Federal University of Technology, Owerri
School of Engineering & Engineering Technology
Petroleum Engineering Department

2019/2020 RAIN SEMESTER EXAMINATION **EXAM. DATE: 02-07-2021**
PET 506: ENHANCED OIL RECOVERY **TIME: 3 Hrs**
Instructions: Attempt any five questions

1 (a) By means of equation, define the following parameters: (i) Em- Microscopic sweep efficiency (ii) E_A- Areal sweep efficiency (iii) E_V- Volumetric sweep efficiency (iv) E_I- Vertical sweep efficiency (b) Clearly differentiate between steam stimulation and steam injection. (c) In a hot water injection project, 500 b/d of hot water has been injected down 7- in casing (6.366 in. ID) to the formation at a constant rate for a period of 30 days. The casing length is 5000 ft. The overall heat transfer coefficient is 56 Btu/hr-ft^2-°F. The thermal conductivity of formation is 1.79 Btu/hr-ft-°F, specific heat of formation is 0.619 Btu/lb$_m$-°F, density of formation is 143.5 lb$_m$/cuft, and water temperature at the surface is 200 °F. The project site is at FUTO with a surface temperature of 70 °F and geothermal gradient of 1 °F/100 ft of depth. Determine water temperature at the bottom of casing and the rate of heat loss from the wellbore. Specific heat of water,C_w =1 Btu/lb-oF. (d) What measures should be taken to check excessive heat loss in a hot water injection project.

2400 psi 4 ft water

2(a) The property and evaluation unit of a conventional oil company has estimated the life span for an economically sustainable steam flooding project to be 340 days. Determine the cumulative oil displaced by the injection of 80% quality steam in the developed 5- spot pattern.
Hint: Determine the economic limit in bbl/d of oil and solve graphically using intervals of 50 days. Explain the trend established in the diagram.
Reservoir and other pertinent data are given as follows:
Initial reservoir temp = 80 °F, Formation porosity = 25 %, Formation thickness =20 ft,
Oil density = 501b/ft^3, Initial oil saturation = 60 %, Water density =62.4 ib/ft^3
Thermal conductivity of the base and cap rock,K = 1.5 BTU/ft-hr-°F, Depth of the formation = 1000ft
Specific heat of rock = 0.21 Btu/lb-°F, Specific heat of oil = 0.50 Btu/lb-°F
Specific heat of water = 1.0 Btu/lb-°F, Thermal Diffusivity of adjoining strata = 0.96 ft^2/d
Sand face temp. at 400 psia = 450 °F, Irreducible oil saturation = 20 %
Rock grain density = 167 lb/ft^3, Water saturation = 20 %
b) Under what condition will steam stimulation be considered the most feasible alternative in EOR
(c) Explain four advantages of thermal recovery by hot fluid injection.

3(a) Categorize the various processes of enhanced oil recovery according to the forces they are meant to overcome. (b) Describe loss of heat in the wellbore (c) Hot fluid injection is limited in use to relatively few reservoirs; briefly describe the characteristics that are beneficial to its success. (d) Clearly differentiate between steam stimulation and steam injection. (e) Write short note on cyclic steam injection.

(4)Two cases of water displacing oil in a flooding operation are being investigated. The viscosities of the two cases are as follows:

Case	Oil viscosity	Water viscosity
1	5 cp	0.5 cp
2	0.4 cp	1.0 cp

(a) Plot the fractional flow curve of the two cases on the same graph paper, given the listed relative permeability and saturation data.
(b) Determine Fractional flow at the front for each of the cases.
(c) Which of the two cases will result to higher cumulative Oil production N_p?

S_w	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80
K_{rw}	0	.002	.009	.020	.033	.051	.075	.100	.132	.170	.208	.251	.300
K_{ro}	.800	.610	.470	.370	.285	.220	.163	.120	.081	.050	.027	.010	0

(5)(a) Briefly explain the factors affecting sweep efficiency during flooding.

(b) Given two phase system of oil and gas, show that fractional flow of water is given by:

$F_w = 1/1+\frac{\mu w}{krw} x \frac{kro}{\mu o}$

(c) Constant pressure drop between the injection and production wells are Δp=7.5 mpa,thickness H=55m,porosity =40%, Soi= 0.80,Sor=0.35, oil viscosity=35cp, viscosity of water=1 cp, oilfvf=1.2, absolute permeability k=101md, krw=0.18,kro=0.87,wellbore radius=0.7ft.
Calculate (i) The mobility ratio (ii)Volume of oil in the reservoir. (iii)The Recovery factor.

(6) (a)(i)Using appropriate diagram, describe why Buckley Leverette displacement concept is regarded as a real case scenario.(ii)What are the assumptions for Buckley Leverette displacement concept.(b)Enumerate 5 Characteristics of Piston-Like Displacement? (c)A heavy oil reservoir is being flooded with a line drive (assume one-directional flooding). The fractional flow of water is found to be 0.75 bbl/bbl at water saturation of 60%. A polymer solution with twice the viscosity of water is used as displacing phase. Assume relative permeability curve for waterflooding and polymer flooding are the same. What is the polymer solution at a saturation of 60% in bbl/bbl