Reg. No.										

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

VII SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER ADDITIONAL OPE EXAMINATIONS, MARCH 2021

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 the terminology proved reserves and potential resources clearly	**3**
1B.	From the basic definitions show that; (a) $E = 35.3\frac{p}{zT}$ (scf/ft^3) (b) $B_g = 0.0283\frac{zT}{p}$(ft^3/scf)	**4**
1C.	Prove that the compressibility of an non-ideal gas, $C_g = \frac{1}{p} - \frac{1}{z}\frac{\partial z}{\partial p}$	**3**
2A.	Define real gas pseudo pressure along with units. Explain each term clearly	**2**
2B.	A 0.70 specific gravity natural gas flows from a 2-inch pipe through a 0.8-inch orifice-type choke at very high Reynolds number. The upstream pressure and temperature are 600 psia and 75 °F, respectively. The downstream pressure is 150 psia. Viscosity of gas is 0.01245 cp. The gas-specific heat ratio is 1.25. (i) What is the expected daily flow rate? (ii) Calculate the downstream temperature considering z_{up}/z_{outlet} as 1 (iii)Is formation of hydrates a potential problem at calculated downstream pressure?	**5**
2C.	Discuss various ways in which water content of natural gas streams is estimated?	**3**
3A.	The well is producing at a stabilized bottom-hole flowing pressure of 2400 psi. The wellbore radius is 0.4 ft. The following data is available k = 0.06 d, h = 20 ft, T = 700 ^{0}R, pe = 4400 psi, re = 1000 ft, s = 0, D = 0, $\bar{\mu}$ = 0.0269 cp, $\bar{Z}$ = 0.827 m(p) at reservoir pressure (pe) is 1072210926.41 psi^2/cp m(p) at wellbore pressure (pwf) is 409978929.11 psi^2/cp Calculate the gas flow rate in Mscf/Day at pwf = 2400 psia using the (a) pressure squared approach (b) m(p) approach (c) Compare the result obtained (a) and (b), summarize the reason if any discrepancy	**5**

3B.	Explain the method to estimate z-factor of natural gas from the experiments using relevant equations	**3**
3C.	Draw and explain the nature of plots for tubing pressure profile. Clearly mention the parameters of x-axis and y-axis clearly.	**2**
4A.	Explain various types of gas sweetening process used in natural gas industry and describe gas sweetening process by absorption using basic flow diagram?	**5**
4B.	Calculate the gas capacity (q_{st}) in MMscfd for oil/gas separator using the Sounders-Brown empirical equation; for the diameter of 50.8 cm vertical separator using following conditions. Operating pressure: 850 psig Operating temperature: 100 °F z=0.8803, ρ_g= 3.88 lb_m/ft^3, ρ_L = 46.11 lb_m/ft^3, K=0.205	**3**
4C.	How can you avoid flooding in existing gas dehydration or gas sweetening (absorption) towers in gas processing plants?	**2**
5A.	a. Derive basic Inflow Performance Relationship (IPR) equation for steady state case using 'p' approach. Solve for incompressible fluid using the following boundary conditions: P(rw)=pw and P(re)=pe Where rw is the bore radius in ft, re reservoir drainage area in ft. State assumptions clearly. b. Draw radial pressure profile for the above case.	**4**
5B.	List and discuss various types of natural gas resources	**3**
5C.	List the (6) equipment or utilities, where the chemical additives are added in oil/gas processing fields	**3**

Formulae Sheet

☑ **Pseudosteady state flow IPR for radial flow gas reservoir using pressure square approach and pressure approach**

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

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

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

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

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

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

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

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

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

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

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

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

$$q_{st} = \frac{2.4D^2Kp}{z(T+460)}\sqrt{\frac{\rho_L - \rho_g}{\rho_g}} \qquad \rho_L = 62.4\frac{141.5}{131.5 + \text{CSG(units}\,^0\,\text{API)}} \qquad\qquad q_L = \frac{1440V_L}{\text{t}}$$

☑ **Pseudocritical Properties**

$$P_{pc} = 709.604 - 58.718\gamma_g$$

$$T_{pc} = 170.491 + 307.344\gamma_g$$

☑ **Compressibility Factor: Brill and Beggs' Correlation Constants**

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

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

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

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