UNIVERSITY OF PETROLEUM & ENERGY STUDIES

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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Examination, July 2020

Programme: BT- APEUP **Semester: VI**
Course Name: Reservoir Engineering-II **Max. Marks: 100**
Course Code: PEAU 3005 **Attempt Duration: 2 Hrs.**

Note: This question paper has two sections, Section A and Section B.
There are total of three questions in this question paper. One in Section A and two in Section B.
Section A consist of multiple choice based questions and has the total weightage of 60%.
Section B consist of long answer based questions and has the total weightage of 40%.
The maximum time allocated to Section A is two Hrs.
Section B to be submitted within 24 hrs from the scheduled time
The section B should be attempted in blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, SAP-id at the top and signature at the bottom (right hand side bottom corner)
Section B will open at 1230 hrs

Section – A (Attempt all the questions)
(60 × 1 marks)

1. MCQ

1. Data necessary for the application of the techniques of material balance **CO2**
   A. Petro physical characterization of the reservoir
   B. Production history of a reservoir
   C. Rate of production from a well
   D. All of the above
2. The reservoir parameters of "A" reservoir are: Area = 80 acres, Net pay thickness = 50 ft, average porosity = 20%, Swc = 10%, Sg = 15%, oil FVF 1.42 rb/stb, Bgi = 0.8 rb/Mscf
   The ratio of gas cap to the oil rim (m) will be **CO2**
   A. 0.125
   B. 0.2
   C. 0.215
   D. 0.25
3. If the initial oil in place in the above reservoir "A" is 281.25 MMstb than the initial gas in place will be
   CO2
   A. 281.25 MM Scf
   B. 79.875 MM Scf

C. 99843.75 MM Scf

D. None of the above

4. The maximum recovery factor that can be obtained with a water flooding process in a reservoir with an initial water saturation Swi =25% and a residual oil saturation 15% **CO2**

A. 50%

B. 60%

C. 70%

D. 80%

5. Between a Bottom-water drive and an Edge-water drive reservoir, which one could have a greater oil recovery factor? **CO2**

A. Bottom-water drive reservoir

B. Edge-water drive reservoir

C. Bottom-water drive and an Edge-water drive reservoir have same recovery

D. None of the above

6. Reserves for high-pressure volumetric dry gas reservoirs are often obtained by extrapolating a plot of p/z vs. Gp to the abandonment point. Equivalent results could be obtained by plotting: **CO2**

A. 1/Bg vs. Gp

B. p vs. Gp

C. p^2 VS. Gp

D. Bg vs. Gp

7. Draw 5 rows of oil wells having 5 wells in each rows. These wells are to be subjected to a water flood using a five spot pattern. To achieve this pattern one should **CO3**

A. convert alternate horizontal rows of wells to injectors

B. convert alternate diagonal rows of wells to injectors

C. convert alternate vertical rows of wells to injectors

D. convert alternate wells in every diagonal to injectors

8. A volumetric (no water influx) dry gas reservoir had an initial pressure of 4750 psia with a gas deviation factor of 0.975.
At an abandonment reservoir pressure of 1,500 psia with a gas deviation factor of 0.992, the gas recovery factor (%) would be most nearly: **CO1**

A. 34.5

B. 65.5

C. 68.9

D. 71.1

9. You are calculating the original gas in place using the volumetric method. Which of the following has the least influence on the result? **CO1**

A. Connate water saturation

B. Initial reservoir pressure

C. Permeability

D. Porosity

10. A commercial oil reservoir has recently been discovered. If the oil reservoir is producing at pressures above the bubble point pressure, the factor in material balance calculations that is far more important than if the reservoir were producing below the bubble point pressure is: **CO2**

A. Water influx

B. Dip angle of the reservoir

C. Produced GOR
D. Formation compressibility

11. A currently depleted and shut-in oil reservoir originally contained 10,000 M STB of under-saturated oil with a formation volume factor of 1.3389 res bbl/ STB and a connate water saturation of 0.35. Cumulative oil production to date has been 937.5 MSTB of oil. The oil formation volume factor is now 1.2761 res bbl/STB Assuming no water influx, the current oil saturation is most nearly:

A. 0.30
B. 0.56
C. 0.60
D. 0.62

12. Name the type of reservoir drive that has a constant GOR most of the producing time and increasing near the end of production? **CO1**
    A. Free gas cap
    B. Water drive
    C. Gravity drive
    D. Solution gas drive
13. What type of reservoir drive maintains a constant reservoir pressure most of the production life? **CO1**
    A. Water drive
    B. Depletion drive
    C. Gravity drainage drive
    D. None of the above
14. Non-Associated Gas **CO1**
    A. Do not contain significant quantities of crude oil
    B. Contains significant quantities of crude oil
    C. Contains carbon dioxide gas
    D. None of the above
15. Which of the following statement is true? **CO2**
    A. The recovery factor of gas cap drive is smaller than that of water drive
    B. The recovery factor of water drive is smaller than that of gas cap drive
    C. The recovery factor of gas cap drive is same as that of water drive
    D. None of the above
16. Type of drive when the hydrocarbon are initially above the bubble point is known as **CO2**
    A. solution gas drive
    B. gas cap drive
    C. gravity drainage drive
    D. None of the above
17. Type of drive when the hydrocarbon are initially having free gas accumulated at the top of the reservoir and receives energy from the high compressibility of the gas is known as **CO1**
    A. Gas cap drive
    B. b Water drive
    C. c solution gas drive
    D. None of the above
18. Select the most appropriate statement on the effect of oil viscosity on fractional flow in a water flooding operation. **CO2**
    A. High viscosity of water reduces the fractional flow

B. High viscosity of oil reduces the fractional flow
C. High viscosity of water increase the fractional flow
D. High viscosity of water and low viscosity of oil reduces the fractional flow

19. The mobility ratio is **CO3**
A. It is the ratio of mobility of the displaced fluid to the mobility of the displacing fluid
B. It is the ratio of mobility of the displacing fluid to the mobility of the displaced fluid
C. It is the ratio of mobility of the oil to the mobility of the gas
D. None of the above

20. The overall recovery factor (efficiency) RF of any secondary or tertiary oil recovery method is dependent on **CO3**
A. Total sweep efficiency
B. Volume of oil left after primary recovery
C. Volume of water injected
D. All of the above.

21. Irregular injection pattern is adopted when **CO2**
A. Availability of water for injection is not regular
B. Reservoir is highly heterogeneous
C. Cost of drilling of injection well is very high
D. None of the above

22. Crestal and Basal Injection Patterns is applied **CO3**
A. In a partial gas cap, drive reservoir
B. In a partial water, drive reservoir
C. In a partial gas cap drive and partial water drive reservoir
D. None of the above

23. In water flooding parameter λ represents **CO3**
A. Displacement efficiency
B. Sweep efficiency
C. Mobility
D. None of the above

24. The name of scientist who proposed that the "apparent" aquifer radius r_a would increase with time is **CO2**
A. Hurst
B. Schilthuis
C. Fetkovich
D. None of the above

25. An under saturated oil reservoir having initial average porosity of 18% and rock compressibility cf = 10×10^{-6} was on production. The reservoir pressure has declined form initial pressure of 5000 psi to 4000 psi. The porosity at 4,000 psi will be **CO1**
A. 0.177
B. 0.178
C. 0.179
D. 0.180

26. The reservoir that is considered most suitable for water flooding if it has **CO3**
A. High reservoir temperature
B. High oil saturation
C. High reservoir heterogeneity
D. All of the above

27. The gas expansion factor (E_g) is **CO2**

A. $35.57\frac{p}{zT}$

B. $35.37\frac{p}{zT}$

C. $0.0282\frac{zT}{p}$

D. $0.282\frac{zT}{p}$

28. Huff and puff injection method in a gas condensate reservoir is **CO1**
    A. Injection of gas through one well and production of gas through another well
    B. Injection of water through one well and production of gas through another well
    C. Injection of gas through one well and production of gas through same well simultaneously
    D. Injection of gas through one well and production of gas through same well alternatively
29. If successive calculations at various times during the producing history of a dry gas reservoir give decreasing values for initial gas in place than **CO1**
    A. The reservoir is operating under partial water drive
    B. There is leakage in gas to other zone
    C. Partial dissolution of gas in aquifer water
    D. Formation of condensate in the reservoir
30. On a calorific basis, what approximate volume of gas is equivalent to one barrel of oil? **CO1**
    A. 4000 scf
    B. 6000 scf
    C. 8000 scf
    D. 10000 scf
31. During pressure depletion operations, the internal pore pressure decreases and causes **CO1**

A. The effective overburden pressure on the reservoir decrease.
B. Sand grains within the pore spaces decrease.
C. The porosity of the reservoir rock increase
D. The bulk volume of the reservoir rock decrease

32. The approximate volume of recoverable gas would be required to justify building a liquefied natural gas (LNG) plant. **CO1**
    A. 2 Tcf
    B. 5 Tcf
    C. 10 Tcf
    D. 15 Tcf
33. For under-saturated oil reservoirs, the total reservoir compressibility c_t is **CO1**
    A. $c_t = S_o c_o + S_w c_w + S_g c_g + c_f$
    B. $c_t = S_o c_o + S_w c_w + S_g c_g$
    C. $c_t = S_o c_o + S_w c_w$
    D. $c_t = S_o c_o + S_w c_w + c_f$
34. The relationship between the gas flow rate and pressure can be expressed as **CO1**
    A. $Q_g = C (p_r^2 - p_{wf}^2)^n$
    B. $Q_g = C (p_r - p_{wf})^n$
    C. $Q_g = C (p_r^2 - p_{wf}^2)$
    D. $Q_g = C (p_r - p_{wf})$

35. Dew drops is a phenomenon in which **CO1**
    A. Liquid drops are formed while doing PVT analysis on a gas condensate sample
    B. Liquid drops are formed at separator condition while producing from wet gas reservoir
    C. Liquid drops are in the reservoir near the well bore
    D. Dew point pressure measurement is done
36. In an active water drive reservoir "A", the rate of production and reservoir pressure remain constant. The water influx into the reservoir from aquifer is 10000 bbl/day. The surface oil and water production rate are 5000 STB/day and 2500 STB /day respectively. The formation volume factor of oil and water is 1.375 bbl / STB, 1.04 bbl/ STB respectively. The flow rate of gas at reservoir condition is **CO2**
    A. 525 scf/day
    B. 525 bbl/day
    C. 500 cf/day
    D. 2500 bbl/day
37. If the formation volume factor of gas of above reservoir "A" is 0.007 bbl/ STB, the rate of production of free gas Qg **CO2**
    A. 4125000 Scf/day
    B. 85000 STB/day
    C. 75000 STB/ day
    D. 65000 STB /day
38. If the current production gas oil ratio (Rp) is 825 SCF/STB from the above reservoir "A", the rate of production of solution gas will be **CO2**
    A. 4050000 scf /day
    B. 3703875 scf/ day
    C. 3503875 scf/ day
    D. None of the above
39. The solution GOR at current reservoir pressure of the above reservoir "A", is **CO2**
    A. 710 scf/bbl
    B. 740 scf/bbl
    C. 700 scf/bbl
    D. None of the above
40. Select the wrong statement from the following. Water encroaches into a reservoir in response to pressure reduction which causes **CO2**
    A. Expansion of gas cap in the reservoir
    B. Expansion of the water due to pressure drop within the aquifer
    C. Expansion of hydrocarbons in the aquifer, if any
    D. Expansion of rock, which decreases porosity of aquifer
41. Select correct statement for the Pot aquifer model used for calculation of water influx **CO2**
    A. It is applicable to all type of reservoir
    B. The rate of water influx from the aquifer into the reservoir equals the rate of withdrawal
    C. Pressure drop in the reservoir is instantaneously transmitted throughout the entire reservoir-aquifer system
    D. All of the above
42. In Schilthuis' Steady-State Model, **t**he water influx constant C in bbl/day/psi is **CO2**

A. $\frac{0.00708\ kh}{\mu w\ ln(\frac{ra}{re})}\ (p-pi)$ (0.00708kh/ μw ln (ra/re))(p - pi)

B. $\frac{0.00708\ kh}{\mu w\ ln(\frac{ra}{re})}\ (pi-p)$ (0.00708kh/ μw ln (ra/re))(pi - p)

C. $\frac{0.00708\ kh}{\mu w\ ln(\frac{ra}{re})}$ 0.00708kh/ μw ln (ra/re)

D. $\frac{0.00708\ kh}{\mu w\ ln(\frac{re}{ra})}$ 0.00708kh/ μw ln (re/ra)

43. A volumetric solution-gas-drive reservoir "C" has an initial water saturation of 20%. The initial oil formation volume factor is reported at 1.5 bbl/STB. When 10% of the initial oil was produced, the value of Bo decreased to 1.38. The present oil saturation will be **CO2**
    A. 80%
    B. 75%
    C. 66%
    D. 65%
44. In the above reservoir "C" the free gas saturation after producing 10% of the initial oil will be **CO2**
    A. 0%
    B. 5%
    C. 14%
    D. 15%
45. Select the correct statement from the followings **CO2**
    A. The water influx constant C may be calculated from the reservoir historical production data at different selected time intervals.
    B. The influx constant can only be obtained when the reservoir pressure stabilizes.
    C. After obtaining the influx constant, it may be applied to both stabilized and changing reservoir pressures.
    D. All of the above
46. The information required for predicting cumulative hydrocarbon production as a function of declining reservoir pressure **CO2**
    A. Actual number of producing wells
    B. Location of each well
    C. Production rate of individual wells
    D. None of the above
47. While predicting cumulative hydrocarbon production using material balance equation which of the following GOR is not required **CO2**
    A. Instantaneous GOR
    B. Liberated GOR
    C. Solution GOR
    D. Cumulative GOR
48. In the expression Gp = $\int_0^{Np}(GOR)$ d N_p, the GOR is **CO2**
    A. Instantaneous GOR
    B. Initial GOR
    C. Solution GOR at current pressure
    D. Cumulative GOR

49. In a producing field, it has been identified that some of the reserves are not drained effectively. The possible remedy of this is **CO4**
    A. Hydro fracturing
    B. Acidization
    C. Infill drilling
    D. None of the above
50. Tracy developed technique to predict the performance of oil reservoir, that is **CO2**
    A. Under saturated reservoir
    B. Saturated reservoir
    C. Both under saturated or saturated reservoir
    D. Under pressure maintenance
51. For a solution-gas-drive reservoir, the Tracy's equation for prediction of hydrocarbon production is **CO2**
    A. $\Delta Np = \frac{N - (N^*p\ \Phi o + G^*p\ \Phi g)}{(\Phi o + (GOR)\ \Phi g)}$ $N - (N^*p\ \Phi o + G^*p\ \Phi g)/(\Phi o + (GOR)\ \Phi g)$
    B. $\Delta Np = \frac{N - (N^*p\ \Phi o + G^*p\ \Phi g)}{(\Phi o + (GOR)avg\ \Phi g)}$ $N - (N^*p\ \Phi o + G^*p\ \Phi g)/(\Phi o + (GOR)avg\ \Phi g)$
    C. $\Delta Np = \frac{N - (Np\ \Phi o + G^*p\ \Phi g)}{(\Phi o + (GOR)avg\ \Phi g)}$ $N - (Np\ \Phi o + G^*p\ \Phi g)/(\Phi o + (GOR)avg\ \Phi g)$
    D. $\Delta Np = \frac{N - (N^*p\ \Phi o + Gp\ \Phi g)}{(\Phi o + (GOR)avg\ \Phi g)}$ $N - (N^*p\ \Phi o + Gp\ \Phi g)/(\Phi o + (GOR)avg\ \Phi g)$
52. The time required for production in performance prediction can be calculated **CO2**
    A. By applying the concept of the inflow performance relation (IPR) in conjunction with the MBE predictions
    B. By Using the minimum bottom-hole flowing pressure, the total field flow rate is determined.
    C. By using A & B above
    D. By using either A or B above

    A water flood is to be conducted at the rate of 7000 bbl/day in an under saturated oil reservoir "Y" having initial water saturation 25% which has dimensions that will result in linear flow. The average cross-sectional area is approximately 78,000 square feet. The water saturation at breakthrough is 0.614. The first row of producers is located 1320 ft from injection wells. Additional data are: B_w = 1.02 RB/STB, μ_o = 1.39 cp, μ_w = 0.50 cp, φ = 22% , k = 50 md, α = 0 B_o = 1.25,
53. If kro/krw is 1.34 at water saturation 50%, the fractional flow at this water saturation in reservoir "Y" will be **CO3**
    A. 0.517
    B. 0.674
    C. 0.820
    D. 0.902
54. If kro/krw is 0.292 at water saturation 60%, the fractional flow at this water saturation in reservoir "Y" will be **CO3**
    A. 0.517
    B. 0.674
    C. 0.820
    D. 0.902

55. If the average water saturation at the time of breakthrough is 0.614, the displacement sweep efficiency at the time of water breakthrough in reservoir "Y" will be most nearly **CO3**
    A. 45%
    B. 48%
    C. 50%
    D. None of the above
56. The cumulative oil recovered from reservoir "Y" at the time of water breakthrough **CO3**
    A. 1.100×10^6 stb
    B. 1.146×10^6 stb
    C. 1.175×10^6 stb
    D. None of the above
57. The approximate time (days) will it take water breakthrough in reservoir "Y" **CO3**
    A. 210 days
    B. 205 days
    C. 200 days
    D. None of the above
58. The volume of cumulative water must be injected to obtain breakthrough in reservoir "Y" will be nearly **CO3**
    A. 1.100×10^6 stb
    B. 1.146×10^6 stb
    C. 1.175×10^6 stb
    D. None of the above
59. If $(df_w/dS_w)_{swf}$ = 2.74, the pore volume of water injected in reservoir "Y" at breakthrough will be nearly **CO3**
    A. 0.234
    B. 0.298
    C. 0.364
    D. None of the above
60. The nearly location of the displacement front after 100 days from the beginning of injection from injector in reservoir "Y" will be **CO3**
    A. 628 ft
    B. 670 ft
    C. 698 ft
    D. None of the above

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Section – B (Attempt all the questions)
(2 × 20 marks)

1. A private operator is interested to enter into a hydrocarbon exploration and production business and wants to open an E & P company. Describe in details the various activities associated in this business right from start to bring oil and gas production at commercial scale with further managing the reservoir for maximum oil recovery.
   After entering the E & P business the exploration scientist after doing necessary studies, informed the operator that the reservoir discovered contains 200 MM bbl. oil in place. The initial reservoir pressure is 6000 psi, bubble point pressure is 4600 psi, and initial water saturation is 30%. The compressibility of formation, oil and water are $c_f = 5 \times 10^{-6}$

psi^{-1}, $c_o = 15 \times 10^{-6}$ psi^{-1}, $c_w = 3 \times 10^{-6}$ psi^{-1}. The viscosity of oil is 1.0 cp near bubble point pressure. The results of PVT studies carried out at reservoir temperature 110 °C are presented in table-1

Table-1 PVT data

Pressure (psig)	Oil FVF (Bo) (v/v)	Gas FVF Bg* 10^{-3} (v/v)	Solution GOR (v/v)	Liberated GOR (v/v)
6000	1.5167	0	190	00
5500	1.5180	0	190	00
5000	1.5200	0	190	00
4600	1.5223	4.71	190	00
4000	1.4867	5.18	170	20
3500	1.4173	5.69	148	42
3000	1.3504	6.57	127	63
2500	1.3072	8.14	97	93
2000	1.2568	10.81	78	112
1500	1.2103	15.96	60	130
1000	1.1696	25.65	40	150
500	1.1331	61.45	20	170
Atm				190

Calculate and present the production and cumulative production of oil and gas for each 200-psi pressure drop from initial reservoir pressure to 3000 psi for quick reference by operator. Use standard relative permeability curves if required. Also, work out the recovery pressure at each pressure drop. Finally present the observation about expected performance of the project you handled. **CO4**

2. As a reservoir engineer, your efforts are to increase the recovery. Kindly suggest best possible method that can be applied to increase the recovery of above reservoir. How will you convince the operator to select water flood technique? If residual oil saturation is 30% and water flood will be started when 10 % of gas saturation was build up at about 4400 psi. Calculate the recovery of oil and gas with increasing water saturation from initial water saturation to residual oil saturation. Present the cumulative oil and gas production at different water saturation up to the residual oil saturation. The density of oil and water is 45 lb/ft^3 and 64.0 lb/ft^3 respectively. The viscosity of water is 0.5 cp.
It is a linear reservoir system having following permeability data.

S_w	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
k_{ro}/k_{rw}	30.23	17.00	9.56	5.38	3.02	1.70	0.96	0.54	0.30	0.17	0.10

Calculate and plot the water saturation profile after every 50 days interval for 250 days and present your observation. While making development plan you already decided well spacing, rate of production and accordingly rate of water injection.

It is observed that the projected ultimate water flood recovery factor is 30% when reaching the economic WOR limit; determine whether an opportunity exists to increase recovery beyond the projected estimate. Give in details with what technology how much additional oil can be recovered beyond 30% re **CO3**

Figure -1