Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A Constituent Institution of MAHE, Manipal)

VII SEMESTER B.TECH. (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, NOV 2018
SUBJECT: NATURAL GAS ENGINEERING [CHE 4001]
REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions. Read the questions carefully.
- Missing data may be suitably assumed.
- Refer formulae sheet

1A.	Explain various types of natural gas resources? Draw the schematic atomic structure of methane hydrates?	**3**
1B.	For the natural gas composition given in the below table, calculate the gas formation volume factor in rb/scf, if the gas density is 3.38 lbm/ft^3.	**3**
1C.	For the natural gas composition described in Q.No. 1B, calculate the compressibility factor at 3000 psia, and 250 ^oF using Brill and Beggs Method.	**4**
2A	Write various well integrity tests performed on gas/oil well and briefly explain?	**3**
2B.	A gas well produces 0.65 specific gravity natural gas. The average reservoir pressure is 4,505 psia. Reservoir temperature is 180 °F. The well was tested at two flow rates:	**3**

Table for Q. 1B:

Component	C_1	C_2	C_3	i-C_4	n-C_4	i-C_5	n-C_5	C_6	N_2	CO_2	H_2S
Mol.fraction	.82	.073	.021	.006	.002	.003	.008	.002	.035	.01	.02

Table for Q. 2B:

	Test Point 1	**Test Point 2**
Flow rate	1,152 Mscf/d	1,548 Mscf/d
Bottom hole pressure	3,025 psia	1,685 psia

Estimate the deliverability of the gas reservoir under a pseudo-steady state flow condition at a flowing bottom hole pressure of 950 psia using the backpressure model with pressure-squared approach.

2C.	Construct IPR curve for well specified in 2B with backpressure model with pressure-squared approach. Use five intervals between base pressure 14.7 psia to average reservoir 4,505 psia.	**4**
3A.	A 0.70 specific gravity natural gas flows from a 2-in pipe through a 1-in nozzle-type choke. The upstream pressure and temperature are 120 psia and 70 °F, respectively. The downstream pressure is 90 psia (measured 2 ft from the nozzle). Viscosity of gas is 0.009459 cp. The gas-specific heat ratio is 1.3. (i) What is the expected daily flow rate? (ii) Is icing a potential problem? Consider z_{up}/z_{outlet} as 1.	**4**
3B.	Explain how the operating gas flow rate is evaluated using the numerical and graphical method from a) Nodal analysis at bottom hole node (IPR and TPR) b) Nodal analysis at wellhead node (WPR and CPR) Clearly mention the parameters of both the axis of each plot.	**6**
4A.	What is real gas pseudo pressure? Explain the various pressure approximations that are used to model the IPR using analytical approach using the real gas pseudo pressure vs pressure plot?	**3**
4B.	Derive steady state IPR using m(p) approach for radial flow of a single phase, compressible fluid through porous and permeable rock $q_{sc} = \frac{\pi kh}{T}\frac{T_{sc}}{P_{sc}}\frac{\left(m(p_e)-m(p_{wf})\right)}{\ln(r_e/r_w)}$ using the following steady state boundary condition $\frac{\partial m(p)}{\partial t}=0$	**4**
4C.	Calculate Absolute Open Flow (AOF) conditions using pseudosteady state analytical expression for radial-flow gas reservoir with pressure square approach for the below given well conditions and discuss the results. Effective permeability to gas: 0.17 md Pay zone thickness: 78 ft Equivalent drainage radius: 1,490 ft Wellbore radius: 0.328 ft Reservoir pressure: 4,613 psia Temperature: 180 °F The average gas viscosity: 0.022 cp The average gas compressibility factor: 0.96 Assume both Darcy skin factor and Non-Darcy coefficient to be zero.	**3**
5A.	Explain the process of sweetening of natural gas by absorption using basic flow diagram.	**3**
5B.	List down the advantages and operating difficulties with solid-desiccant dehydration of natural gas.	**4**
5C	What are natural gas hydrates and also explain hydrate forming conditions?	**3**

Formulae Sheet
☑ **Pseudocritical Properties** $P_{pc} = 709.604 - 58.718\gamma_g$ $T_{pc} = 170.491 + 307.344\gamma_g$ $P_{pc} = 678 - 50(\gamma_g - 0.5) - 206.7y_{N_2} + 440y_{CO_2} + 606.7y_{H_2S}$ $T_{pc} = 326 + 315.7(\gamma_g - 0.5) - 240y_{N_2} - 83.3y_{CO_2} + 133.3y_{H_2S}$
☑ **Compressibility Factor: Brill and Beggs' Correlation Constants** $A = 1.39(T_{pr} - 0.92)^{0.5} - 0.36T_{pr} - 0.1$ $B = (0.62 - 0.23T_{pr})P_{pr} + \left(\frac{0.066}{T_{pr} - 0.86} - 0.037\right)P_{pr}^2 + \frac{0.32P_{pr}^6}{10^{9(T_{pr}-1)}}$ $C = 0.132 - 0.32\log(T_{pr})$ $D = 10^\wedge(0.3106 - 0.49T_{pr} + 0.1824T_{pr}^2)$
☑ **Pseudosteady state flow IPR for radial flow gas reservoir using pressure square approach and pressure approach** $q = \frac{kh\left[m(\bar{p}) - m(p_{wf})\right]}{1424T\left[\ln\left(\frac{0.472r_e}{r_w}\right) + s + Dq\right]}$ $q = \frac{kh\left[\bar{p}^2 - p_{wf}^{\ 2}\right]}{1424\bar{\mu}\ \bar{z}\ T\left[\ln\left(\frac{0.472r_e}{r_w}\right) + s + Dq\right]}$ $q = \frac{kh\left[\bar{p} - p_{wf}\right]}{141.2\text{X}10^3\bar{B}_g\ \bar{\mu}\left[\ln\left(\frac{0.472r_e}{r_w}\right) + s + Dq\right]}$
☑ **Gas Reservoir Deliverability: Empirical Models (Forchheimer and Backpressure model)** $\bar{p}^2 - p_{wf}^2 = Aq + Bq^2$ $\qquad$ $q = C(\bar{p}^2 - p_{wf}^2)^n$
☑ **Wellbore Performance: The Average Temperature and Compressibility Factor Method** $p_{wf}^2 = Exp(s)p_{hf}^2 + \frac{6.67X10^{-4}[Exp(s) - 1]fq_{sc}^2\bar{z}^2\bar{T}^2}{d_i^5\cos\theta}$ $\qquad$ $s = \frac{0.0375\gamma_g L\cos\theta}{\bar{z}\bar{T}}$ $f = \left[\frac{1}{1.74 - 2\log\left(\frac{2\varepsilon}{d_i}\right)}\right]^2$

☑ **Choke Performance: Gas Passage for Subsonic and Sonic flow**

$$Q_{sc} = 1248CAP_{up}\sqrt{\frac{k}{(k-1)\gamma_g T_{up}}\left[\left(\frac{P_{dn}}{P_{up}}\right)^{\frac{2}{k}} - \left(\frac{P_{dn}}{P_{up}}\right)^{\frac{k+1}{k}}\right]}$$

$$Q_{sc} = 879CAP_{up}\sqrt{\left(\frac{k}{\gamma_g T_{up}}\right)\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

☑ **Sounders-Brown empirical equation for gas capacity of oil/gas separators**

$$q_{st} = \frac{2.4D^2Kp}{z(T+460)}\sqrt{\frac{\rho_L - \rho_g}{\rho_g}}$$

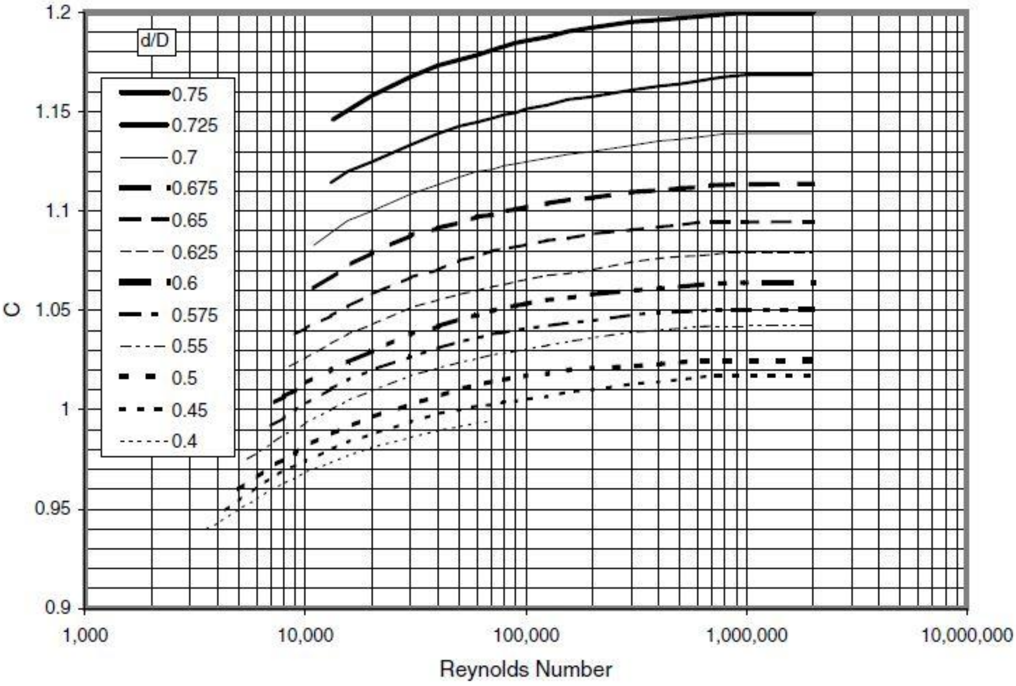

Figure 5–1 Choke flow coefficient for nozzle-type chokes.

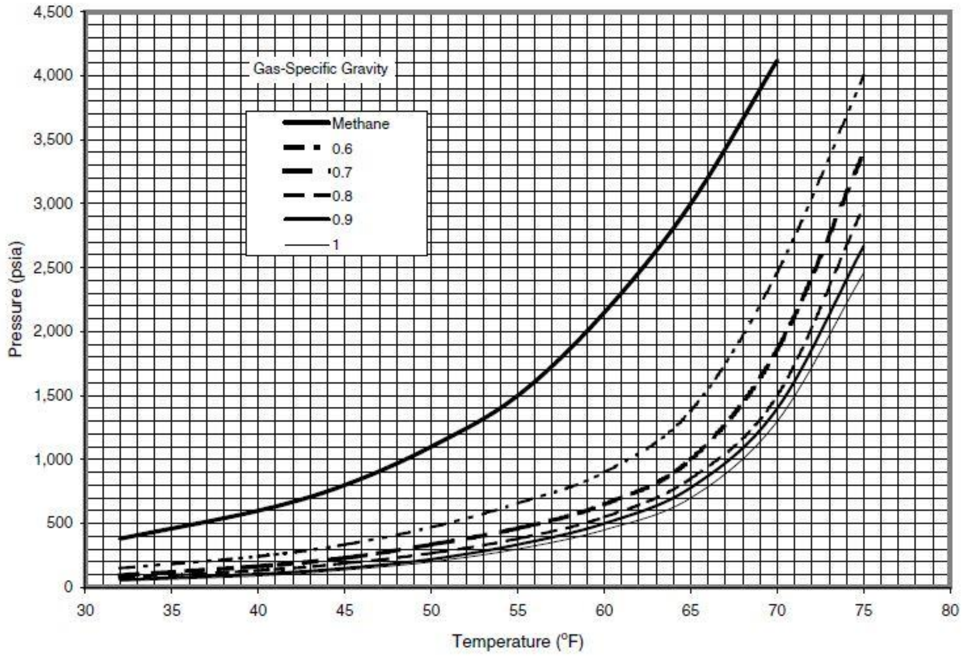

Figure 12–4 Hydrate-forming conditions of natural gases (Courtesy of SPE-AIME).