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

Harmattan Semester Examination, 2019/2020
PET 403: Reservoir Engineering 11
Instructions: Answer all questions

Date: 10/2/2020
Time: 2.5 Hrs

1. (a) Using phase envelope, label and define the following terms
   i. Bubble point curve ii. Critical point iii. Dew point curve
   iv. Cricondentherm v. Cricondenbar

(b) Convert the laboratory differential liberation data presented in table below to the required PVT parameters, Bo, Rs and Bg, for field use, for the separator conditions of flash shrinkage factor c_{bf} as 0.7993 (stb/rbb) and flash solution gas oil ratio R_{sif} of 510 scf/stb: Hint: $Bo = Vo/c_{bf}$ (rb/stb), $Rs = R_{sif} - (5.615F/c_{bf})$ (scf/stb), $Bg = 1/(5.615E)$ (rb/scf)

Pressure	Relative Gas Vol. (at p and T) V_g	Relative Gas Vol. (sc) V_g	Cumulative Relative Gas Vol. (sc) F	Gas expansion Factor E	Z-factor Z	Relative Oil Vol. (at p and T) V_o
3330 (p_b)						1.0000
3000	.0460	8.5211	8.5211	185.24	.868	.9769
2700	.0417	6.9731	15.4942	167.22	.865	.9609
2400	.0466	6.9457	22.4399	149.05	.863	.9449
2100	.0535	6.9457	29.3856	129.83	.867	.9298
1800	.0597	6.5859	35.9715	110.32	.874	.9152
1500	.0687	6.2333	42.2048	90.73	.886	.9022
1200	.0923	6.5895	48.7943	71.39	.901	.8884
900	.1220	6.4114	55.2057	52.55	.918	.8744
600	.1818	6.2369	61.4426	34.31	.937	.8603
300	.3728	6.2297	67.6723	16.71	.962	.8459
14.7 (200°F)			74.9557			.8296
14.7 (60°F)			74.9557			.7794

All volumes are measured relative to the unit volume of oil at the bubble point pressure of 3330 psi

2. (a) Why are reservoir fluids sampling conducted on virgin reservoirs or in new wells in undepleted zones for PVT Analysis?
(b) It is planned to initiate a water injection scheme in the reservoir whose PVT properties are defined in table below. The intention is to maintain pressure at the level of 2700 psia (pb = 3330 psia). If the current producing gas oil ratio of the field (Rp) is 800 scf/stb;

Pressure (psia)	$B_o = \frac{V_{t_2}}{c_{s_2}}$ (rb/stb)	R_s $R_{si} = \frac{0.615\ F}{c_{s_2}}$ (scf/stb)	$B_g = \frac{1}{0.615\ B_f}$ (rb/scf)
4000 (p_i)	1.2417 (B_{oi})	510 (R_{si})	
3500	1.2480	510	
3330 (p_b)	1.2511 ($B_{ob} = \frac{1}{c_{o_1}}$)	510	.00087
3000	1.2222	460	.00096
2700	1.2022	401	.00107
2400	1.1822	362	.00119
2100	1.1633	304	.00137
1800	1.1450	257	.00161
1500	1.1287	214	.00196
1200	1.1115	167	.00249
900	1.0940	122	.00339
600	1.0763	78	.00519
300	1.0583	35	.01066

i. What would be the initial water injection rate required to produce 15,000 stb/d of oil?
ii. What would have been the initial injection rate if gas was to be injected?
iii. Assuming the pressure could be maintained at the bubble-point pressure (pb =3330 psia), what would be the initial water injection rate to produce 15,000 stb/d of oil and also what would have been the initial injection rate if gas was to be injected?
iv. Compare the results of i, ii and that from iii. What can you deduce from the results?

3. (a) A natural gas with a specific gravity of 0.6 is flowing in linear porous media at 150°F. The upstream and downstream pressures are 3300 psi and 2994.73 psi, respectively. The cross sectional area is constant at 5500 ft^2. The total length is 2400 ft with an absolute permeability of 54 md. Calculate the gas flow rate in scf/day (p_{sc} = 14. 7 psia, T_{sc} = 520°R). Z-factor has been determined from the Standing-Katz chart as: Z = 0.78

b) Show that for a linear flow of compressible fluid, that the flow rate is given as :

$$Q_{sc} = \frac{0.111924 Ak\left(P_1^2 - P_2^2\right)}{TLZ\mu_g}$$

4. (a) The following data are available in FUTO field 1:

$P_e = 2610 psi$, $P_{wf} = 1905 psi$, $r_e = 610 ft$, $r_w = 0.26 ft$, $B_o = 1.25 bbl/stb$, $\mu_o = 2.6 cp$, $k = 0.16 d$, $h = 30 ft$, $c_o = 26x10^{-6} psi^{-1}$.

Assuming a slightly compressible fluid, calculate the oil flow rate. Compare the result with that of an incompressible fluid

(b) An oil well in the Nameless Field is producing at a stabilized rate of 700 STB/day at a stabilized bottom-hole flowing pressure of 1800 psi. Analysis of the pressure buildup test data indicates that the pay zone is characterized by a permeability of 140 md and a uniform thickness of 25 ft. The well drains an area of approximately 50 acres. The following additional data is available:

r_w = 0. 25 ft, A = 50 acres\ B_o = 1. 25 bbl/STB, μ_o = 2. 8cp

Calculate the pressure profile (distribution) and list the pressure drop across 1 ft intervals from r_w to 1.25 ft, 4 to 5 ft, 19 to 20 ft, 99 to 100 ft, and 744 to 745 ft.