National Exams December 2018

17-Pet-A2, Petroleum Reservoir Fluids

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam.
3. Approved Casio or Sharp calculator is permitted.
4. FIVE (5) questions constitute a complete exam paper.
5. The first five questions as they appear in the answer book will be marked.
6. All questions are of equal value unless otherwise stated and all parts in a multipart question have equal weight.
7. Clarity and organization of your answers are important, clearly explain your logic.
8. Pay close attention to units, some questions involve oilfield units, and these should be answered in the field units. Questions that are set in other units should be answered in the corresponding units.
9. A formula sheet is provided at the end of questions

Question 1 (20 Marks)

a) Draw schematics of pressure-temperature (PT) diagram for a pure component and show different phase regions, critical point, triple point, melting point curve, and sublimation point curve (**5 points**).

b) What are the basic classification of reservoir fluids? Name four type of reservoir fluids (**2 points**).

c) If you have a mixture of normal butane (nC_4) and iso-butane (nC_4) in two phase conditions, what will be the degree of freedom of this system? (**3 points**).

Define the following terms in one or two sentences

d) Retrograde condensation (**2 points**)

e) Constant composition expansion (CCE) (**2 points**).

f) Undersaturated oil (**2 points**).

g) Test separator (**2 points**).

h) Sour gas (**2 points**).

Question 2 (20 Marks)

A PVT test on formation water has shown 20 standard m^3 of CO_2 is dissolved in one standard m^3 of water (20 Sm^3/Sm^3). The water density at standard condition is 1000 kg/m^3 and the molecular weights of the CO_2 and water are 44 and 18 g/mole, respectively.

a) Calculate mass fraction of CO_2 dissolved in water. Assume volume of one mole of gas at standard conditions is 22.4 Liters,

b) Calculate formation volume factor of water at reservoir condition if the water density at reservoir condition is 900 kg/m^3. **Hint**: start with the definition of the formation volume factor and $V=m/\rho$, where V is volume, m is mass and ρ is density.

Question 3 (20 Marks)

A reservoir contains a single-phase dry natural gas at 1400 psia and 200°F. The reservoir pore volume is determined to be 12.394×10^6 ft^3. The gas specific gravity is 0.6. Calculate the following:

a) Gas deviation factor, Z,

b) Gas density in lb_{mass}/ft^3,

c) Reservoir gas volume at standard conditions (p_{sc}=14.7 and T_{sc}=60°F),

d) Number of mole of gas in the reservoir.

Question 4 (20 Marks)

One mole of n-decane (C_{10}) is brought into equilibrium with unknown amount ethane (C_2) of in a visual PVT cell at high pressure and high temperature. The resultant mixture volume is 90 % liquid and 10% gas at the cell condition. The equilibrium constants (*K*-values) for n-decane and ethane are estimated from a correlation to be 0.005, 8, respectively.

a) Calculate the number of mole of ethane in the cell,

b) Determine the equilibrium composition (mole fractions of n-decane and ethane) in the gas and liquid phases in the PVT cell.

Question 5 (20 Marks)

A gas reservoir has a pressure of 1400 psia and a constant temperature of 200 °F. Use the gas compressibility chart (Z-factor chart) given to estimate the coefficient of gas isothermal compressibility, c_g in 1/psi? What is the isothermal gas compressibility if one assumes the reservoir gas is ideal?

The gas specific gravity is 0.6.

Critical Pressure, p_c=670 psia,

Gas pseudo reduced pressure, $p_{pr} = 2$,

Gas pseudo reduced temperature, $T_{pr} = 1.8$,

Question 6 (20 Marks)

a) Draw a schematic for typical shape of oil viscosity (μ_o) as a function of pressure at constant reservoir temperature.
b) Draw a schematic for typical shape of oil formation volume factor (B_o) as a function of pressure at constant reservoir temperature.
c) Draw a schematic for typical shape of total formation volume factor (B_t) as a function of pressure at constant reservoir temperature.
d) Draw a schematic for typical shape of solution-gas-oil-ratio (R_{so}) as a function of pressure at constant reservoir temperature.
e) Draw a schematic for typical shape of coefficient of oil isothermal compressibility (c_o) as a function of pressure at constant reservoir temperature.

In all cases mark the reservoir bubble point pressure in your plots.

Question 7 (20 Marks)

a) A sample of reservoir high pressure liquid with volume of 400 cc under reservoir conditions was passed through a separator and into a stock tank at atmospheric pressure and 60 °F. The liquid volume in the stock tank was 274 cc. A total of 1.21 SCF of gas was released. Calculate the oil formation volume factor in resbbl/SCF and solution-gas-oil ratio in SCF/STB.

b) 274 cc of oil at standard conditions was placed in a laboratory cell. 37500 cc of gas at standard condition was added to the cell and the gas and oil were brought into equilibrium at 200 °F. The pressure was raised until the last bubble of gas was dissolved in the oil. At this point, cell volume was 400 cc and pressure was 2620 psia. Pressure in the cell was reduced to 2253 psia by increasing the total cell volume to 430 cc. At that point the oil volume in the cell was 388 cc and the gas volume in the cell was 42 cc. Calculate the total formation volume factor at 2253 psia. What is the solution gas oil ratio (R_{so}) in SCF/STB at 2253 psia if the gas formation volume factor is given to be 0.01 reservoir cc/ standard cc.

Formula Sheet

Real gas law

$pV = ZnRT$

where p in psia, T in °R, V in ft³, R=10.732 psi-ft³/(lb$_{mol}$-°R)

Pseudo critical pressure and temperature

$T_{pc} = 168 + 325\gamma_g - 12.5\gamma_g^2$ in ^oR

$p_{pc} = 677 + 15.0\gamma_g - 37.5\gamma_g^2$ in $psia$

Reduced temperature: $T_r = \frac{T}{T_c}$

Reduced pressure: $p_r = \frac{p}{p_c}$

where γ_g is the gas specific gravity (Air=1)

Average molecular weight: $M_{av} = \sum y_i M_i$

Pseudo critical Temperature: $T_{pc} = \sum y_i T_{pc_i}$

Reduced temperature: $T_r = \frac{T}{T_c}$

Pseudo critical pressure: $p_{pc} = \sum y_i p_{pc_i}$

Reduced pressure: $p_r = \frac{p}{p_c}$

Gas density: $\rho = \frac{pM}{ZRT}$

where ρ is gas density in lb$_{mass}$/ft³, p in psia, T in R, M is molecular weight in lb$_{mass}$/lb$_{mole}$ (MW of Air =28.97), R=10.732 psi-ft³/(lb$_{mol}$-°R)

Gas formation volume factor, $B_g = 0.02827\frac{ZT}{p}$ in $\frac{\text{ft}^3}{\text{SCF}}$, where p in psia, T in °R.

Total or two-phase formation volume factor: $B_t = B_o + B_g(R_{sob} - R_{so})$

Coefficient of isothermal oil compressibility: $c = -\frac{1}{B_{ob}}\left(\frac{dB_o}{dP}\right)_T$

Flash calculations: $\sum_i \frac{z_i}{1+V(K_i-1)} = 1$, $x_i = \frac{z_i}{1+V(K_i-1)}$

Isothermal gas compressibility: $c_g = \frac{1}{p} - \frac{1}{Z}\left(\frac{dZ}{dP}\right)_T = \frac{1}{p} - \frac{1}{Z}\left(\frac{1}{p_c}\frac{dZ}{d\Pr}\right)_T$

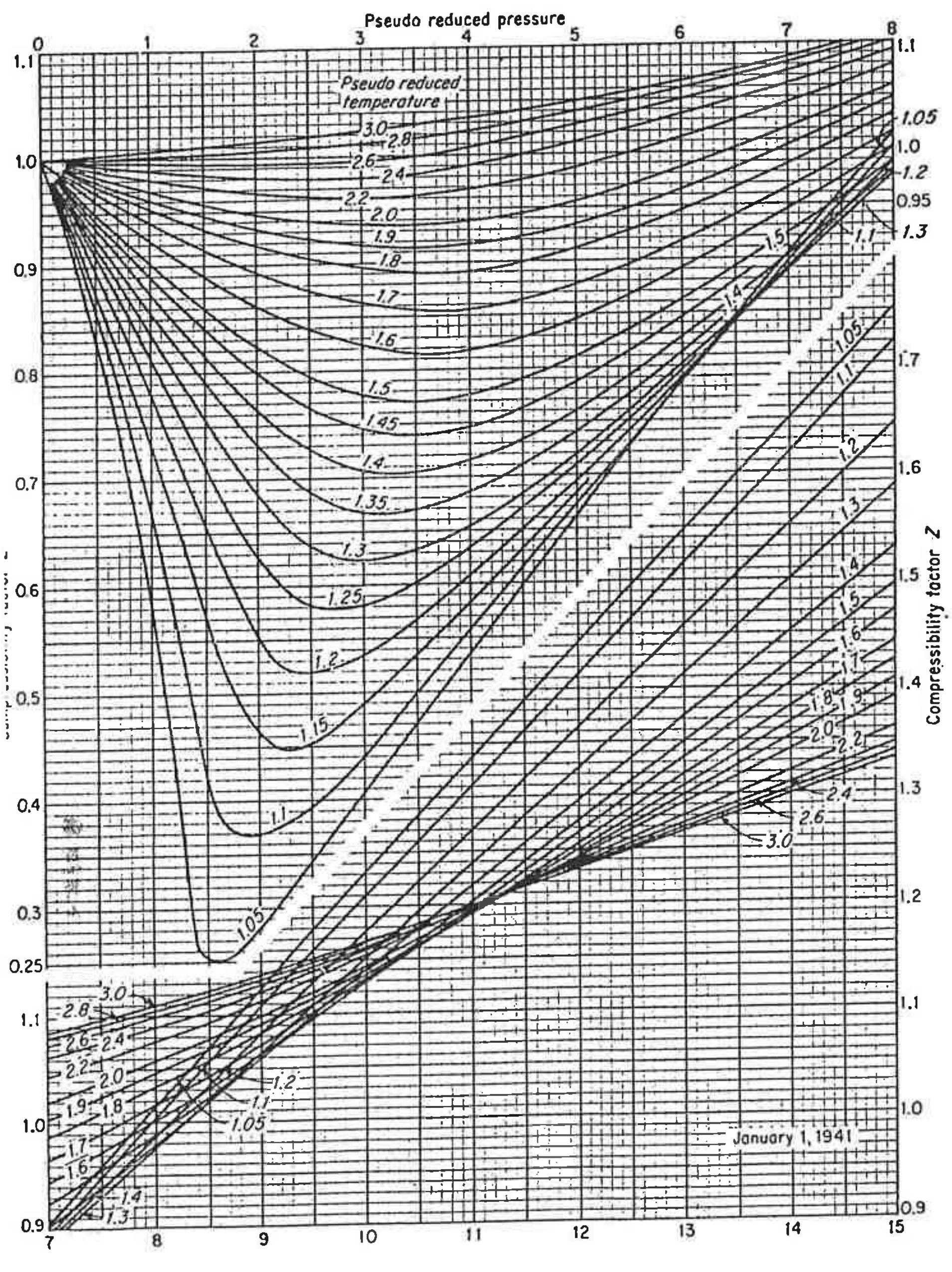
Conversion Factors

1 m³ = 6.28981 bbl =35.3147 ft³

1 atm =14.6959488 psi =101.32500 kPa=1.01325 bar

1 m = 3.28084 ft = 39.3701 inch

1kg = 2.20462 lb$_{mass}$


Pseudo reduced pressure
Pseudo reduced temperature
Compressibility factor Z
January 1, 1941