National Exams December 2016

98-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. One of two calculators is permitted any Casio or Sharp approved models.
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 ofyour 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

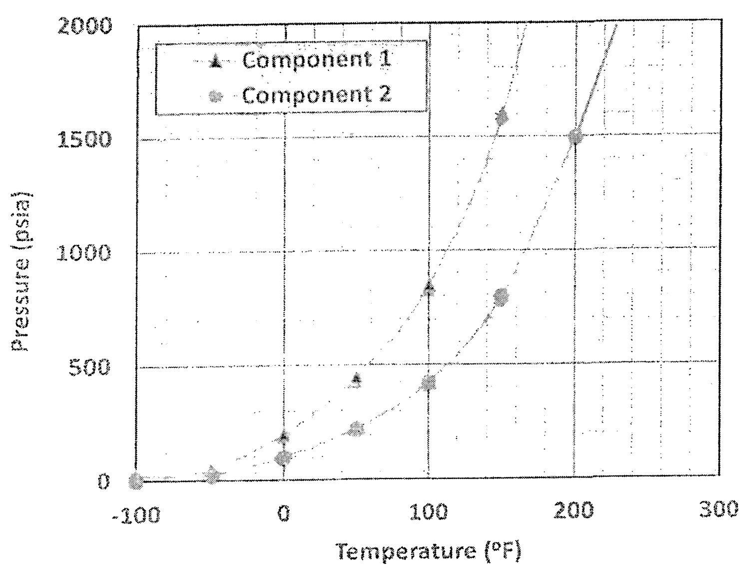
Question 1 (20 Marks)

a) What are the basic classification of reservoir fluids? Name four type of reservoir fluids.
b) Name three common non-hydrocarbon components in reservoir fluids.
c) What is the specific gravity of an oil with API gravity of 30?
d) What does API stand for?
e) If we have two oil samples with API gravities of 15 and 45, respectively, which one may be classified as black oil?
f) What is Liquefied Petroleum Gas (LPG)?
g) What is the difference between Liquefied Natural Gas (LNG) and Natural Gas Liquids (NGL)?
h) If you have a mixture of propane and butane in two phase conditions, what will be the degree of freedom of this system?
i) Draw pressure-temperature (PT) diagram of a pure component and determine gas, liquid, and solid regions.
j) Describe triple point.

Question 2 (20 Marks)

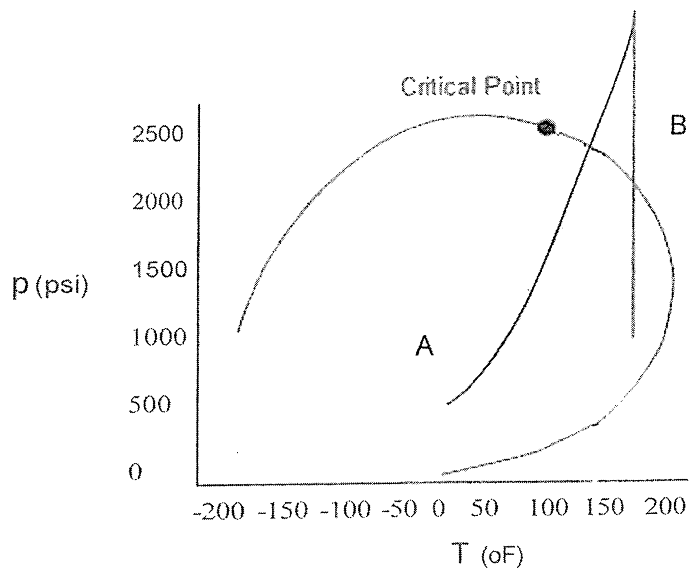
Given the following diagram for two pure components, answer the following questions:

a) Which component is heavier?
b) What is the state of component 1 at 1000 psia and 140 °F?
c) What is the state of component 2 at 1000 psia and 140 °F?
d) What is the state of component 2 at 1500 psia and 200 °F?



Question 3 (20 Marks)
The phase envelope of a certain reservoir fluid is given in the following diagram. The critical point for this reservoir fluid is at T=lOO op and 2450 psi.

a) Describe the phase behaviour of this reservoir fluid along the pressure decline paths A and B shown in the diagram,
b) Determine reservoir path and production tubing path,
c) Estimate cricondenbar and cricondentherm,
d) If large volume of dry gas is injected into this reservoir does the cricondenbar decrease or increase? How about the cricondentherm?



Question 4 (20 Marks)

The following composition (in mole fraction) is available for a reservoir fluid.

a) Convert the given mole fractions to mass fraction.

Component	Mole fraction (%)	Molecular weight (g/gm)
Nitrogen	0.83	28.01
Hydrogen sulfide	0.12	34.08
Carbon dioxide	0.93	44.01
Methane	24.62	16.04
Ethane	6.26	30.07
Propane	6.77	44.10
i-Butane	1.86	58.12
n-Butane	4.71	58.12
i-Pentane	2.72	72.15
n-Pentane	1.55	72.15
C6+	49.63	72.15

b) If 0.7 mole of the above reservoir fluid is mixed with 0.3 mole of gas with the following composition in a PVT cell, what would be the composition of the resultant fluid?

Component	Mole fraction(%)
Nitrogen	2.31
Methane	70.27
Ethane	11.75
Propane	7.89
i-Butane	1.52
n-Butane	3.34
i-Pentane	1.18
n-Pentane	0.72
C6+	1.02

Question 5 (20 Marks)

One mole of hexane is brought into equilibrium with unspecified amount of methane in a PVT cell. The resultant mixture volume is 80% liquid and 20% gas at the cell condition. The equilibrium constants (K-values) for hexane and methane are estimated from a correlation to be 0.01, 10, respectively.

a) Calculate the number of mole of methane in the cell,
b) Determine the equilibrium composition (mole fractions of hexane and methane) in the gas and liquid phases in the PVT cell.

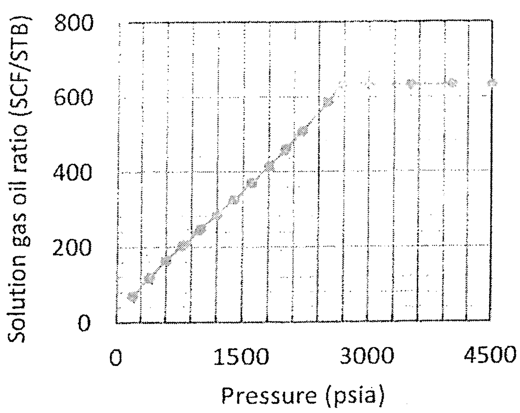
Question 6 (20 Marks)
A natural gas has the following composition. Calculate the molecular weight, specific gravity, density, and the gas formation volume factor at 2000 psia and 100°F.

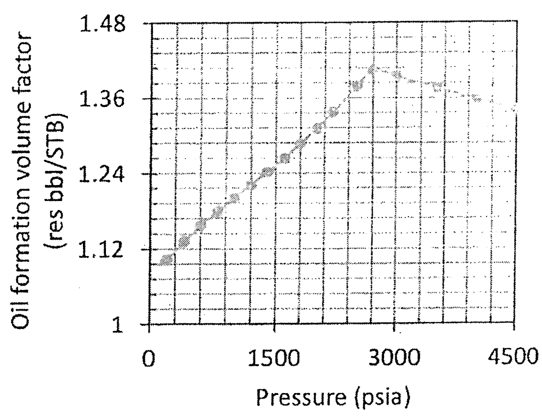
Components	Mole fraction	Molecular weight (lb_{mass}/lb_{mole})
Nitrogen	0.0062	28.01
Carbon dioxide	0.0084	34.08
Hydrogen sulfide	0.0068	44.01
Methane	0.8667	16.04
Ethane	0.0391	30.07
Propane	0.0280	44.10
Normal butane	0.0224	58.12
Normal pentane	0.0224	72.15

Question 7 (20 Marks)

The following data are available from a laboratory test carried out on a black oil at 225 °F. Gas deviation factor (Z) at 1000 psia is 0.95.

a) What is the bubble point pressure of this oil?
b) Calculate the total formation volume factor at 1000 psia?
c) Estimate the isothermal compressibility of oil above bubble point pressure,
d) Calculate the change in oil volume when reservoir pressure drops from an initial pressure of 4500 to 3000 psia.





Formula Sheet

Real gas law

$pV = ZnRT$

where p in psia, T in °R, V in ft^3, R=10.732 psi-ft^3/(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: $T_r = \dfrac{T}{T_c}$

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

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: $T_r = \dfrac{T}{T_c}$

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

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

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

where ρ is gas density in lb$_{mass}$/ft^3, p in psia, T in R, M is molecular weight in lb$_{mass}$/lb$_{mole}$ (MW of Air =28.97), R=10.732 psi-ft^3/(lb$_{mol}$-°R)

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

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

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

Phase equilibrium relations:

$$\begin{cases} \sum_i \dfrac{z_i}{1+V(K_i-1)} = 1, & x_i = \dfrac{z_i}{1+V(K_i-1)}, \quad \sum_i x_i = 1, \\ \sum_i y_i = 1, & \sum_i z_i = 1, \quad K_i = \dfrac{y_i}{x_i}, \quad L + V = 1 \end{cases}$$

Conversion Factors

1 m^3 = 6.28981 bbl =35.3147 ft^3

1 atm =14.6959488 psi =101.32500 kPa=1.01325 bar

1 m = 3.28084 ft = 39.3701 inch

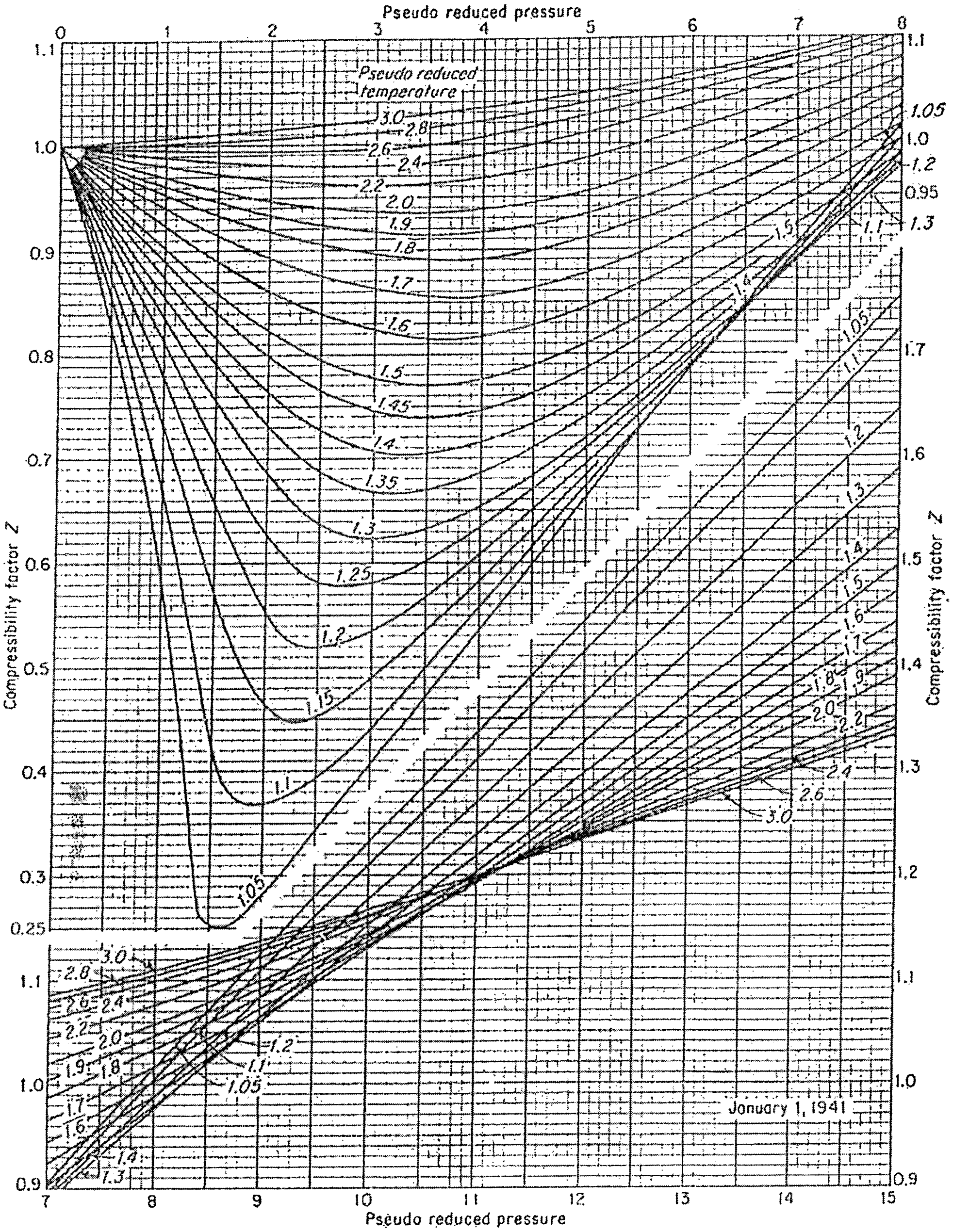


Fig. 4-16. Compressibility factor for natural gases. *(Standing and Katz, 4-87. Courtesy AIME.)*