Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A Constituent Institution of MAHE, Manipal)

VII SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, DEC 2021

SUBJECT: NATURAL GAS ENGINEERING [CHE 4051]

REVISED CREDIT SYSTEM
(24/12/2021 - FN)

Time: 75 mins MAX. MARKS: 20

Instructions to Candidates:

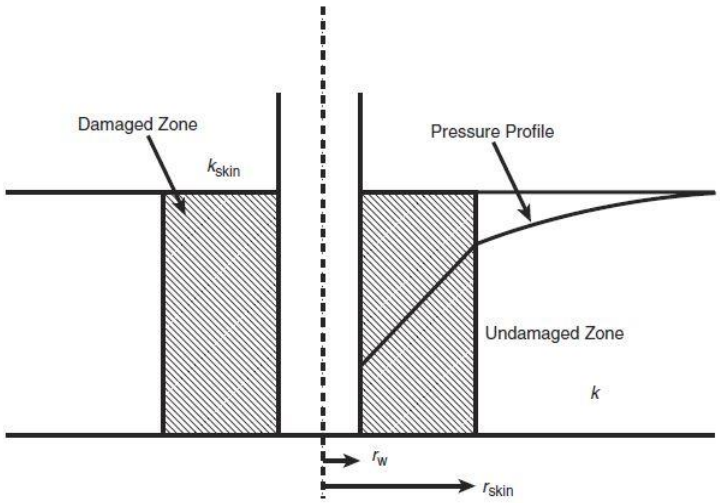
- Answer **ALL** the questions. Read the questions carefully.
- Missing data may be suitably assumed.
- Refer formulae sheet

1 The well is producing at a stabilized bottom-hole flowing pressure (pwf) of 2000 psi. The wellbore radius (rw) is 0.4 ft. The following additional data is available:
s =0, D=0, k = 0.05 d, h =30 ft, T= 600 °R, pe = 4400 psi, re = 2000 ft

P	mu (cP)	Z
0	0.012	1
400	0.0128	0.937
800	0.0142	0.882
1200	0.0158	0.832
1600	0.0175	0.794
2000	0.0195	0.77
2400	0.0208	0.763
2800	0.0226	0.775
3200	0.0246	0.797
3600	0.0256	0.827
4000	0.0269	0.86
4400	0.0285	0.896

Based on above data. Solve the below 3 questions.

A	Find the value of Pseudo pressure at pwf = 3200 psi in (psi^2/cP)	**3**
B	Calculate the gas flow rate using m(p) approach in Mscf/day at stabilized bottom-hole pressure	**5**
C	Calculate arithmetic average pressure	**2**

2A.	Explain the rationale behind Average TZ method and Cullender Smith method along with relevant equations to solve single phase gas well tubing string - ODE governing equation.	**4**
2B.	Explain skin effect using the below illustration for skin zone near well bore 	**3**
2C.	Write few lines about methane hydrates formation in Natural Gas Processing Fields	**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

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

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

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

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

☑ 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**

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

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

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

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