UNIVERSITY OF MINES AND TECHNOLOGY. TARKWA

FIRST SEMESTER EXAMINATIONS, NOV/DEC 2017

COURSE NO: PE375

COURSE NAME: **NATURAL GAS ENGINEERING**

CLASS: **PE3** TIME: 3HRS

Name: ____ Index Number: _______________

SECTION A. ***Carefully read each question and then answer whether the statement is true(T) or false(F)*** ***(NB: Wrong answer attracts negative 0.5)***

1. When the Reynold number is less than one, the gas flow in the porous media can be described by the Darcy's law.
2. Under lean oil absorption method, the fraction of natural gas liquids that goes into the oil solution increases with decreasing their volatilities.
3. At the critical point, the liquid and vapor phases have the same concentration.
4. In water-drive gas reservoirs, the amount of gas trapped increases with decreasing the pressure at which water breakthrough.
5. Gas well IPR generally determines gas production rate as a linear function of pressure drawdown.
6. Gas viscosity is function of pressure, temperature and composition and is predominantly important in laminar flow regime.
7. Single-point test is generally classified under the transient gas well deliverability testing.
8. According to corresponding states theory, the deviation of a real gas from the ideal gas is the same for different gases at the same corresponding reduced pressure and temperature.
9. The flow-after-flow test lost its popularity because of associated high flaring of valuable gas.
10. Sales gas that leaves a plant is usually dry if cryogenic hydrocarbon liquid recovery is used.

SECTION B. Carefully read each question and then select the letter of the correct answer

A hydrocarbon system has the following composition as shown in the table below. Use it to answer questions 11, 12 & 13

Component	Methan e	Ethane	Propane	i-Butane	n-Butane	i-Pentane	n-Pentane	Hexane	Heptane plus
Mole %	59.52	5.36	4.71	2.03	2.39	1.80	1.61	2.60	19.98

11. Which the following best describe the hydrocarbon system
    - a. Associated gas
    - b. Wet gas
    - c. Dry gas
    - d. Sweet dry gas

12. Which of the following is true during isothermal depletion of the hydrocarbon system?
    - a. The separator pressure will remain in the single-phase region
    - b. The separator pressure will be greater than the reservoir pressure
    - c. The separator pressure will enter the two-phase envelope
    - d. The formation volume factor will remain unchanged

13. For surface processing of the hydrocarbon system which of the following will you recommend for high recovery rates of all the NGLs?
    - a. Oil absorbing method
    - b. Glycol absorbing method
    - c. Cryogenic expansion method
    - d. Claus process

Figure 1 is a material balance plot for gas reservoir. Use the figure to answer questions 14, 15 & 16

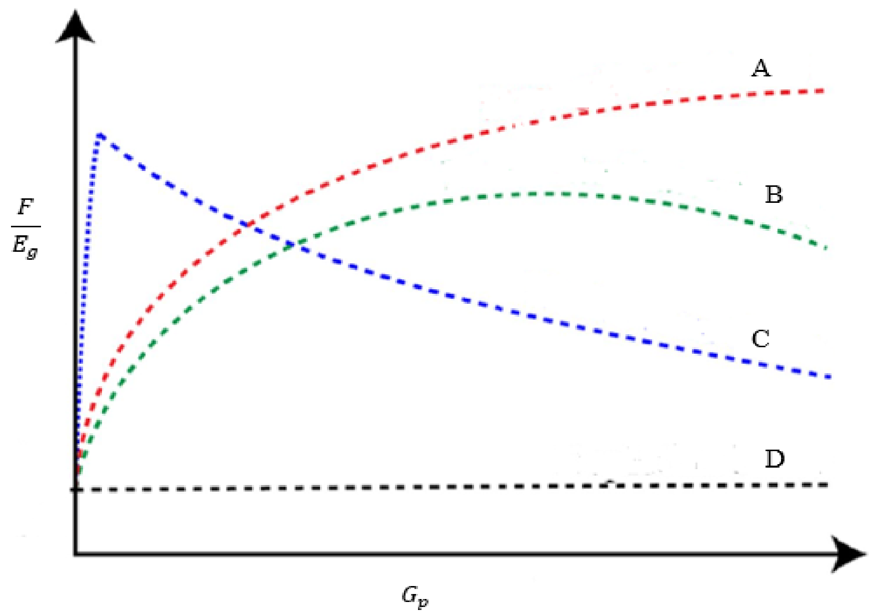

Figure 1

14. Figure 1 is commonly known in the oil and gas industry as

a. Cole plot
b. Energy plot
c. Havlena-Odeh plot
d. Fetkovich plot

15. The graph labelled 'B' is an indication of

a. Strong aquifer drive
b. Depletion drive
c. Weak aquifer drive
d. Partial aquifer drive

16. The intercept is the estimate of

a. Gas initially-in-place
b. Initial water influx
c. Expected ultimate gas recovery
d. Water influx constant

17. How many SCF of an ideal gas are required to fill a 100 cubic tank to a pressure of 40 psig when the temperature of the gas in the tank is 90 ºF?

a. 250
b. 351

c. 379

d. 278

18. The hydrocarbon pore volume of gas reservoir was estimated to be 470 $MMft^3$. If deviation factor is 0.82 at the initial conditions of 2600 psia and 150 °F, what is the initial gas-in-place at standard conditions?

a. 52.4 Bscf

b. 86.5 Bscf

c. 48.5 Bscf

d. 35.2 Bscf

19. Non-Darcy flow effect is significant near wellbore because

a. the velocity of the gas increases with increasing cross-sectional area near the wellbore

b. the gas becomes lighter in composition as it approaches the wellbore

c. gas viscosity increases causing reduction in velocity of the gas.

d. velocity of the gas increases due to increased volumetric rate as the pressure reduces near the wellbore causing fluid expansion.

20. The backpressure model expressed in terms of exact solution to gas diffusivity equation is given as $q = C[\Delta m(p)]^n$. For fully turbulent conditions n is

a. 1

b. 0.5

c. between 0.5 and 1

d. 2

21. Which of the following nonhydrocarbon constituents makes natural gas stream sour?

a. Water vapour

b. Hydrogen sulphide

c. Carbon dioxide

d. Nitrogen

22. The isochronal test was modified purposely

a. for a very tight gas well

b. to achieve shorter stabilized flow conditions

c. to obtain larger average pressure

d. to reduce the impact of near wellbore conditions

23. When using the bottom-hole node in nodal analysis, the upstream equipment of the node is described by

a. Tubing Performance curve

b. Choke Performance curve

c. Inflow Performance curve

d. Wellhead Performance curve

24. The isochronal deliverability test for gas wells was introduced by

a. Katz, 1950
b. Dake, 1959
c. Rawlins and Schellhardt, 1936
d. Cullender, 1955

25. Which of the following is not a liquid dehydrating agent?

a. Methanol
b. Silica gel
c. Tetraethylene
d. Ethylene

26. The following are reasons for natural gas sweetening except

a. sour gas composition increases the natural gas specific gravity
b. sour gas can be extremely harmful to breathe
c. sour can be corrosive
d. Hydrogen sulphide gas has an economic value.

27. The real gas pseudopressure is expressed as

a. $\int \frac{2p}{z\mu_g} dp$
b. $\int \frac{p}{z\mu_g} dp$
c. $\int \frac{p^2}{z\mu_g} dp$
d. $\frac{1}{2}\int \frac{p}{z\mu_g} dp$

28. Which of these bottomhole pressure approximation methods consider z-factor as a function of pressure P and average temperature $\overline{T}$.

a. Cunlleder and Smith' s method
b. Average temperature and deviation factor method
c. Sukkar and Cornell method
d. both a and c

29. A real gas system at 1000 psia and 90 °F with z-factor estimated to be 0.872 has a density of 3.31 lb/ft^3. The density of gas at ideal condition is?

a. 3.79 lb/ft^3
b. . 6.24 lb/ft^3
c. 2.89 lb/ft^3
d. 2.45 lb/ft^3

30. The respective pseudocritical pressure and temperature of following natural gas are:

Component	yi	Pci, psia	Tci °R
CH4	90%	668	343
C_2H_6	5%	708	550
N_2	5%	493	227

a. 661; 348
b. 616; 483
c. 753; 532
d. 782;385

31. Pick the odd one out.

a. Gas from tight gas
b. Associated gas
c. Coalbed methane
d. Gas from gas hydrates

32. Given that the tubing flowing temperature and flowing buttonhole temperature are respectively 80 °F and 440 °F. What is the log mean average temperature?

a. 180 °R
b. 260 °R
c. 560 °R
d. 705 °R

33. Estimate the velocity of a gas flowing through a tubing of diameter 0.17 ft at a rate of 5.153 MMscfd. [Take B_g to be 0.00599ft^3/scf].

a. 12.47 ft/s
b. 13.74 ft/s
c. 14. 47 ft/s
d. 15.74 ft/s

use the following statement and table 1 to answer questions 34 to 36

A volumetric gas reservoir produced 600 MMscf of 0.65 specific gravity gas when the reservoir pressure declined from 3800 to 2500 psi. The reservoir temperature is reported at 140°F.

Table 1

P	B_g ft^3/scf
3800	0.004333
2500	0.006503
650	0.025638

34. Calculate the gas initially in place.
    a. 1.28 Bscf
    b. 1.89 Bscf
    c. 1.19 Bscf
    d. 1.79 Bscf

35. What is remaining reserves to an abandonment pressure of 650 psia?
    a. 1.49 Bscf
    b. 0.894 Bscf
    c. 1.05 Bscf
    d. 2.15 Bscf

36. What is the recovery factor at abandonment pressure of 650 psia?
    a. 83%
    b. 59%
    c. 49%
    d. 68%

37. The two common acid gases found in natural gas systems are
    a. H_2S and CO
    b. CO_2 and H_2S
    c. N_2 and CO_2
    d. N_2 and O_2

38. Find the specific gravity of a gas mixture whose apparent molecular is 20.22 lb/lb-mole
    a. 0.658
    b. 0.698
    c. 0.6
    d. 0.724

39. Which of the following must be known before the use of single-point deliverability test becomes practically possible?
    a. n or B
    b. C or A
    c. n or A
    d. C or B

40. The specific gravity of a natural gas system is estimated to be 0.67. What is the density of the natural gas system at standard conditions of 14.7 psia and 60 °F?

a. 0.0451 lbm/ft^3
b. 0.0342 lbm/ft^3
c. 0.0512 lbm/ft^3
d. 0.0763 lbm/ft^3

Section B. Answer any three questions of this section. Each question carries equal marks

Q1a. **Figure b1** shows how a gas well performance can be determined. The nodal analysis performed considered the bottom-hole as the solution node. Study the figure carefully and precisely describe it completely and how it impacts design of gas wells. [You may use table where appropriate]

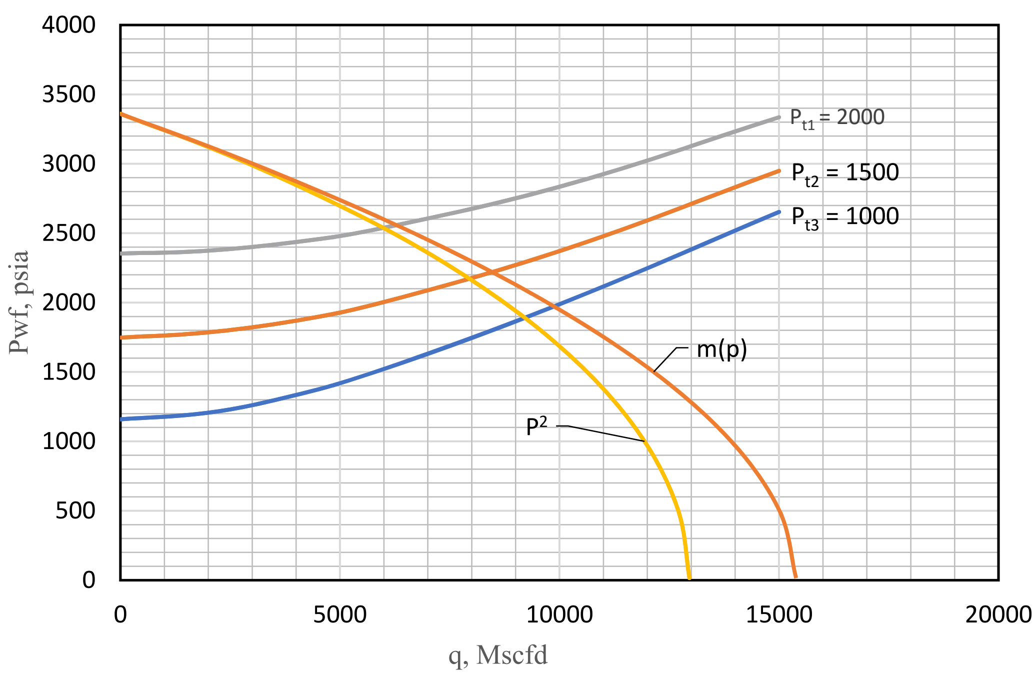

figure B1

Q1b. The following information on a water-drive gas reservoir is given:

Bulk volume = 100,000 acre-ft; Gas Gravity = 0.6; Porosity = 15%

S_{wi} = 25%; T = 140°F; Pi = 3500 psia

Reservoir pressure has declined to 3000 psia while producing 30MMMscf of gas and no water production. Calculate cumulative water influx. Take B_w = 1 rb/stb. You may use the following the table b1.

P, psia	z
3500	0.890
3000	0.876

Q2 **[20 marks]**

2a. Given the following production history given in ***table B2*** obtained from a volumetric dry gas reservoir.

P,psia	z	Gp, Bcf
1885	0.767	6.873
1620	0.787	14.002
1205	0.828	23.687
888	0.866	31.009
645	0.9	36.207

i. plot p/z vs Gp

ii. Using your graph in 'i' estimate the gas-initially-in place

iii. What is the tecovery factor if the pressure is drawn down to 300 psia (Take z = 0.949)

2b. In a recycling plant 250,000 ft^3 of gas at 2500 psia and temperature 100 ºF, is compressed to 4000 psia and 150ºF and put back into the sand at these conditions. What is the volume of the gas at it is injected into the sand? The gas composition is given ***table B3***.

table B3

component	Mole Fraction y_i	Molecular weight M_i	Critical Pressure Pc_i	Critical Temperature Tc_i
Methane	0.75	16	666.4	343.33
Ethane	0.15	30.1	706.5	549.92
Propane	0.1	44.1	616.4	666.06

Q3. **[20 Marks]**

3a. The ***table B4*** below is the result of a particular deliverability test conducted on one of the gas wells in Ghana.

table B4.

	Duration, hours	Pressure, psia	flow rate q, MMscfd
Initial Shut-in	20	1948	
Flow 1	12	1784	4.5
Shut-in	12	1927	
Flow 2	12	1680	5.6
Shut-in	12	1911	
flow 3	12	1546	6.85
Shut-in	12	1887	
flow 4	12	1355	8.25
Extended flow	81	1233	8
Extended shut-in	120	1948	

i. Name the type of the deliverability test that was conducted.

ii. Clearly illustrate the result by sketching plots of q vs t and p vs t

iii. What is the main condition that necessitates the application of this test?

3b. A natural gas mixture has its specific gravity estimated to be 0.7. Calculate the weight of the gas mixture in lbm if it occupies an enclosed space of 3.37 ft^3 at a state point of 2000 psia and 160 °F. Assume $T_{pc} = 170.5 + 307.3\gamma_g$ and $P_{pc} = 709.6 - 58.7\gamma_g$. Compare the mass of the gas at ideal conditions.

Q4. **[20 Marks]**

a. Mention one specific efficient method or process for the following natural gas processing.

i. Ethane extraction

ii. Water vapour removal

iii. Acid gases removal

b. What is principle that justifies application of the isochronal deliverability test of gas wells.

c. Given the following reservoir and fluid properties of a natural gas system

Gas specific gravity: 0.65 Wellbore radius; 0.3 ft External reservoir radius: 1053 ft

Skin factor: 2.8 Non-Darcy coefficient: 0.0001 d/Mscf

Average reservoir pressure: 3360 psia Pay zone thickness: 178 ft Reservoir temperature: 150 °F Permeability: 1 md

Assuming psudosteady-state flow conditions

i. Calculate the exact flow rate at flowing bottom-hole pressure of 2500 psia

ii. Calculate the exact absolute open flow potential of the system.

iii. Assuming P^2-approach calculate the flow rate at flowing bottom-hole pressure of 2500 psia.

iv. Comment on the difference between your answers i and iii

table B5.

P_{wf}, psia	$m(p) x 10^6$, $Psia^2/cp$
14.7	0.0028
500	22.3544
1000	86.1727
1500	186.7246
2000	319.0193
2500	476.8017
3000	654.0597
3360	790.3892

Take average viscosity and z-factor to be 0.02035 and 0.854 respectively.

Daniel Ocran (1st Examiner)

Samuel Tawiah (2nd Examiner)

merry Christmas

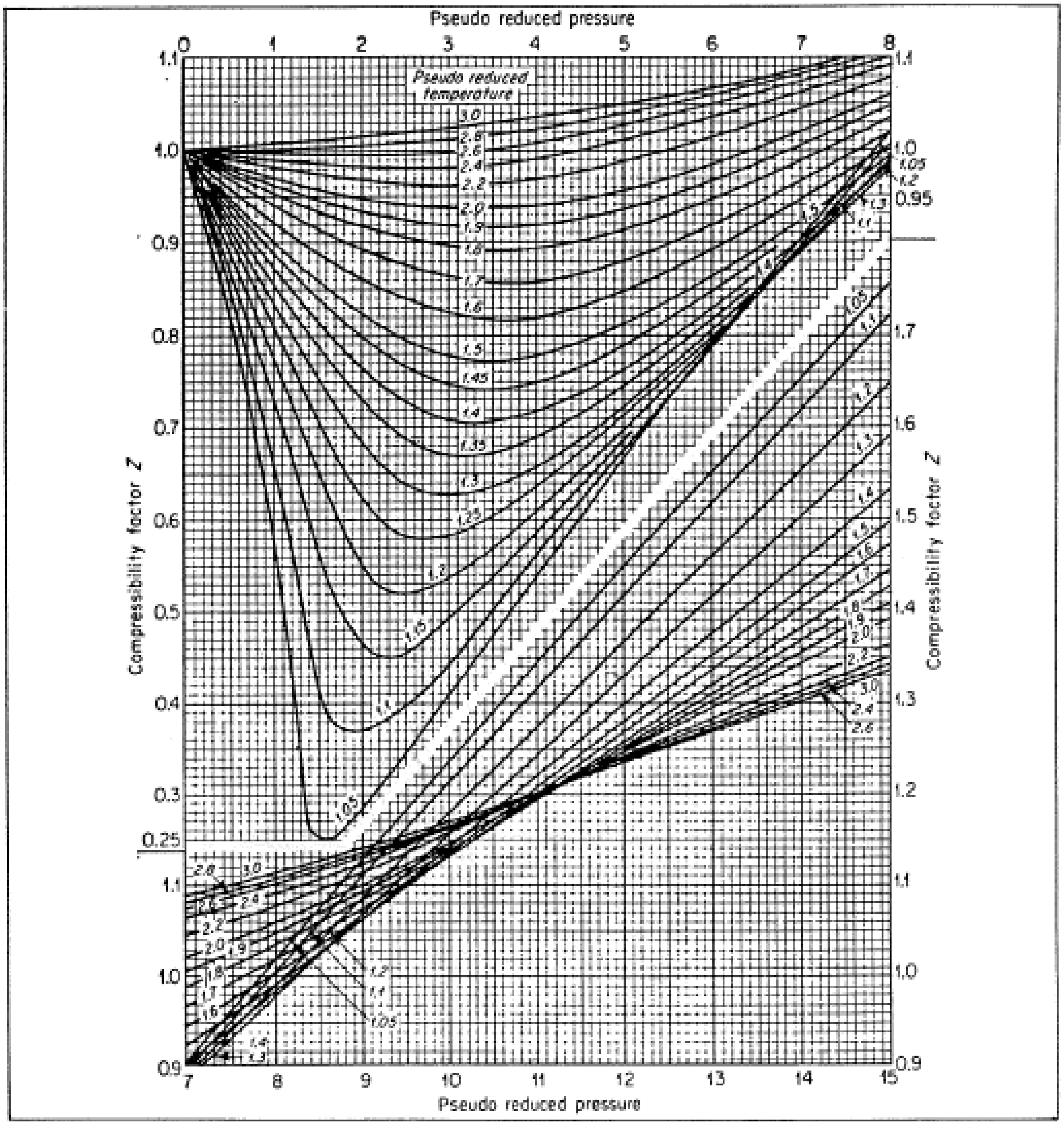

Fig. 2-6. Compressibility factors for natural gases. Courtesy Gas Processors Suppliers Association.

$$q = \frac{kh\left[m(\overline{p}) - m(p_{wf})\right]}{1424\, T\left[\ln\left(\frac{0.472\, r_e}{r_w}\right) + s + Dq\right]}; \quad q = \frac{kh\left(\overline{p}^2 - p_{wf}^2\right)}{1424\, \bar{\mu}\, \bar{z}\, T\left[\ln\left(\frac{0.472\, r_e}{r_w}\right) + s + Dq\right]}$$

$$q = \frac{kh\left(\bar{p} - p_{wf}\right)}{141.2x10^3\, \bar{B}_g\, \bar{\mu}\left[\ln\left(\frac{0.472 r_e}{r_w}\right) + s + Dq\right]} \quad ; \quad G = \frac{G_p B_g - (W_e B_w - W_p B_w)}{B_g - B_{gi}} \quad ; \quad B_g = \frac{P_{sc}}{T_{sc}} \frac{zT}{p} \quad ;$$

$$G = \frac{43560 Ah\phi(1 - S_{wi})}{B_{gi}}; \frac{pV_m}{zT} = constant; \quad T_{pc} = 168 + 325\gamma_g - 12.5\gamma_g^2$$

$$P_{pc} = 677 + 15\gamma_g - 37.5\gamma_g^2$$