Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Course: Petroleum Transport System & Operations-1 **Semester:** 1
Programme: M.Tech. Pipeline Engineering **Time:** 03 hrs.
CODE: CHPL 7004 **Max. Marks: 100**
Instructions: ***i.*** Attempt all questions. ***ii.*** Missing data can be suitably assumed

SECTION A

S. No.		Marks	CO
Q1	Define compressor ratio for a centrifugal and reciprocating compressors.	**5**	**CO1**
Q2	Differentiate between $NPSH_A$ and $NPSH_R$	**5**	**CO2**
Q3	Explain Line Pack volume and Line Fill Volume	**5**	**CO2**
Q4	Explain the term "Adiabatic efficiency" and hydraulic balance in compressors.	**5**	**CO3**

SECTION B

Q5	Explain the reasons that lead to Gas Hydrates formation in Pipelines and the preventive measures that can be taken to avoid them in subsea pipelines	**10**	**CO5**
Q6	A 16 in. crude oil pipeline (0.250 in. wall thickness) having internal roughness of 0.002 inches, is 30 miles long from point A to point B. The flow rate at the inlet A is 4000 bbl. / hr. The crude oil properties are specific gravity of 0.85 and viscosity of 10 cSt at a flowing temperature of 70° F. **(a)** Calculate the pressure required at A without any pipe loop. Assume, 50 psi, delivery pressure at the terminus B and a flat pipeline elevation profile. **(b)** If a 10 mile, portion CD, starting at milepost 10 is, looped with an identical 16 in. pipeline, calculate the reduced pressure at A.	**10**	**CO1**
Q7	Calculate the compressor horsepower required for an adiabatic compression of 106 MMSCFD gas with inlet temperature of 68°F and 725 psia pressures. The discharge pressure is 1305 psia. Assume the compressibility factors at suction and discharge conditions to be $Z_1 = 1.0$ and $Z_2 = 0.85$, respectively, and the adiabatic exponent = 1.4, with the adiabatic efficiency = 0.8. If the mechanical efficiency of the compressor driver is 0.95, what BHP is required? Also, calculate the outlet	**10**	**CO1**

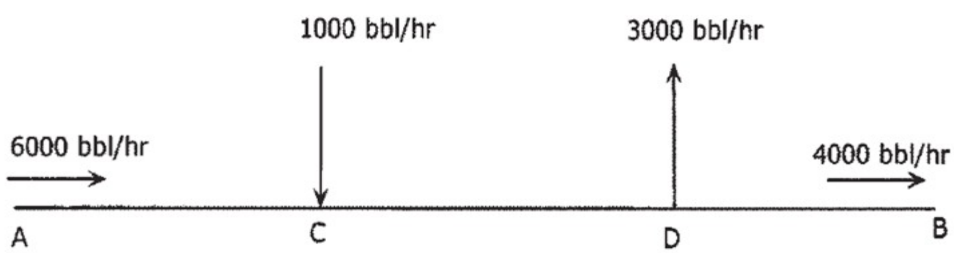
	temperature of the gas.		
Q8	Explain the reasons for the two-phase flow in pipelines. Also, explain with figures the different flow patterns observed in two-phase flow. Explain the Bakers Chart to identify the flow pattern in multiphase flow	**10**	**CO5**
	SECTION-C		
Q9	In the Figure 1, shown below, the pipeline from station A to station B is 48 miles long and is 18 in. in nominal diameter, with 0.281 in. wall thickness. It is, constructed of 5LX-65 grade steel. At station A, crude oil of specific gravity, 0.85 and 10 cSt viscosity enters the pipeline at a flow rate of 6000 barrel per hour. At station, C (milepost-22) a new stream of crude oil with specific gravity of 0.82 and 3.5 cSt viscosity enters the pipeline at a flow rate of 1000 barrel per hour. The mixed stream then continues to station D (milepost 32) where 3000 barrel per hour is, stripped off the pipeline. The remaining volume continues to the end of the pipeline at point B. **(a)** Calculate the pressure required at dispatch station A to deliver the crude oil at station B at a minimum delivery pressure of 50 psi. Also calculate the specific gravity and viscosity of crude oil delivered at station B. Assume elevations at A,C,D and B to be 100, 150, 250 and 300 feet respectively. Use, Colebrook-White equation for pressure drop calculation and assume pipe roughness of 0.002 in. **(b)** Calculate the BHP required to- maintain 6000 barrel per hour of flow rate at A, assuming 50 psi, pump suction pressure at A and 80% pump efficiency? **(c)** If, a positive displacement (PD) pump is used, to inject the stream at C, that itself receives the liquid at 50 psi, and has 80% efficiency what pressure and HP is required at C. 	**20**	**CO1, CO2, CO3**

	Figure 1		
Q10	A natural gas pipeline runs 140 miles from Dadri to Panipat. The pipeline is of NPS 16, 0.250 in. wall thickness. Through calculations, it was found that the pipeline should not be operated at a pressure above 1200 psig. The gas specific gravity and viscosity were found to be 0.6 and 8×10^{-6} lb. per feet per second, respectively. The pipe roughness is assumed 700µ inch, and the base pressure and base temperature are 14.7 psia. and 60°F, respectively. The gas flow rate is 175 MMSCFD at 80°F, and the delivery pressure required at Panipat is 800 psig. **a)** Calculate the pressure required at Dadri to deliver the gas at Panipat at the desired pressure of 800 psig. **b)** The pipeline operator arbitrary choses to install the compressor station at the midpoint of the pipeline. Show through calculations if the location of compressor station at mid- point is optimum. If not, calculate the exact location of compressor station. **Assume *Z*= 0.85**.	**20**	**CO1, CO2, CO3**

APPENDIX

All Notations have their usual meaning and units

1. **Reynolds Equation for Gas Pipelines:**

$$\mathrm{Re} = 0.5134\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \quad \text{(SI)}$$

$$\mathrm{Re} = 0.0004778\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \quad \text{(USCS)}$$

2. **Reynolds No. for Crude Oil Pipelines**

   a) **R=92.24 Q/(ν D)**

   Where: Q=Flow rate, bbl/day; D=Internal diameter, in.; ν=Kinematic viscosity, cSt

   b) **R=353,678 Q/(νD)**

   Where: Q=Flow rate, m^3/hr.; D=Internal diameter, mm; ν= Kinematic viscosity, cSt

3. **Pressure Drop per unit length for oil pipelines (USCS)**

$$\mathbf{Pm = 0.0605\ fQ^2\ (Sg/D^5)}$$

Pm = pressure drop due to friction (psi/mile); Q= Liquid flow rate (bbl. per day); D = Pipe Internal- diameter, in.

4. **Colebrook White Equation**

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$

5. **Coversion Equations for SSU to Centistokes**

$$Centistokes = 0.226(SSU) - \frac{195}{SSU} \qquad 32 \le SSU \le 100$$

$$Centistokes = 0.220(SSU) - \frac{135}{SSU}$$

6. **Horsepower required to compress gas in compressor** $SSU \succ 100$

7. $$HP = 0.0857\left(\frac{\gamma}{\gamma-1}\right)QT_1\left(\frac{Z_1+Z_2}{2}\right)\left(\frac{1}{\eta_a}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right]$$

Adiabatic Efficienecy of Compressor

$$\eta_a = \left(\frac{T_1}{T_2 - T_1}\right)\left[\left(\frac{z_1}{z_2}\right)\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]$$

8. **BHP required to pump the liquid**

$$BHP = \frac{QP}{2449E}$$

Q=flow rate (bbl./hr.); **P**=Differentia pressure (psi)

9. **Relation between Head and Pressure drop in liquid pipelines**

$$H(feet) = \frac{2.31psi}{G}$$