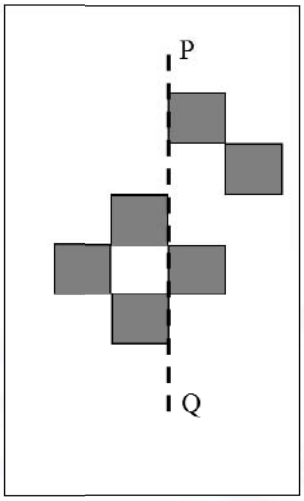
General Aptitude (GA)

Q.1 – Q.5 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

Q.1	**The current population of a city is 11,02,500. If it has been increasing at the rate of 5% per annum, what was its population 2 years ago?**
(A)	9,92,500
(B)	9,95,006
(C)	10,00,000
(D)	12,51,506

Q.2	***p* and *q* are positive integers and $\frac{p}{q}+\frac{q}{p}=3$,** **then,** $\frac{p^2}{q^2}+\frac{q^2}{p^2}=$
(A)	3
(B)	7
(C)	9
(D)	11

Q.3	 **The least number of squares that must be added so that the line P-Q becomes the line of symmetry is _____**
(A)	4
(B)	3
(C)	6
(D)	7

Q.4	***Nostalgia* is to *anticipation* as _____ is to _____** **Which one of the following options maintains a similar logical relation in the above sentence?**
(A)	Present, past
(B)	Future, past
(C)	Past, future
(D)	Future, present

Q.5	**Consider the following sentences:** **(i) I woke up from sleep.** **(ii) I woked up from sleep.** **(iii) I was woken up from sleep.** **(iv) I was wokened up from sleep.** **Which of the above sentences are grammatically CORRECT?**
(A)	(i) and (ii)
(B)	(i) and (iii)
(C)	(ii) and (iii)
(D)	(i) and (iv)

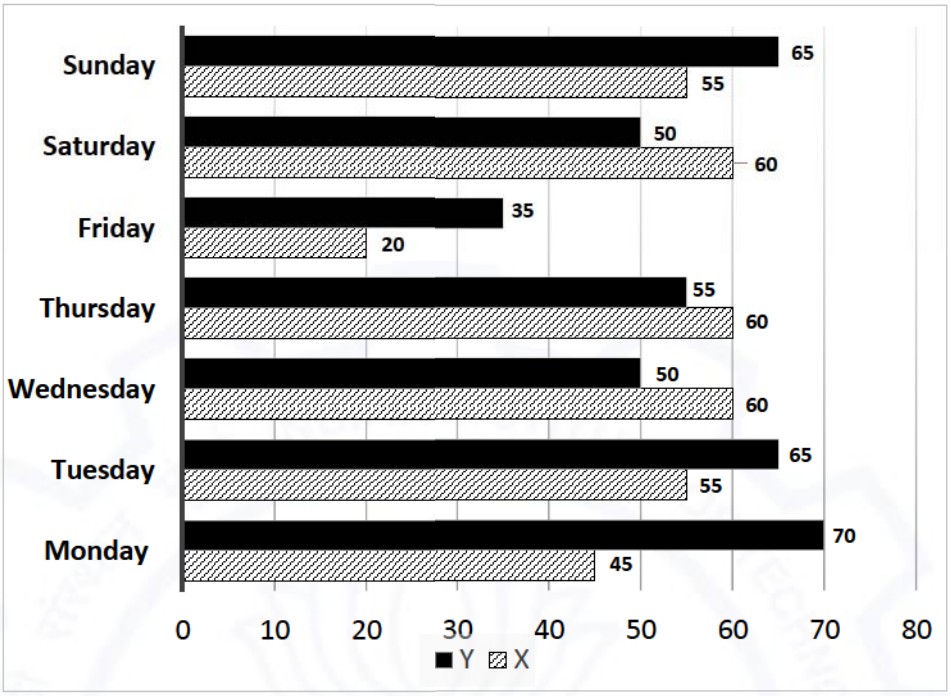
Q. 6 – Q. 10 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

Q.6	**Given below are two statements and two conclusions.** **Statement 1: All purple are green.** **Statement 2: All black are green.** **Conclusion I: Some black are purple.** **Conclusion II: No black is purple.** **Based on the above statements and conclusions, which one of the following options is logically CORRECT?**
(A)	Only conclusion I is correct.
(B)	Only conclusion II is correct.
(C)	Either conclusion I or II is correct.
(D)	Both conclusion I and II are correct.

Q.7	**Computers are ubiquitous. They are used to improve efficiency in almost all fields from agriculture to space exploration. Artificial intelligence (AI) is currently a hot topic. AI enables computers to learn, given enough training data. For humans, sitting in front of a computer for long hours can lead to health issues.** **Which of the following can be deduced from the above passage?** (i) **Nowadays, computers are present in almost all places.** (ii) **Computers cannot be used for solving problems in engineering.** (iii) **For humans, there are both positive and negative effects of using computers.** (iv) **Artificial intelligence can be done without data.**
(A)	(ii) and (iii)
(B)	(ii) and (iv)
(C)	(i), (iii) and (iv)
(D)	(i) and (iii)

Q.8	**Consider a square sheet of side 1 unit. In the first step, it is cut along the main diagonal to get two triangles. In the next step, one of the cut triangles is revolved about its short edge to form a solid cone. The volume of the resulting cone, in cubic units, is _____**
(A)	$\frac{\pi}{3}$
(B)	$\frac{2\pi}{3}$
(C)	$\frac{3\pi}{2}$
(D)	3π

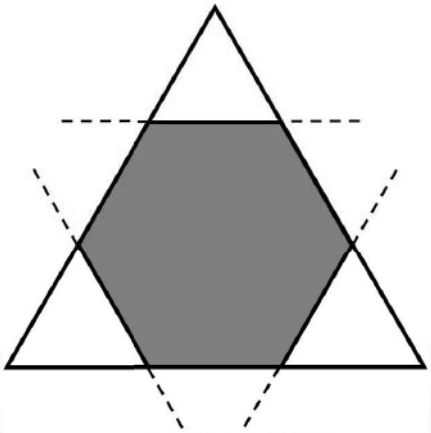
Q.9



The number of minutes spent by two students, X and Y, exercising every day in a given week are shown in the bar chart above.

The number of days in the given week in which one of the students spent a minimum of 10% more than the other student, on a given day, is

(A)	4
(B)	5
(C)	6
(D)	7

Q.10	 **Corners are cut from an equilateral triangle to produce a regular convex hexagon as shown in the figure above.** **The ratio of the area of the regular convex hexagon to the area of the original equilateral triangle is**
(A)	2 : 3
(B)	3 : 4
(C)	4 : 5
(D)	5 : 6

Petroleum Engineering (PE)

Q.1 – Q.13 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

Q.1	**MOPU (in the context of offshore drilling and production systems) stands for**
(A)	Mobile Offshore Process Unit
(B)	Mobile Offshore Piping Unit
(C)	Mobile Offshore Production Unit
(D)	Mobile Oil Production Unit

Q.2	**Which ONE of the following statements is INCORRECT?**
(A)	Conductor is the outer casing of a well
(B)	Riser is used for transporting fluid
(C)	Conductor and riser have the same functions
(D)	Conductor is used for shielding the well flow lines from external forces

Q.3	**Which ONE of the following offshore installations uses Dynamic Positioning System (DPS) for station keeping?**
(A)	Jacket
(B)	Jack-up
(C)	Semi-submersible
(D)	Tension Leg Platform

Q.4	**Which ONE of the following is NOT a primary safety system for offshore installations?**
(A)	Emergency Shut Down
(B)	Isolation
(C)	Fire Protection
(D)	Blowdown

Q.5	**The primary function of the thruster in the Dynamic Positioning System (DPS) of an offshore installation is**
(A)	To apply thrust in the direction opposite to the resultant environmental force
(B)	To apply thrust in the same direction as the resultant environmental force
(C)	To apply thrust in the direction opposite to the motion
(D)	To apply thrust in the same direction as the motion

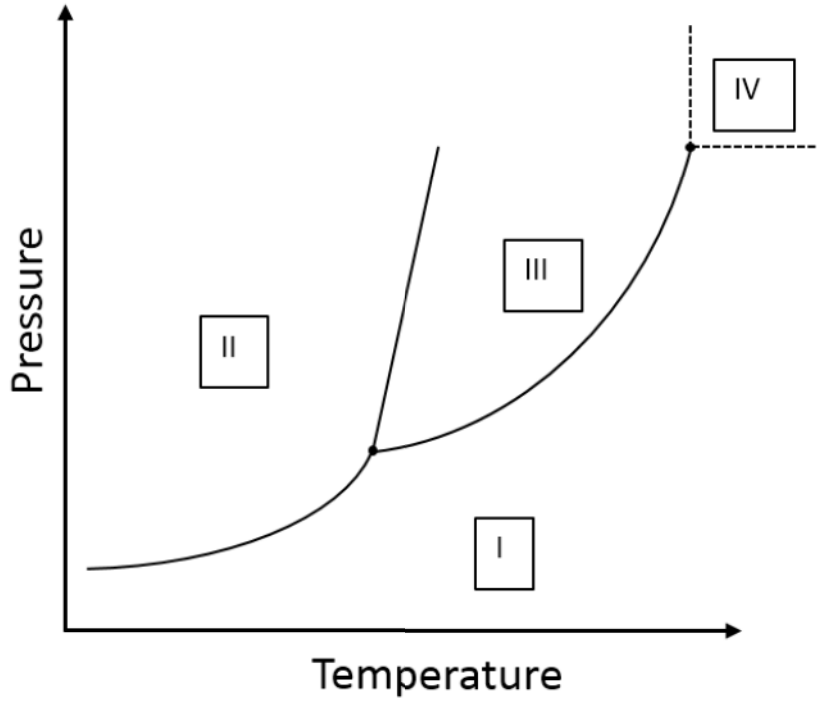
Q.6	**Select the CORRECT firefighting system for electrical switchgear room in an offshore facility.**
(A)	Wet chemical
(B)	Halon system
(C)	Foam
(D)	Water sprinklers

Q.7	**Which ONE of the following options can be used to quantify secondary porosity?**
(A)	Sonic and Gamma Ray Logs
(B)	Sonic and Neutron Logs
(C)	Sonic and Caliper Logs
(D)	Density and Neutron Logs

Q.8	**Among the options given below, what is the typical temperature range for significant oil generation in a source rock associated with conventional crude-oil reservoirs?**
(A)	10 °C – 40 °C
(B)	60 °C – 175 °C
(C)	225 °C – 325 °C
(D)	350 °C – 425 °C

Q.9	**In the original Darcy's law as proposed by Henry Darcy, which of the following drives the fluid flow through a fully saturated sand column?**
(A)	Pressure-gradient or hydraulic-gradient
(B)	Viscous force per unit volume
(C)	Capillary force per unit volume
(D)	Inertial force per unit volume

Q.10	**At which ONE of the following scales is Darcy's law for fluid flow through a porous medium applicable?**
(A)	Nano-scale
(B)	Molecular-scale
(C)	Microscopic-scale
(D)	Macroscopic-scale

Q.11	**Pressure – Temperature phase diagram of CO_2 is shown below. Identify the correct phases from the given options.**
	
(A)	I = Solid Phase, II = Liquid Phase, III = Gas Phase, IV = Supercritical Phase
(B)	I = Gas Phase, II = Supercritical Phase, III = Solid Phase, IV = Liquid Phase
(C)	I = Supercritical Phase, II = Liquid Phase, III = Solid Phase, IV = Gas Phase
(D)	I = Gas Phase, II = Solid Phase, III = Liquid Phase, IV = Supercritical Phase

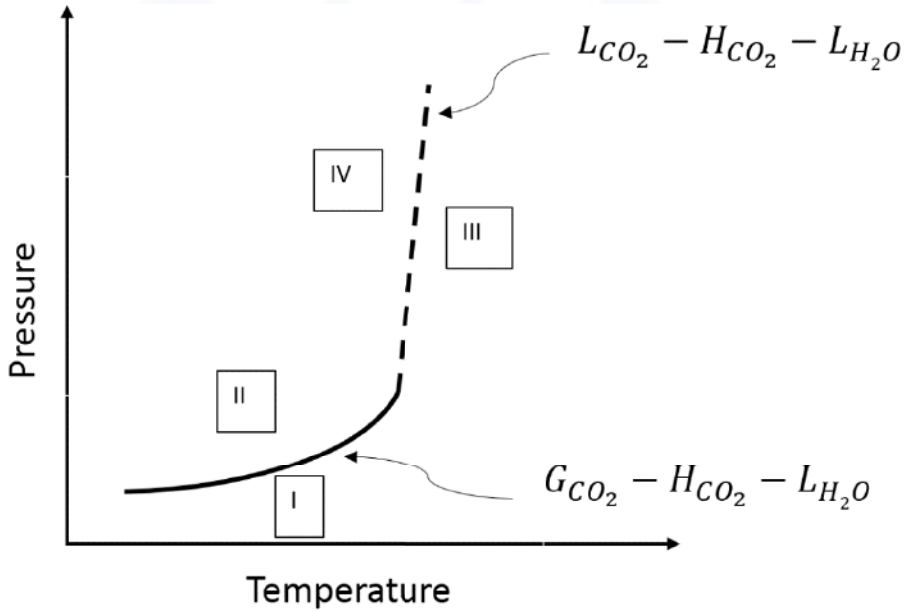
Q.12	**A measure of the potential of crude oil to form surfactants for Enhanced Oil Recovery (EOR) is given by the Total Acid Number (TAN). TAN is the mass of _____ (in milligrams) that is required to neutralize one gram of crude oil.**
(A)	$Ca(OH)_2$
(B)	NaCl
(C)	KOH
(D)	NaOH

Q.13	**In Water-Alternating-Gas (WAG) injection, the purpose of the injection is to _____I_____ the "relative permeability" of gas and to ____II_____ the "mobility" of the gas.**
(A)	I = reduce, II = enhance
(B)	I = reduce, II = reduce
(C)	I = enhance, II = reduce
(D)	I = enhance, II = enhance

Q.14 – Q.19 Multiple Select Question (MSQ), carry ONE mark each (no negative marks).

Q.14	**Solids that may possibly form in the offshore pipelines during the production of oil and gas from deep-water reservoirs are**
(A)	Wax
(B)	Char
(C)	Hydrates
(D)	Asphaltenes

Q.15	**Oil and gas pipelines, which are at an elevated pressure (about 3 MPa) and sub-ambient temperature (below 298 K), may get blocked by the formation of solid hydrates. One of the strategies adopted to inhibit the formation of hydrates is the injection of Thermodynamic Hydrate Inhibitors (THIs) into the reservoir fluid.** **Identify all suitable chemicals that are commonly used as THIs.**
(A)	Sodium Chloride
(B)	Methanol
(C)	Polyvinylpyrrolidone
(D)	Sodium Dodecyl Sulphate

Q.16	**When CO_2 and liquid water are brought in contact with each other, they may form solid hydrates. The three-phase hydrate boundary is shown in the Pressure -Temperature plot given below.** **Identify the correct statements.** **G = Gas Phase, H = Hydrate Phase, L = Liquid Phase** 
(A)	Hydrates are stable in region I
(B)	Hydrates are stable in region II
(C)	Hydrates are stable in region III
(D)	Hydrates are stable in region IV

Q.17	**Heavy oil recovered from reservoirs can be represented by $C_XH_{1.5X}$. Suitable processes to reduce the density of heavy oil are**
(A)	Carbon Rejection
(B)	Pyrolysis
(C)	Hydrogenation
(D)	Filtration

Q.18	**Identify the CORRECT statements for a $n \times n$ matrix.**
(A)	Under elementary row operations, the rank of the matrix remains invariant
(B)	Under elementary row operations, the eigenvalues of the matrix remain the same
(C)	If the elements in a row can be written as a linear combination of two or more rows, then the matrix is singular.
(D)	The rank of the matrix is equal to n if the determinant of the matrix is zero.

Q.19	**During a drilling operation, kick occurs if**
(A)	the shear ram in the Blow Out Preventer (BOP) does not work.
(B)	the formation pressure is equal to the drilling fluid pressure.
(C)	the volume of the mud used to fill the hole is less than that of the pipe being pulled out.
(D)	the formation pressure is more than the drilling fluid pressure.

Q.20 – Q.25 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

Q.20	**The value of $\lim_{x\to 0} \frac{4x^3-2x^2+x}{3x^2+2x}$ is _____ (correct up to one decimal place).**

Q.21	**Given two complex numbers, $z_1 = 4 + 3i$ and $z_2 = 2 - 5i$, the real part of $(z_1\overline{z_2})$ is_____.**

Q.22	**The number of 'three-digit numbers' that can be formed using the digits from 1 to 9 without the repetition of each digit is _____.**

Q.23	**The estimate for the root of the function $f(x) = e^{2x} + 2x$ after one iteration with an initial guess of $x_0 = 0$, using the Newton-Raphson method is_____ (correct up to two decimal places).**

Q.24	**A saturated oil reservoir has an average reservoir pressure of 3000 psia, tested for flowing bottom-hole pressure (BHP) of 2000 psia and production rate of 500 STB/day. The maximum reservoir deliverability based on Vogel's equation for two-phase flow is _____ STB/day.**

Q.25	**If the specific heat ratio of natural gas is 1.28, the critical pressure ratio (ratio of outlet pressure to upstream pressure) through a choke is _____ (round off to two decimal places).**

Q.26 – Q.37 Multiple Choice Question (MCQ), carry TWO mark each (for each wrong answer: – 2/3).

Q.26 Match the suitable artificial lift methods (GROUP I) to meet the requirements (GROUP II) given in the table.

GROUP I	GROUP II
(P) Progressive cavity pump	(I) To deliver high-water cut (95%) oil with high flow rate.
(Q) Electric submersible pump	(II) To deliver a fluid with viscosity of 1000 cP.
(R) Sucker rod pump	(III) To deliquify a gas-well with 5 bbl/day water.
(S) Gas lift	(IV) To be used in a sandy oil well to produce 5000 bbl/day.

(A) P – I, Q – II, R – IV, S – III

(B) P – II, Q – I, R – IV, S – III

(C) P – I, Q – II, R – III, S – IV

(D) P – II, Q – I, R – III, S – IV

Q.27 **Match the Enhanced Oil Recovery (EOR) methods (GROUP I) with the corresponding laboratory tests (GROUP II).**

GROUP I	GROUP II
(P) Gas injection EOR	(I) Interfacial tension studies
(Q) In-situ combustion EOR	(II) Screen viscometer test
(R) Polymer flooding EOR	(III) Minimum miscibility pressure test
(S) Surfactant-Alkaline EOR	(IV) Oxidation cell test

(A) P – III, Q – II, R – I, S – IV

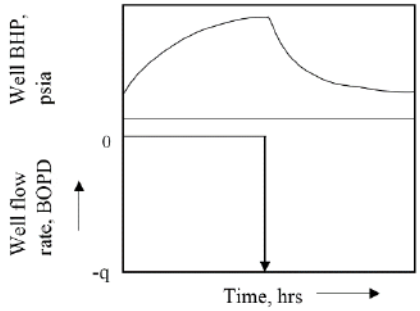
(B) P – II, Q – IV, R – I, S – III

(C) P – III, Q – IV, R – II, S – I

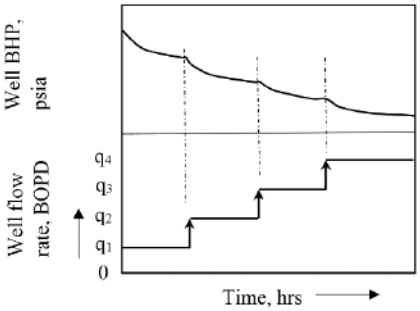
(D) P – III, Q – II, R – IV, S – I

Q.28 **Identify the following well test methods corresponding to the transient pressure profiles in the figures given below. (BHP: Bottom-hole pressure, BOPD: Barrels of oil per day)**

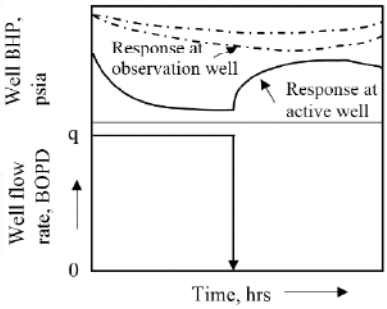
(P) **Flow-after-flow test**
(Q) **Interference test**
(R) **Fall-off test**
(S) **Modified isochronal test**



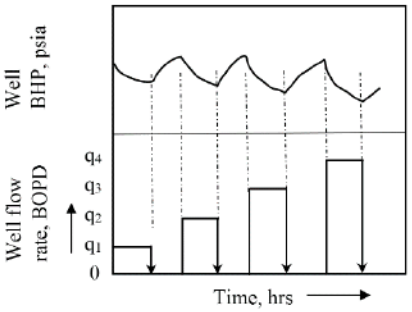
(I)



(II)



(III)



(IV)

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

Q.29 **Match the following wire-line logging methods (GROUP I) based on the physical principles of measurements (GROUP II).**

GROUP I	GROUP II
(P) Induction Log	(I) Measures natural radioactivity of a formation.
(Q) Gamma-Ray Log	(II) Measures induced magnetic moment of hydrogen nuclei (protons).
(R) Sonic Log	(III) Measures electrical resistivity/conductivity.
(S) Nuclear Magnetic Resonance Log	(IV) Measures elastic wave propagation properties.

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

Q.30 **Match the following rock types (GROUP I) with their respective chemical compositions (GROUP II) from the given options.**

GROUP I	GROUP II
(P) Sandstone	(I) A non-clastic carbonate rock consisting mainly of the mineral calcite.
(Q) Limestone	(II) A non-clastic chemical rock composed of mineral halite.
(R) Shale	(III) A siliciclastic rock formed mainly of sand.
(S) Rock salt	(IV) A fissile rock with a laminated structure, formed by consolidation of clay or mud.

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

Q.31 The following equations describe the transient fluid flow in a typical petroleum reservoir system. Here, p is pressure, x and r are the spatial coordinates in rectangular and cylindrical systems respectively, and t is time. Also, ϕ (porosity), μ (viscosity), c_f (formation compressibility), c_t (total compressibility) and k (permeability) are constant coefficients.

Match the equations (GROUP I) with their corresponding descriptions (GROUP II).

GROUP I	GROUP II
(P) $\frac{\partial^2 p}{\partial r^2}+\frac{1}{r}\frac{\partial p}{\partial r}=\frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t}$	(I) Equation in Cartesian coordinates used to describe incompressible fluid flow.
(Q) $\frac{\partial^2 p}{\partial x^2}=\frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t}$	(II) Equation in Cartesian coordinates used to describe slightly compressible fluid flow.
(R) $\frac{\partial^2 p}{\partial x^2}+c_f\left(\frac{\partial p}{\partial x}\right)^2=\frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t}$	(III) Equation in cylindrical coordinates used to describe slightly compressible fluid flow.
(S) $\frac{\partial^2 p}{\partial r^2}+\frac{1}{r}\left(\frac{\partial p}{\partial r}\right)+c_f\left(\frac{\partial p}{\partial r}\right)^2=\frac{\phi\mu c_t}{k}\frac{\partial p}{\partial t}$	(IV) Equation in cylindrical coordinates used to describe incompressible fluid flow.

(A) P – IV, Q – I, R – II, S – III

(B) P – IV, Q – III, R – II, S – I

(C) P – III, Q – IV, R – II, S – I

(D) P – III, Q – IV, R – I, S – II

Q.32	**Select the INCORRECT statement related to Enhanced Oil Recovery (EOR) techniques from the following options.**
(A)	Alkaline flooding recovers crude oil by reduction of interfacial tension (IFT) and reversal of wettability of rocks.
(B)	In-situ combustion recovers crude oil by the application of heat, thus lowering the viscosity of the crude oil.
(C)	Nitrogen flue gas flooding recovers crude oil by vaporizing the lighter components of the crude oil.
(D)	Polymer flooding recovers crude oil by reducing the viscosity and increasing the mobility of water.

Q.33 Match the petroleum reservoir forming traps (GROUP I) with their general classifications (GROUP II).

GROUP I	GROUP II
(P) Dome and Anticlinal Trap	(I) A geological structure with bodies of porous lithofacies embedded in impermeable lithofacies.
(Q) Salt Dome	(II) A geological structure formed by the tectonic uplift and/or folding of sedimentary rocks.
(R) Fault Trap	(III) A geological structure caused by the upward intrusion of a diapiric body of halite.
(S) Lenticular Trap	(IV) A geological plane with a sealing effect that acts as a fluid migration barrier for reservoir rocks.

(A) P – III, Q – II, R – IV, S – I

(B) P – II, Q – III, R – IV, S – I

(C) P – III, Q – I, R – II, S – IV

(D) P – II, Q – III, R – I, S – IV

Q.34	**An Ideal Pressure Buildup Test yields a single straight line for all times, when shut-in Bottom-Hole Pressure (P_{ws}) is plotted against $\log_{10}\frac{(t_p+\Delta t)}{\Delta t}$. Here t_p is the well production time and Δt is the time elapsed since shut-in. However, in an actual Pressure Buildup Test, a non-linear curve is obtained which can be logically divided into distinct regions.** **Choose the INCORRECT option from the following.**
(A)	A late-time region, in which the radius of investigation has reached the well's drainage boundaries.
(B)	A middle-time region during which the pressure transient has moved away from the wellbore and into the bulk formation.
(C)	An early-time region during which a pressure transient is moving through the formation nearest the wellbore.
(D)	An early-time region during which a pressure transient is moving away from the drainage boundary.

Q.35	**When two immiscible fluid phases are placed in contact with a solid surface, one phase usually is attracted to solid more strongly than the other phase. The more strongly attracted phase is called the 'wetting phase'.** **The inter-molecular interaction of the non-wetting phase with the solid is ___I___ than its intra-molecular interaction. Due to this, the non-wetting phase tends to occupy the ____II____ of the reservoir.**
(A)	I = stronger, II = smaller pores
(B)	I = stronger, II = larger pores
(C)	I = weaker, II = smaller pores
(D)	I = weaker, II = larger pores

Q.36	**Coal bed methane is methane gas adsorbed in coal seams. To desorb the methane from the coal seam it should be exposed to CO_2 and (or) N_2. Which ONE of the following is an appropriate reason to enhance the desorption process?**
(A)	N_2 is used because it has low kinetic energy compared to CH_4
(B)	CO_2 is used as it has high kinetic energy compared to CH_4
(C)	CO_2 is used as it strongly binds with coal compared to CH_4
(D)	N_2 is used as it strongly binds with coal compared to CH_4

Q.37 **Match the platforms (GROUP I) with appropriate support systems (GROUP II).**

GROUP I	GROUP II
(P) Semi-submersible platform	(I) Tether
(Q) Spar platform	(II) Turret Mooring
(R) Tension leg platform	(III) Catenary Mooring
(S) FPSO	(IV) Column Stabilised Unit

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

Q.38 – Q.39 Multiple Select Question (MSQ), carry TWO mark each (no negative marks).

Q.38	**Select the CORRECT statements from the following.** **Well testing operations on a typical crude oil reservoir**
(A)	do not measure rock and fluid properties of the reservoir when the well is flowing or shut-in.
(B)	measure variation in pressure response of the reservoir with time when the well is flowing or shut-in.
(C)	measure productivity index and partial well completion.
(D)	do not measure length and conductivity of hydraulic fractures.

Q.39	**Crude oil from oil sands contains bitumen and asphaltene and this crude is heavy and viscous at room temperature. Assume that one such crude oil is represented by $C_XH_{1.2X}O_Y$. For easier transportation through pipelines it should be processed further. Identify the processes which help in transportation of this crude oil.**
(A)	Drying
(B)	Vis-breaking
(C)	Coking process
(D)	Hydro-treating

Q.40 – Q.55 Numerical Answer Type (NAT), carry TWO mark each (no negative marks).

Q.40	**Given matrix $A = \begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$. The eigenvalue corresponding to the eigenvector $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$ is _____.**

Q.41	**The maximum value of the function $f(x) = x^4 - 8x^2 + 2$ for $-2 \leq x \leq 2$ is _____.**

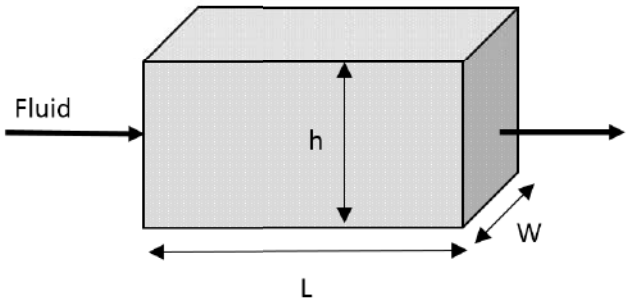
Q.42	**Given the second order ordinary differential equation: $y'' + 3y' - 4y = 0$ with the initial conditions $y(0) = 3$, and $y'(0) = -7$, the value of $y(1)$ is _____ (round off to two decimal places).**

Q.43	**The directional derivative of $f(x, y, z) = x^2 + 3y^2 + z^2$, at point (2,1,0) along the unit vector in x-direction, $\hat{\imath}$, is _____.**

Q.44	**A productivity test conducted on a crude oil well indicates a stabilized flow rate of 150 STB/day (water-free oil production) at a bottom-hole flowing pressure of 935 psig. After shutting the well for 24 hours, the bottom-hole pressure reached a static value of 1250 psig.** **The Absolute Open Flow (AOF) potential of the well is _____STB/day.**

Q.45 A porous medium (shown schematically in the figure) has the following properties.

Length L = 600 m, Width W = 8 m, Height h = 0.5 m,
Permeability k = 100 mD, Porosity ϕ = 15%.



An incompressible fluid having a viscosity of 2 cP is flowing through a porous medium at the inlet and exit pressures of 7×10^6 Pa and 6×10^6 Pa, respectively.

The actual fluid velocity through the porous medium is _____ $\times 10^{-7}$ m/s.

(1 Darcy = 10^{-12} m^2)

Q.46 A tubing with an inner diameter of 2.259 inch delivers oil from a well at the rate of 1000 bbl/day. The API gravity and viscosity of the oil are 40° and 1.2 cP, respectively. The tubing makes an angle of 15° with the vertical. Assuming a fanning friction factor of 0.006, the pressure-drop over a length of 1000 ft tubing is _____ psi (round off to nearest integer).

[1 bbl = 5.615 ft^3]

Q.47 A cylindrical crude oil reservoir with a radius of 3000 ft is under water influx from a cylindrical aquifer with an estimated radius of 9000 ft. The reservoir has the following properties.

Aquifer thickness, h = 40 ft

Porosity, ϕ = 15%

Formation compressibility, $C_f = 4.5 \times 10^{-6}$ psi^{-1}

Water compressibility, $C_w = 4.0 \times 10^{-6}$ psi^{-1}

Assuming a pot reservoir model with fractional encroachment angle as unity, the water influx into the reservoir for a pressure drop of 700 psi is _____ MMbbl (million barrels) (round off to two decimal places).

(π = 3.14, 1 bbl = 5.615 ft^3)

Q.48	A heavy oil reservoir with an initial oil recovery of 10% has the following properties. Confined area A = 1.5 acres, thickness of the reservoir h = 15 ft, effective porosity ϕ = 15%, irreducible water saturation S_{wr} = 25%, oil formation volume factor B_o = 1.10 bbl/STB. An in-situ combustion test was conducted in the above reservoir. Oil recovery due to the combustion process at the well is observed to be 12000 bbl. The total (overall) oil recovery at the end of the in-situ combustion process is _____% (round off to nearest integer) of the original oil in place. (1 acre = 43560 ft^2, 1 bbl = 5.615 ft^3)

Q.49	A double acting duplex pump with a rod diameter of 2.5 inch and a stroke of 20 inch is to be operated at 60 strokes per minute for drilling down to 10000 ft. The flow rate is 600 gpm. If the volumetric efficiency of the pump is 80%, the liner size is_____ inch (round off to one decimal place). [1 gallon = 231 inch^3]

Q.50	The fluid flow through an under-saturated oil reservoir is driven by solution gas drive mechanism. The reservoir parameters are as given below. Compressibility of water, $c_w = 1 \times 10^{-6}$ psi^{-1} Compressibility of formation, $c_f = 1 \times 10^{-5}$ psi^{-1} Connate water saturation, $S_{wc} = 0.2$ Initial reservoir pressure, $p_i = 4000$ psi Reservoir pressure at bubble-point, $p_b = 3000$ psi Oil formation volume factor, $B_{oi} = 1.24$ rb/STB Formation volume factor at bubble point pressure, $B_{ob} = 1.26$ rb/STB. The percentage of oil recovered as a fraction of the Original Oil in Place (OOIP) is _____% (round off to one decimal place).

Q.51 During drilling, a well is damaged out to a radial distance of 5 ft from the periphery of the wellbore so that the permeability within the damaged zone is reduced to $1/50^{th}$ of the undamaged effective permeability. After completion, the well is stimulated so that the permeability out to a radial distance of 15 ft from the periphery of the wellbore is increased to twenty times the permeability of the undamaged zone.

The radial inflow equation for stabilized flow conditions under semi-steady state conditions is given by

$$p_e - p_{wf} = \frac{q\mu}{2\pi k_e h}\left[\ln\left(\frac{r_e}{r_w}\right) - \frac{1}{2} + S\right],$$

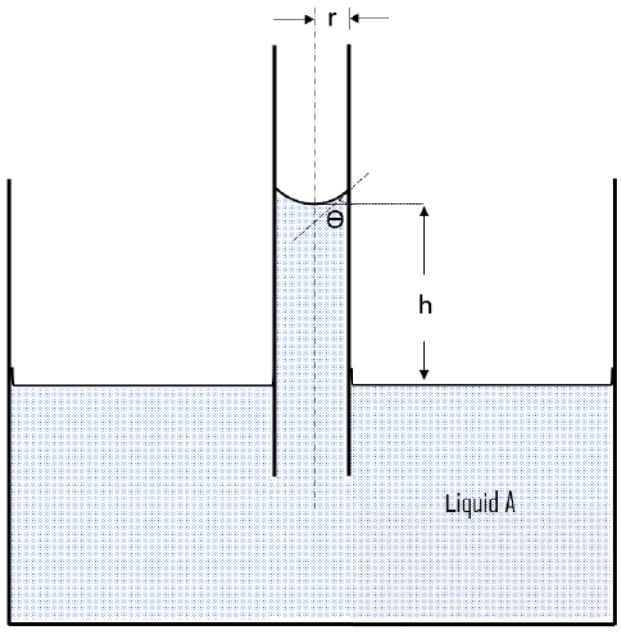
where p_e is effective pressure, p_{wf} is flowing bottom-hole pressure, q is flow-rate, μ is viscosity, k_e is average effective permeability, h is reservoir thickness, r_e is drainage radius, r_w is wellbore radius and S is skin factor.

If $r_w = 0.5$ ft and $r_e = 500$ ft, then the increase in Productivity Index ratio $\left(= \frac{PI_{stimulated-well}}{PI_{unstimulated-well}}\right)$ is _____ (round off to one decimal place).

Q.52 A depleted and shut-in oil reservoir originally contained 25×10^6 STB of oil with a formation volume factor of 1.35 res bbl/STB and a connate water saturation of 0.25. Cumulative oil production to date has been 2.5×10^6 STB of oil. The oil formation volume factor is now 1.25 res bbl/STB. Assuming no water influx, the gas saturation in the reservoir is _____ % (round off to one decimal place).

Q.53 **Surface tension of liquid A in a capillary is being measured in the laboratory using capillary rise (refer the figure given below). The capillary radius (r) is 100 µm, the height of liquid column (h) is 10 cm and $\Theta = 38^{o}$. Density of air can be neglected. Assume liquid A to have the same density as water.**

Surface tension of liquid A at room temperature is _____dynes/cm (round off to one decimal place).



Q.54	**Miscible displacement process is one of the EOR techniques. The performance of this process depends on fluid physical properties that affect flow behavior in a reservoir. Two of the important properties are density and viscosity. Consider the use of CO_2 for one such process. The density of CO_2 at the reservoir condition is _____ lb/ft^3 (round off to one decimal place).** **Relevant data for this calculation are given below.** **Reservoir temperature = 300 °F (422 K)** **Reservoir pressure = 1470 psig (100 atm)** **Compressibility factor (z) at the reservoir condition = 0.5** **Values of Universal Gas Constant (R) in different units are listed below.** **Universal Gas Constant (R) = 8.314 $m^3.Pa.K^{-1}mol^{-1}$** **= 10.731 psi. ft^3.lb. mol^{-1} $°R^{-1}$** **= 0.082 L. atm. K^{-1} mol^{-1}**

Q.55	**In a counter current heat exchanger, the hot fluid enters at 175 °F and exits at 100 °F. The cold fluid enters at 75 °F and exits at 85 °F. For the calculation of heat transfer rate, consider the tube surface area (per unit length) to be 0.26 ft^2/ft and a tube length of 40 ft. The overall heat transfer coefficient of the exchanger is 100 BTU/hr-ft^2. The minimum number of tubes required in the exchanger for a heat duty of 15×10^5 BTU/hr is_____ (round off to nearest integer).**

END OF THE QUESTION PAPER

Graduate Aptitude Test in Engineering (GATE 2021)

Answer Keys and Marks for Subject/Paper: Petroleum Engineering (PE)

Q. No.	Session	Question Type MCQ/MSQ/NAT	Section Name	Answer Key/Range	Marks	Negative Marks
1	4	MCQ	GA	C	1	1/3
2	4	MCQ	GA	B	1	1/3
3	4	MCQ	GA	C	1	1/3
4	4	MCQ	GA	C	1	1/3
5	4	MCQ	GA	B	1	1/3
6	4	MCQ	GA	C	2	2/3
7	4	MCQ	GA	D	2	2/3
8	4	MCQ	GA	A	2	2/3
9	4	MCQ	GA	C	2	2/3
10	4	MCQ	GA	A	2	2/3
1	4	MCQ	PE	C	1	1/3
2	4	MCQ	PE	C	1	1/3
3	4	MCQ	PE	C	1	1/3
4	4	MCQ	PE	C	1	1/3
5	4	MCQ	PE	A OR C	1	1/3
6	4	MCQ	PE	B	1	1/3
7	4	MCQ	PE	B	1	1/3
8	4	MCQ	PE	B	1	1/3
9	4	MCQ	PE	A	1	1/3
10	4	MCQ	PE	D	1	1/3

GATE 2021 Answer Key for Petroleum Engineering (PE)

Q. No.	Session	Question Type MCQ/MSQ/NAT	Section Name	Answer Key/Range	Marks	Negative Marks
11	4	MCQ	PE	D	1	1/3
12	4	MCQ	PE	C	1	1/3
13	4	MCQ	PE	B	1	1/3
14	4	MSQ	PE	A; C; D	1	0
15	4	MSQ	PE	A; B	1	0
16	4	MSQ	PE	B; D	1	0
17	4	MSQ	PE	A; C OR A; B; C	1	0
18	4	MSQ	PE	A; C	1	0
19	4	MSQ	PE	C; D OR D	1	0
20	4	NAT	PE	0.5 to 0.5	1	0
21	4	NAT	PE	-7 to -7	1	0
22	4	NAT	PE	504 to 504	1	0
23	4	NAT	PE	-0.25 to -0.25	1	0
24	4	NAT	PE	960 to 990	1	0
25	4	NAT	PE	0.52 to 0.57	1	0
26	4	MCQ	PE	D	2	2/3
27	4	MCQ	PE	C	2	2/3
28	4	MCQ	PE	C	2	2/3
29	4	MCQ	PE	B	2	2/3
30	4	MCQ	PE	C	2	2/3
31	4	MCQ	PE	A	2	2/3
32	4	MCQ	PE	D	2	2/3
33	4	MCQ	PE	B	2	2/3

GATE 2021 Answer Key for Petroleum Engineering (PE)

Q. No.	Session	Question Type MCQ/MSQ/NAT	Section Name	Answer Key/Range	Marks	Negative Marks
34	4	MCQ	PE	D	2	2/3
35	4	MCQ	PE	D	2	2/3
36	4	MCQ	PE	C	2	2/3
37	4	MCQ	PE	A	2	2/3
38	4	MSQ	PE	B; C; OR A; B; C	2	0
39	4	MSQ	PE	B; C; D	2	0
40	4	NAT	PE	3 to 3	2	0
41	4	NAT	PE	2 to 2	2	0
42	4	NAT	PE	2.71 to 2.79	2	0
43	4	NAT	PE	4 to 4	2	0
44	4	NAT	PE	580 to 610	2	0
45	4	NAT	PE	5 to 6	2	0
46	4	NAT	PE	340 to 360	2	0
47	4	NAT	PE	1.36 to 1.50	2	0
48	4	NAT	PE	68 to 78	2	0
49	4	NAT	PE	6.5 to 7.5	2	0
50	4	NAT	PE	2.6 to 3.0	2	0
51	4	NAT	PE	32 to 42	2	0
52	4	NAT	PE	11 to 14	2	0
53	4	NAT	PE	61 to 65	2	0
54	4	NAT	PE	15.7 to 16.1	2	0
55	4	NAT	PE	MTA	2	0

GATE 2021 Answer Key for Petroleum Engineering (PE)

Q. No.	Session	Question Type MCQ/MSQ/NAT	Section Name	Answer Key/Range	Marks	Negative Marks
MTA means Marks to All						