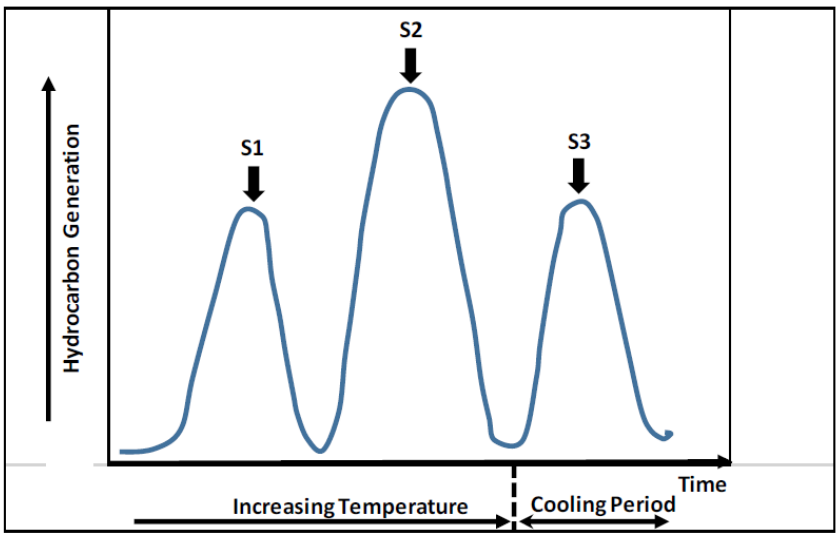
Large m means more cementation

R – Perfectly cemented – S1

Q – Poorly cemented – S2

P - Fractured – S3

Q.43 Typical parameters obtained in the pyrolysis experiment of the source rock materials are shown in the Figure. Which one of the following is NOT true about pyrolysis in source rock analysis?



(A) Peak S1 represents volatilization of existing hydrocarbons.
(B) Peak S2 represents breakdown of kerogen and generation of hydrocarbons.
(C) Peak S3 represents Tmax, the temperature at which most hydrocarbons are generated.
(D) S1/(S1+S2) represents the production index.
Ans:C

Q.44 A single well encounters multiple clean sands of exactly the same thickness, porosity and permeability. Rw is the formation fluid resistivity and Rmf is the mud filtrate resistivity

P. Rmf > Rw	I. No deflection
Q. Rmf = Rw	II. Positive deflection
R. Rmf < Rw	III. Negative deflection

Which one of the following match the relation between Rw and Rmf to that of Self Potential (SP) log deflection?
(A) P-I,Q-III,R-II
(B) P-III,Q-I,R-II
(C) P-II,Q-I,R-III
(D) P-I,Q-II,R-III
Ans: B

Q.45 Which one of the following options is **NOT** a part of the mud logs prepared by the drill-site geologist?
(A) Rate of Penetration (ROP)
(B) Chromatograph showing presence of C1 to C5 concentration
(C) Lithology from drill cutting and its interpretation
(D) Reservoir unit delineation based on volume of shale (Vsh)
Ans:D

Q.46 Match the following:

P. Location of storing the kelly on the trip	I. Mousehole
Q. Location of storing the next drill pipe	II. Rathole
R. Location of storing pump pressure gauges	III. Top drive
S. Rotational system that controls a drill string without a kelly	IV. Standpipe

(A) P-II, Q-I, R-IV, S-III
(B) P-IV, Q-II, R-III, S-I
(C) P-II, Q-I, R-III, S-IV
(D) P-IV, Q-III, R-II, S-I
Ans:A

Q.47 A box contains 2 red and 3 black balls. Three balls are randomly chosen from the box and are placed in a bag. Then the probability that there are 1 red and 2 black balls in the bag, is _____ .
Ans:0.59 – 0.61
Exp:
P(A) = P(R,B,B) + P(B,R,B) + P(B,B,R)

$$= \frac{2}{5} x \frac{3}{4} x \frac{2}{3} + \frac{3}{5} x \frac{2}{4} x \frac{2}{3} + \frac{3}{5} x \frac{2}{4} x \frac{2}{3}$$

$$= \frac{3\ x12}{60}$$

$$= 0.6$$

Q.38 The values of a function (x) over the interval [0,4] are given in the table below:

x	0	1	2	3	4
$f(x)$	1	0.5	0.2	0.1	0.06

Then, according to the trapezoidal rule, the value of the integral $\int_0^4 f(x)dx$ is_____(round off to 2 decimal places).
Ans:0.73
Exp:

$$\int_0^4 f(x)dx = \frac{h}{2}\,[f(0) + f(4) + 0.5(f(1) + f(2) + f(3))]$$

$$= 0.5\ [1+0.06 + 0.5(0.5+0.2+0.1)]$$

$$= 0.73$$

Q.49 Oil is produced at a constant rate from a well in a bounded reservoir. The variation of the bottom-hole pressure with time is shown in the given Table. The magnitude of the slope of the pressure vs time curve that you would use to find the drainage area is _____ psi/day (round off to 1 decimal place).

Time (days)	Flowing bottom- hole pressure (psi)	Time (days)	Flowing bottom- hole pressure (psi)
0	3500	6	2512
1	2864	7	2482
2	2725	8	2452
3	2644	9	2422
4	2587	10	2392
5	2542	11	2362

Ans:30

Exp:

The time from which the pressure in the reservoir decreases linearly is the time that the semi steady state has been reached.from day 5 the pressure has been decreasing at a rate of 30 psi per day .so the slope of the pressure vs time curve that should be used is 30 psi/day

Q.50 In a core flood experiment of immiscible and incompressible displacement of oil (μo = 1 cP) with water (μw = 1 cP), only axial flow is observed. The relative permeability of water is given by $krw = Sw^2$, where Sw is water saturation. The relative permeability of oil is given by $kro = (1 - Sw)^2$. The gravity and capillary pressure are neglected. From the fractional flow and water saturation relationship, the saturation of water at the flood front is

____ % (round off to 1 decimal place).

Ans:69 – 72

Exp:

Mobility ratio is given by

$$M = \frac{Mobility\ of\ water}{Mobility\ of\ oil} = \frac{\lambda w}{\lambda o} = \frac{Krw}{Kro}\ x\ \frac{\mu o}{\mu w} = \frac{Krw}{Kro}$$

$$M = \frac{Krw}{Kro} = \frac{Sw^2}{(1-Sw)^2}$$

$$fw = \frac{1}{1+\frac{1}{M}} = \frac{Sw^2}{(1-Sw)^2+Sw^2}$$

At flood front saturation we get

$$fwf = \frac{Swf^2}{(1-Swf)^2+Swf^2} \text{ ----------1}$$

Given

$$fw = \frac{Sw^2}{(1-Sw)^2+Sw^2}$$

Differentiating on both sides we get

$$\frac{\partial fw}{\partial Sw} = \frac{2Sw}{(1-Sw)^2+Sw^2} - \frac{Sw^2\,(-2(1-Sw)+2Sw)}{[(1-Sw)^2+Sw^2]^2}$$

$$\frac{\partial fw}{\partial Sw} = \frac{2Sw\,[(1-Sw)^2+Sw^2]}{[(1-Sw)^2+Sw^2]^2} - \frac{Sw^2\,(-2(1-Sw)+2Sw)}{[(1-Sw)^2+Sw^2]^2}$$

$$\frac{\partial fw}{\partial Sw} = \frac{2Sw\,[(1-Sw)^2+Sw^2]-Sw^2\,(-2(1-Sw)+2Sw)}{[(1-Sw)^2+Sw^2]^2}$$

$$= \frac{2Sw[2Sw^2-2Sw+1]-Sw^2\,(4Sw-2)}{[(1-Sw)^2+Sw^2]^2}$$

$$= Sw\frac{[4Sw^2-4Sw+2]-4Sw^2+2Sw)}{[(1-Sw)^2+Sw^2]^2}$$

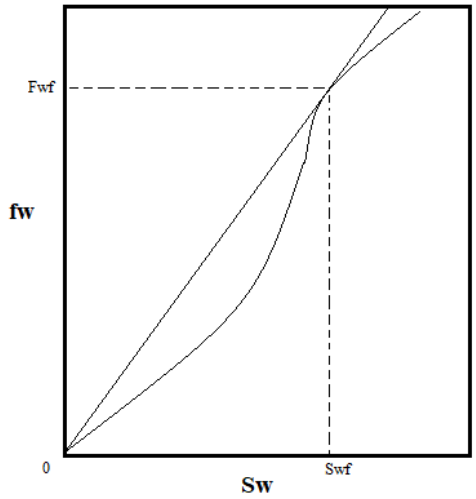
$$\frac{\partial fw}{\partial Sw} = \frac{Sw(-2Sw+2)}{[(1-Sw)^2+Sw^2]^2}$$

The Slope at Flood front saturation is given by

$$(\partial fw/\partial Sw\,)Swf = \frac{Swf(-2Swf+2)}{[(1-Swf)^2+Swf^2]^2} \text{ -------2}$$

Given Krw = Sw^2

The Krw = 0 at Sw =0 so a graph can be drawn as hown in the figure below



From graph the slope of the line drawn from the origin to the flood front point can be found by

$$m = \frac{Fwf-0}{Swf-0} = \frac{Fwf}{Swf}$$

But the slope of the line is also given by $\left(\frac{\partial Fw}{\partial Sw}\right)$swf

Therefore

$$\left(\frac{\partial Fw}{\partial Sw}\right)\text{swf} = \frac{Fwf}{Swf}$$

i.e. from equation I and 2 we get

$$\frac{Swf(-2Swf+2)}{[(1-Swf)^2+Swf^2]^2} = \frac{Swf}{(1-Swf)^2+Swf^2}$$

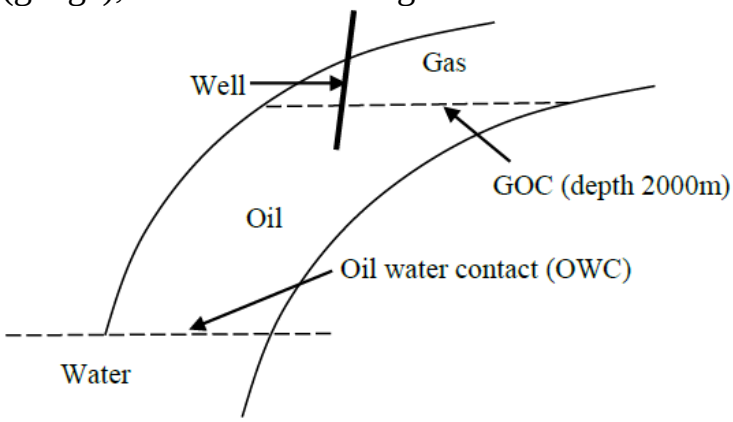
2(1- Swf) = $(1-Swf)^2 + Swf^2$

2 – 2 Swf = $2Swf^2$ – 2Swf +1

1 = 2 Swf^2

Swf = $\frac{1}{\sqrt{2}}$ = 0.7071

Q.51 In an oil well, the pressure at the gas oil contact (GOC) at a depth of 2000 m is 205 bar (gauge), as shown in the figure.



The static oil pressure gradient is 0.08 bar/m in the pay zone. If a constant hydrostatic pressure gradient of 0.1 bar/m prevails throughout the subsurface, then the thickness of the oil column is _____m (round off to 1 decimal place).

Ans:240 – 260

Exp:

Pressure at the Oil water column is given by 0.1 bar/m x (2000+h) = 0.1(2000+h) bar

Pressure due to the oil and gas is given by 1 bar + 205 bar + (0.08xh) = 206+ 0.08h

Equating both pressures we get

0.1(2000+h) = 205 + 0.08h

200 + 0.1h = 205 + 0.08h

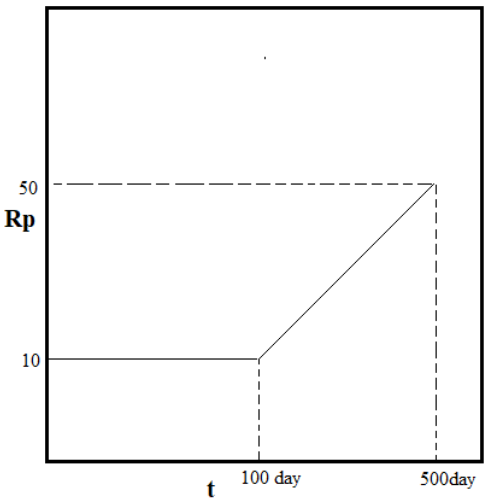
(0.1-0.08) h = 5

h = 250 m

Q.52 Oil is produced at a constant rate of 10 m3/day from a reservoir for 500 days. The producing gas oil ratio (GOR) is constant at 10 $\frac{\text{m3 gas}}{\text{m3 oil}}$ for the first 100 days. Then, the producing gas oil ratio increases linearly and on the 500th day the measured GOR is 50 $\frac{\text{m3 gas}}{\text{m3 oil}}$.The cumulative produced gas oil ratio after 500 days of production is___ $\frac{\text{m3 gas}}{\text{m3 oil}}$ (round off to 1 decimal place). Assume that all volumes are measured at STP.

Ans: 25.5 – 26.5

Exp:



Cumulative oil produced in the 500 days = 10 m3/day x 500day = 5000 m3 oil

Cumulative gas produced in the first 500 days = Area under the curve

= [10m3 gas/m3 oil x 10 m3/day x 500 day] + 0.5 x 400 day x 40 m3 gas/m3 oil x 10 m3/day

= 50000 + 80000

= 130000 m3 gas

Cumulative gas oil ratio = $\frac{130000 \text{ m3 gas}}{5000 \text{ m3 oil}}$ = 26 m3gas/m3oil

Q.53 A pressure build-up test was conducted in a well after 1000 days of producing oil at a constant rate of 0.01 reservoir-m3/s. The two shut-in bottom-hole pressure readings taken at 0.5 day and 1 day after shut-in are 150×10^5 Pa and 151×10^5 Pa, respectively. These pressure points correspond to the linear region of the Horner's plot. The reservoir thickness is 100 m and oil viscosity is 0.001 Pa.s. The permeability of the reservoir is _____mD (round off to 1 decimal place). [1 mD = 10^{-15} m2].

Ans:52 – 58

Exp:

tp = 1000 days

$\Delta t1 = 0.5\ day$

$\frac{tp+\Delta t1}{\Delta t1} = \frac{1000.5}{0.5} = 2001$

$\log(\frac{tp+\Delta t1}{\Delta t1})$ = log (2001) = 3.30125

$\Delta t2 = 1\ day$

$\frac{tp+\Delta t2}{\Delta t2} = \frac{1001}{1} = 1001$

$\log(\frac{tp+\Delta t2}{\Delta t2})$ = log (1001) = 3.00043

Slope of the Horner plot is given by

m = $\frac{151 \times 105 \text{ Pa} - 150 \times 105 \text{ Pa}}{3.30125 - 3.00043}$ = 3.324 x 10^5 Pa

m = $2.303 \frac{q\mu}{4\pi Kh}$

$2.303\frac{q\mu}{4\pi Kh} = 3.324 \text{ x } 105 \text{ Pa}$

$k = \frac{2.303\ q\ \mu}{4\pi h\ x3.324 \text{ x } 105 \text{ Pa}} = \frac{2.303\ x0.01\frac{m3}{sec}x0.001\ Pa.sec}{4\pi\ x\ 100m\ x3.324 \text{ x } 105 \text{ Pa}}$ = 5.5134 x 10^{-14} m2 = 55.134 x 10^{-15} m2 = 55.134 mD

Q.54 In an oil reservoir, the residual oil saturation in the volume flooded with polymer solution is 20%. The initial water saturation is 20%. The volumetric sweep efficiency is 50%. The maximum possible recovery factor for the reservoir is _____% (round off to 1 decimal place).

Ans:36 – 39

Exp:

Given Sor = 0.2

Swi = 0.2 i.e. Soi = 0.8

Microscopic displacement efficiency = $\frac{Soi-Sor}{Soi} = 1 - \frac{Sor}{Soi} = 1 - \frac{0.2}{0.8} = \frac{3}{4} = 0.75$

Maximum Possible recovery factor = Microscopic displacement efficiency x Volumetric sweep efficiency

= 0.75 x 0.5

=0.375

= 37.5%

Q.55 An electrical submersible pump (ESP) delivers well fluid with 100% watercut. In the ESP, the impeller diameter is 0.1 m and speed is 3600 rpm. The total head developed by the ESP is 300 m (water column height). If the stage efficiency of the ESP is 60%, then the minimum number of stages required is _____ (round off to nearest integer). [g = 9.81 m/s2]

Ans:27 – 29

Exp:

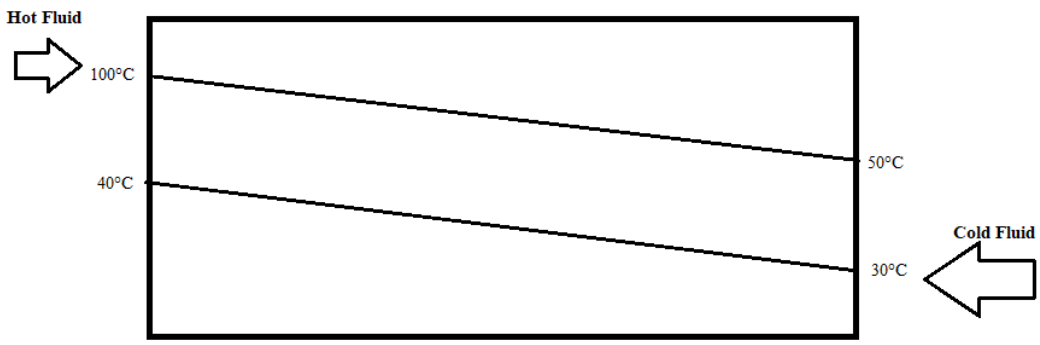
Head developed by Centrifugal pump is given by = $\frac{V^2}{2g}$

where v = linear velocity = 2 π r x n =2π ×0.05 x (3600/60) = 18.84 m/s

Thus, Head developed = $(18.84)^2/2\times9.8$ = 18.10 m

Minimum number of stages = $\frac{\text{Total head developed}}{(\text{Head of single stage pump} \times \text{Efficiency})}$ / =300/18.1×0.6 = 27.6

Q.56 In a counter flow heat exchanger, hot fluid enters at 100°C and leaves at 50°C. Cold fluid enters at 30°C and leaves at 40°C. If heat losses are ignored, then the logarithmic mean temperature difference (LMTD) is ___°C (round off to 1 decimal place).
Ans:35 – 38
Exp:



$$\text{LMTD} = \frac{(100-40)-(50-30)}{\ln(\frac{100-40}{50-30})} = \frac{40}{\ln(\frac{60}{20})} = 36.41°C$$

Q.57 A model porous block of cross sectional area (A) and length (L) is made up of N independent capillaries of equal radii (r) and length (L). The porosity of the block is 10%, and the permeability for a laminar, incompressible and steady state flow is 0.02 mD. If the flow is only through the capillaries, then the value of r is _____x 10^{-6} cm (round off to 1 decimal place). [1 mD = 10^{-15} m2].
Ans: 3 – 5
Exp:

$$K = \emptyset \frac{r^2}{8}$$

$$0.02 \times 10^{-15} \text{ m2} = 0.1 \frac{r^2}{8}$$

$$r = 4 \times 10^{-8} \text{m}$$
$$= 4 \times 10^{-6} \text{ cm}$$

Q.58 A model porous medium of 5 cylindrical capillaries of radii varying from 60 to 100 micrometers (refer Table) is subjected to Mercury Injection Capillary Pressure (MICP) treatment. The capillaries are being filled in an increasing order of their entry pressure. The magnitude of $(\sigma \cos \theta)_{r-Hg}$ is 367 dyne/cm
,where σ is the interfacial tension and θ is the contact angle. The minimum applied mercury pressure to achieve 50% mercury saturation in the sample is _ ____× 10 dyne/cm2 (round off to 1 decimal place).

Radius (µm)	Cross-sectional area (µm2)	Cross sectional area (fraction)	Cumulative area (fraction)
60	11304	0.11	1.00
70	15386	0.15	0.89
80	20096	0.19	0.74
90	25434	0.25	0.55
100	31400	0.30	0.30
Total Area =	103620		

Ans:81 – 83
Exp:
In order to achieve 50% mercury saturation cumulative area covered by mercury should be 50 %. Thus minimum pressure required to achieve 50 % of cumulative area would be at a radius of 90 µm

Therefore, minimum pressure, Pc = $\frac{2\sigma\cos\theta}{r}$ = $\frac{2x367}{9\,x\,10^{-3}}$ = 81555.5 dyne/cm2 = 81.5 x 10^3 dyne/cm2

Q.59 The sonic log parameters from an exploratory well in a reservoir are as follows:
Measured P-wave transit time ($\Delta tlog$) = 85 µs/ft
True resistivity (Rt) = 10 ohm-m
Matrix transit time (Δtma) = 45 µs/ft
Fluid transit time (Δtfl) = 205 µs/ft
Formation water resistivity at reservoir temperature (Rw) = 0.1 ohm-m
The hydrocarbon saturation (in percentage) in the reservoir is _____(round off to 1 decimal place).

[Hint: Wyllie time average equation is Δtlog = (1-ϕ)Δtma + ϕ Δtfl and formation water resistivity has the correlation Rw = $\frac{1}{a}\emptyset^2\ Rt\ \ Sw^2$, where Sw is water saturation, ϕ is porosity and a = 1]
Ans: 59 – 61

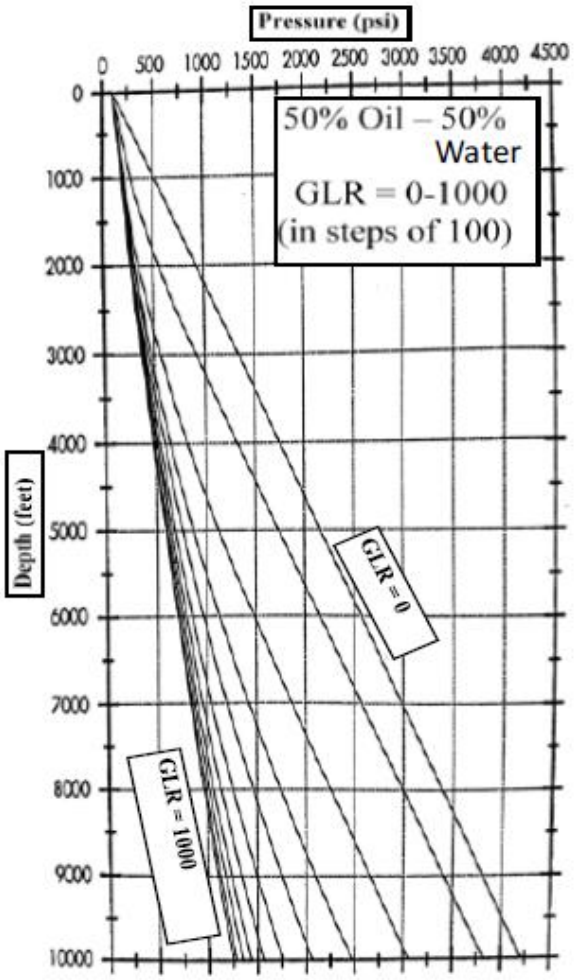
$$\emptyset = \frac{\Delta tlog - \Delta tmat}{\Delta tfl - \Delta tmat} = \frac{85-45}{205-45} = \frac{40}{160} = 0.25$$

Rw = $\frac{1}{a}\emptyset^2\ Rt\ \ Sw^2$

0.1 = $\frac{1}{1}0.25^2\ 10\ \ Sw^2$

Sw = 0.4
So = 0.6

Q.60 A vertical well of 8000 ft is producing below bubble point pressure. Oil and water each is produced at the rate of 500 bbl/day. The indicated bottom hole pressure is 3000 psi. If the same gas to liquid ratio (GLR) is maintained, using the given figure, the new bottom hole pressure at 5000 ft is _____psi.

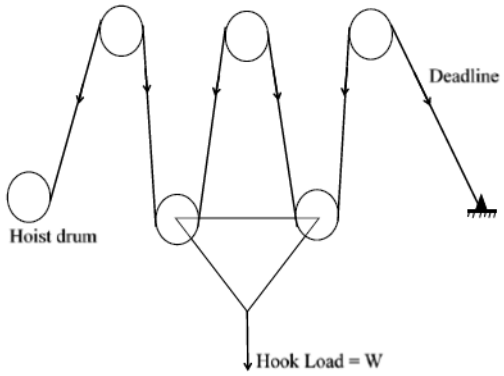


Ans:1600 – 1900

Exp:

As per the pressure gradient curve identify suitable GLR curve for depth 8000 ft with BHP as 3000 psi. Move upward along with the identified GLR curve till a depth of 5000 ft and draw a vertical line from that 5000 ft point. Thus new established bottom hole pressure would be 1750 psi.

Q.61 In a drilling rig, the crown block and the traveling block have three and two sheaves, respectively. A single wireline connects the hoisting drum to the deadline anchor as shown in the figure. Neglect the weight of the pulleys and the wireline, and friction between the sheaves and wireline. The ratio of the deadline load to static crown load is __(round off to 2 decimal places).



Ans:0.16 – 0.18
Exp:
Given
Number of running lines = 4 and E = 1
Deadline load = $\frac{W}{4}$
Fastline load = $\frac{W}{4}$
Hook load = W
Static crown load = W+ $\frac{W}{4} + \frac{W}{4} = \frac{3W}{2}$
The ratio of the deadline load to static crown load = $\frac{deadline\ load}{static\ crown\ load} = \frac{W/4}{3W/2} = \frac{1}{6}$ = 0.167

Q.62 Cement weighing 100 kg is mixed with 50 liters of water. The specific gravity of cement is 3.14 and the density of water is 1000 kg/m3. Neglecting volume changes, the resulting density of the slurry is_____kg/m3 (round off to 1 decimal place).
Ans:1820 – 1880
Exp:
1m3 = 1000 lit

Material	Density (Kg/lit)	Weight (Kg)	Volume (lit)
Cement	3.14	100	100/3.14 = 31.847
Water	1	50	50 lit
		Total weight = 100+50 kg = 150 kg	Total Volume = 31.847+50 =81.847lit

Slurry density = $\frac{Total\ weight}{Total\ Volume} = \frac{150kg}{81.847} = 1.8327\frac{kg}{lit} = 1832.7\frac{kg}{m3}$

Q.63 In an active water drive during a certain period, the rate of production and reservoir pressure remain constant. The water influx into the reservoir from the aquifer is 6000 bbl/day. The surface oil and water production rates are 3000 STB/day and 1500 STB/day, respectively. The current production gas to oil ratio is 825 SCF/STB, and the formation volume factors at the current pressure for oil, water and gas are 1.375 bbl/STB, 1.04 bbl/STB and 0.007 bbl/STB, respectively. The solution gas to oil ratio at the current pressure is _SCF/STB (round off to 1 decimal place).

Ans:739 – 815

Exp:

We = Qo [Bo + (Rp - Rs)Bg] + QwBw

6000 bbl/day = 3000 STB/day [1.375 + (825-x)0.007] + 1500 STB/day x 1.04

6000 = 3000[1.375+ (825-x)0.007] +1560

x = 825-15 = 810 SCF/STB

Q.64 In a water flooding experiment, the pressure gradients in the displacing and displaced phases are 400 psi/ft and 350 psi/ft, respectively. Assume that the displacement front is stable in the absence of capillary and gravity forces. Consider that only water flows upstream and only oil flows downstream of the displacement front. Then the mobility ratio for this immiscible displacement process is _(round off to 2 decimal places).

Ans:0.85 – 0.90

Exp:

Given

(dP/dl) displacing = 400 psi/ft

(dP/dl) displaced = 350 psi/ft

From darcy law

$$\frac{Q}{A} = \frac{K}{\mu}\frac{dP}{dl}$$

$$\frac{dP}{dl}\ \alpha\ \frac{\mu}{K}$$

Mobility ratio = $\frac{Mobility\ of\ displacing}{Mobility\ of\ displaced} = \frac{(K/\mu)displacing}{(K/\mu)displaced} = \frac{(dp/dl)displaced}{(dp/dl)displacing} = \frac{350}{400}$ =0.875

Q.65 In a pressure draw-down testing, the well bore flowing pressure (Pwf) is given by

$$P_{wf} = P_i - \frac{162.6\ q\ \mu\ B}{kh}\left[log\left(\frac{kt}{\emptyset\mu c r_w^2}\right) - 3.23 + 0.87\ S\right].$$

The following data is given in the oil field units,

Initial reservoir pressure (Pi) = 5000 psia

Pressure after 1 hr of production (P1hr) = 4000 psia

Oil flow rate (q) = 500 STB/day

Porosity (Ø) = 0.25

Viscosity of oil (μ) = 2 cP

Formation volume factor of oil (B) = 1.2 bbl/STB
Formation thickness (h) = 20 ft
Total compressibility (c) = 30 × 10^{-6} psi-1
Well bore radius (rw) = 0.3 ft

The slope of Pwf versus log t is −100 psi/cycle. Then, the skin factor (S) for this well is __ (round off to 1 decimal place).

Ans: 5 – 7
Exp:

$$m = \frac{162.6\, Q\mu Bo}{Kh}$$

$$K = \frac{162.6\, Q\mu Bo}{m\, h}$$

$$= \frac{162.6\, x\, 500\, x\, 2\, x 1.2}{100\, x\, 20}$$

= 97.56 mD

$$Pi - P1hr = m[\log \frac{k}{\emptyset \mu Ctrw^2} - 3.23 + 0.87S]$$

$$5000 - 4000 = 100\, [\log \frac{97.56}{0.25\, x\, 2\, x\, 30 \times 10{-}6\, x0.3^2} - 3.23 + 0.87S]$$

S = 6.18