Reg. No.										

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

VII SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, FEB 2022

SUBJECT: NATURAL GAS ENGINEERING [CHE 4051]

REVISED CREDIT SYSTEM
(24/02/2022 - AN)

Time: 75 mins MAX. MARKS: 20

Instructions to Candidates:

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

1A.	A well produces, from a gas reservoir (6000 psia and 200°F), the gas mixture with following compositions. <table><tr><td>Component</td><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>C5</td><td>H_2S</td><td>CO_2</td><td>N_2</td></tr><tr><td>Molefraction</td><td>0.82</td><td>0.08</td><td>0.028</td><td>0.009</td><td>0.02</td><td>0.02</td><td>0.013</td><td>0.01</td></tr></table>Evaluate the value of (a) apparent molecular weight (b) specific gravity assuming air molecular weight as 29	**3**
1B.	What is CPR? Explain in detail how CPR is evaluated.	**4**
1C.	Explain gas methane hydrates and its formation.	**3**
2A.	Design a number of trays and water rate for trayed-type glycol contactor for a field installation to meet the following requirements: Gas flow rate: 20 MMscfd Gas specific gravity: 0.65 Operating line pressure: 750 psig Maximum working pressure of contactor: 1,440 psig Gas inlet temperature: 100 °F Outlet gas water content: 3 lb H2O/MMscf Design criteria: GWR = 3 gal TEG/lbm H2O with 99.5% TEG Please refer constants data sheet and graph sheets if required.	**4**
2B.	Describe gas dehydration absorption process using basic flow diagram?	**3**
2C.	Discuss how the nodal analysis is done using the bottom-hole node along with inflow and outflow profiles using graphical method along with relevant equations?	**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

$$A = 1.39(T_{pr} - 0.92)^{0.5} - 0.36T_{pr} - 0.1$$

$$B = (0.62 - 0.23T_{pr})P_{pr} + \left(\frac{0.066}{T_{pr} - 0.86} - 0.037\right)P_{pr}^2 + \frac{0.32P_{pr}^6}{10^{9(T_{pr}-1)}}$$

$$C = 0.132 - 0.32\log(T_{pr})$$

$$D = 10\hat{\ }(0.3106 - 0.49T_{pr} + 0.1824T_{pr}^2)$$

☑ IPR for radial flow gas reservoir using m(p), pressure square approach and pressure approach

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

$$q = \frac{kh\left[\bar{p} - p_{wf}\right]}{141.2\text{X}10^3\bar{B}_g\ \bar{\mu}\left[\ln\left(\frac{0.472r_e}{r_w}\right) + s + Dq\right]}$$

$$q = \frac{kh\left[m(\bar{p}) - m(p_{wf})\right]}{1424T\left[\ln\left(\frac{0.472r_e}{r_w}\right) + s + Dq\right]}$$

☑ Gas Reservoir Deliverability: Empirical Models (Forchheimer and Backpressure model)

$$\bar{p}^2 - p_{wf}^2 = Aq + Bq^2 \qquad\qquad q = C(\bar{p}^2 - p_{wf}^2)^n$$

☑ 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**

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

☑ **Wellbore Performance: The Average Temperature and Compressibility Factor Method**

$$p_{wf}^2 = Exp(s) p_{hf}^2 + \frac{6.67X10^{-4}[Exp(s)-1] f q_{sc}^2 \bar{z}^2 \bar{T}^2}{d_i^5 \cos\theta} \qquad s = \frac{0.0375 \gamma_g L \cos\theta}{\bar{z}\bar{T}}$$

$$f = \left[\frac{1}{1.74 - 2\log\left(\frac{2\varepsilon}{d_i}\right)} \right]^2$$

Table 8–4 Specific Gravity Correction Factors for Trayed Glycol Contactors (Sivalls 1977)

Gas-Specific Gravity (air = 1)	Correction Factor (C_g)
0.55	1.14
0.60	1.08
0.65	1.04
0.70	1.00
0.75	0.97
0.80	0.93
0.85	0.90
0.90	0.88

Table 8–3 Temperature Correction Factors for Trayed Glycol Contactors (Sivalls 1977)

Operating Temperature (°F)	Correction Factor (C_t)
40	1.07
50	1.06
60	1.05
70	1.04
80	1.02
90	1.01
100	1.00
110	0.99
120	0.98

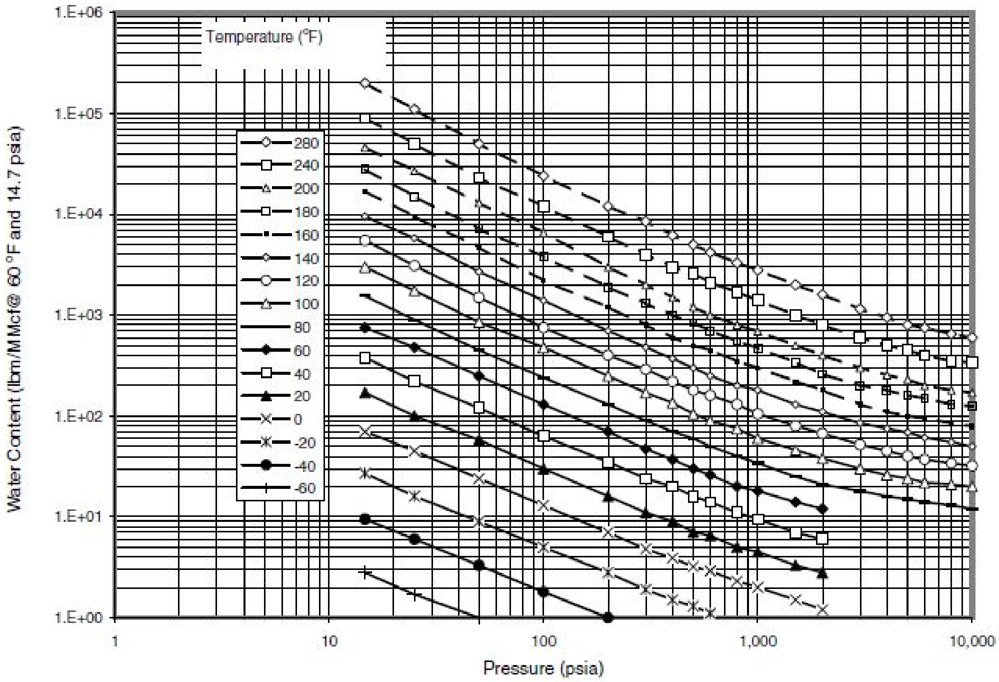

Figure 8–1 Water content of natural gases (Duplicated with data in the chart of McKetta and Wehe 1958).

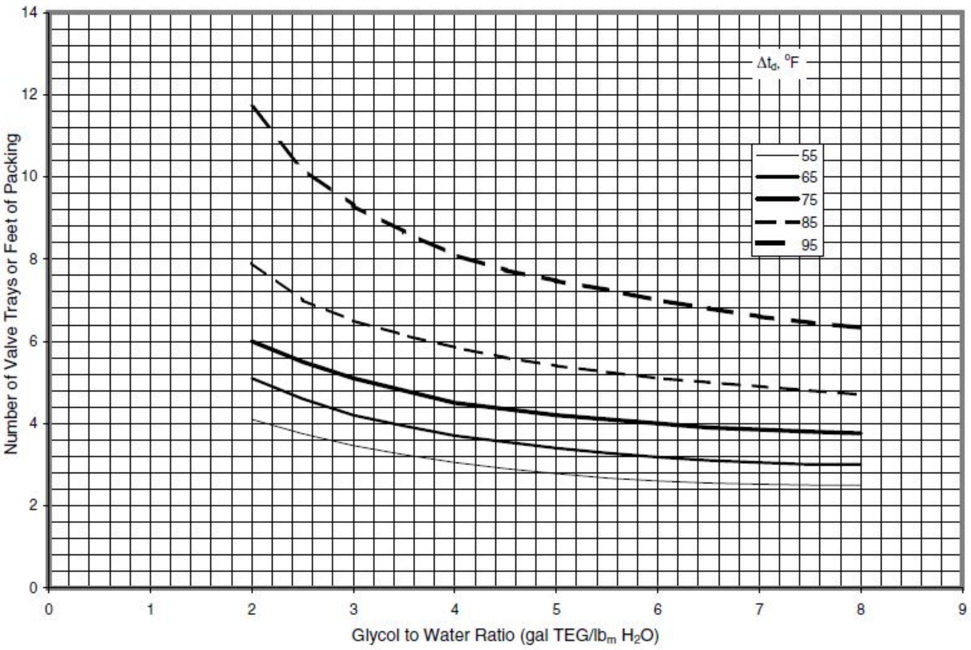

Figure 8–7 The required minimum height of packing of a packed contactor, or the minimum number of trays of a trayed contactor (Sivalls 1977).