KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.E.
Year : II
Exam Roll No. :
Time: 30 mins.
Registration No.:

Course : CHEG 212
Semester : II
F. M. : 10
Date 7 0 JUL 2023

SECTION "A"
[20Q. × 0.5 = 10 marks]

Encircle the most appropriate alternative from each set of choices.

1. Which of the following is used as specific gravity in sugar industry?
a. API gravity
b. Brix gravity
c. Baumé gravity
d. Sucrose gravity

2. Which fluid can resist a small shear stress indefinitely?
a. Bingham plastics
b. Pseudoplastics
c. Dilatant
d. Viscoelastic

3. When a liquid in a piping network encounters an abrupt flow restriction due to closing of a valve, it is locally compressed. The resulting acoustic waves vibrate the pipe. This is known as______.
a. block flow
b. water hammer
c. supersonic wave
d. cavitation

4. Under what condition is the Poiseulle equation used?
a. steady laminar flow of Newtonian fluids in circular pipes
b. unsteady laminar flow of Newtonian fluids in circular pipes
c. steady turbulent flow of Newtonian fluids in circular pipes
d. unsteady laminar flow of Newtonian fluids in rectangular channels

5. The dynamic viscosity of air at 25°C and 350 kPa is 1.83×10^{-5} kg/m·s. For air, gas constant is 0.287 kJ/kg-K. The kinematic viscosity of air in m^2/s at this state is__________.
a. 0.533×10^{-5}
b. 1.27×10^{-5}
c. 0.480×10^{-5}
d. 4.5×10^{-6}

6. Which parameter is NOT related in the Bernoulli equation?
a. density
b. velocity
c. time
d. elevation

7. Bernoulli's equation is a form of__________.
a. mechanical energy balance
b. frictional heating balance
c. compressible mass balance
d. block flow balance

8. Consider laminar flow of water at 15°C in a 0.55-cm-diameter pipe at a velocity of 0.8 m/s. We know $\Delta P/\rho = Q\,\Delta x\,(\mu/\rho)\;128/(\pi D^4)$. Take μ as 10^{-3} Pa·s. The pressure drop of water for a pipe length of 35 m in kPa is__________.
a. 8.1
b. 7.8
c. 29.6
d. 23.5

9. In fluid flow analyses, which boundary condition can be expressed as $V_{fluid}=V_{wall}$?
a. free-surface
b. interface
c. no-slip
d. symmetry

10. Which type of container has the least metal in the walls to store high-pressure fluids?
a. cylindrical
b. capsule
c. spherical
d. rectangular

11. When we assume that tensile stress is uniform over the wall thickness in a tank of oil refinery, what is this assumption known as?
a. thin-walled assumption b. thick-walled assumption
c. isothermal assumption d. isentropic assumption

12. When the entire fluid flow is represented by its average velocity, the assumption is known as___________.
a. mixed flow b. plug flow c. laminar flow d. inviscid flow

13. Which pump has significant $NPSH_R$ that increases with increasing flow rate?
a. centrifugal b. positive displacement
c. peristaltic d. sliding-vane

14. When two streams at different velocities mix and exchange momentum, such as in a Bunsen burner, which equation is applicable?
a. Bernoulli b. Euler
c. Friction factor d. Momentum balance

15. What do you primarily use when designing full-size equipment from test on small-scale physical models?
a. viscosity b. scaling factors
c. dimensionless groups d. Bernoulli equation

16. Which equipment uses a fixed pressure difference, and a variable geometry?
a. pitot tube b. rotameter c. venturimeter d. orificemeter

17. Why many compressors are staged, with intercooling?
a. to decrease time b. to decrease the work requirement
c. to slow down the process d. to prevent corrosion

18. The boundary-layer thickness for a point on an airplane wing 2.2 ft from the leading edge, when the plane is flying 210 mi/h through air, in inches is__________.
(Take $\nu = 1.61 \times 10^{-4}$ ft^2/s, 1 mi = 5280 ft.)
a. 0.22 b. 0.022 c. 3.9 d. 0.064

19. In fluid flow in a porous medium, which equation fits the pressure drop data satisfactorily for all Reynolds numbers?
a. Ergun b. Blake-Cozeny c. Burke-Plummer d. Colebrook

20. What is the length scale of the smallest eddies in mixing of two fluids?
a. synoptic b. mesoscale c. Kolmogorov d. Prandtl

KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

10 JUL 2023

Level : B.E.
Year : II
Time : 2 hrs. 30 mins.

Course : CHEG 212
Semester : II
F.M. : 40

SECTION "B"

Attempt *ALL* questions. The data or information not given in the questions should be assumed properly.

1. A helium balloon has a flexible skin of negligible weight and infinite capacity for expansion, so that the helium is always at the same pressure as the surrounding air. If the balloon moves up and down slowly, then the temperature of the gas in the balloon will be practically the same as that of the surrounding air. If the mass of helium in the balloon is 6 kg, how much payload can it lift under 0.01 atm and –17°C? Assume that helium behaves as an ideal gas. Do not assume that air is a constant-density fluid. [4]

2. In the vessel in Fig. 1, water is flowing steadily in frictionless flow under the barrier. What is the velocity of the water flow under the barrier? [5]

3. Water is flowing at a velocity of 1 m/s in a pipe 0.4 m in diameter. In the pipe is an orifice with a hole diameter of 0.2 m. What is the measured pressure drop across the orifice? Use Fig. 3. [5]

4. Two large water reservoirs are connected by 5000 ft of 8-in pipe. The level in one reservoir is 200 ft above the level in the other, and water is flowing steadily through the pipe from on reservoir to the other. Both reservoirs are open to the atmosphere. How many gallons per minute are flowing? Use Fig. 5. [7]

5. In Fig. 2, water is being pumped through a 4-in. pipe. The length of the pipe plus the equivalent length for fittings is 2300 ft. The design flow rate is 175 gal/min. At this flow rate, what pressure rise across the pump is required? Take pressure drop per 100 ft as 0.774 psi. [6]

OR

A nozzle is attached to a fire hose by a bolted flange. What is the force tending to tear apart that flange when the valve in the nozzle is closed? The pressure on the bolted flange is 100 psig. The cross-sectional area of the flange is 10 $in.^2$. [6]

6. In a factory, a centrifugal pump has inlet pipe of 2-in. size and diameter of 2.067 in., outlet pipe of 1.5-in. size and diameter of 1.61 in., impeller inner diameter of 2.067 in., outer diameter of 6.75 in., rotational velocity of 1750 rpm. Assume zero friction. The required volumetric flow rate is 80 gpm. Use pump map in Fig. 4 to answer the following: [7×1=7]
   a) What is the pump head?
   b) Will the above experimental head be higher or lower than the equation-based zero-friction head?
   c) What is the pressure rise through the pump?
   d) What is the required power input?
   e) What is the efficiency of the pump?
   f) Can this pump handle small amounts of suspended solids better than P.D. pumps?
   g) What is the $NPSH_R$?

7. Answer in brief (*ANY TWO*): [2×3 = 6]
   a) Simplification of Navier-Stokes equation by Prandtl
   b) Algorithm to select π's by Buckingham's theorem
   c) Deriving Euler equation from Navier-Stokes equation

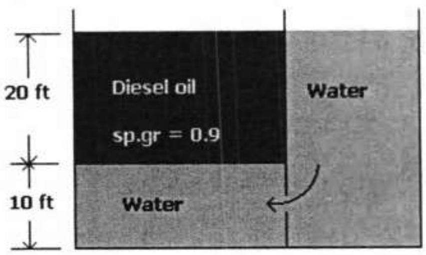

Fig. 1.

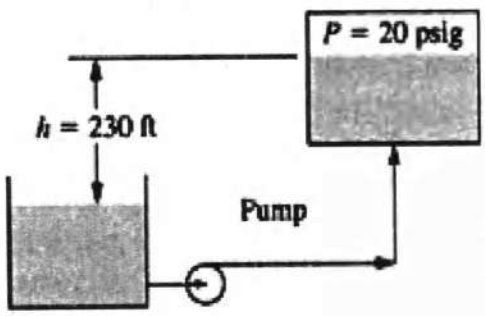

Fig. 2.

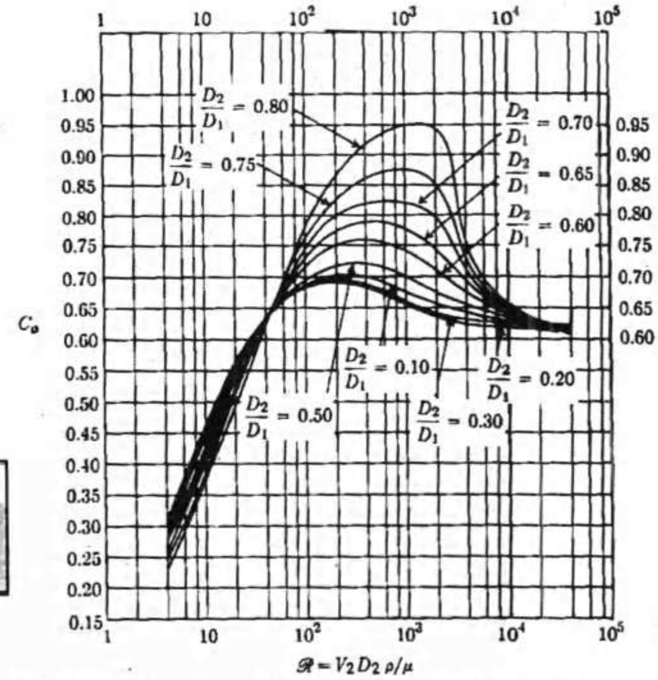

Fig. 3: Discharge coefficients for drilled-plate orifices.

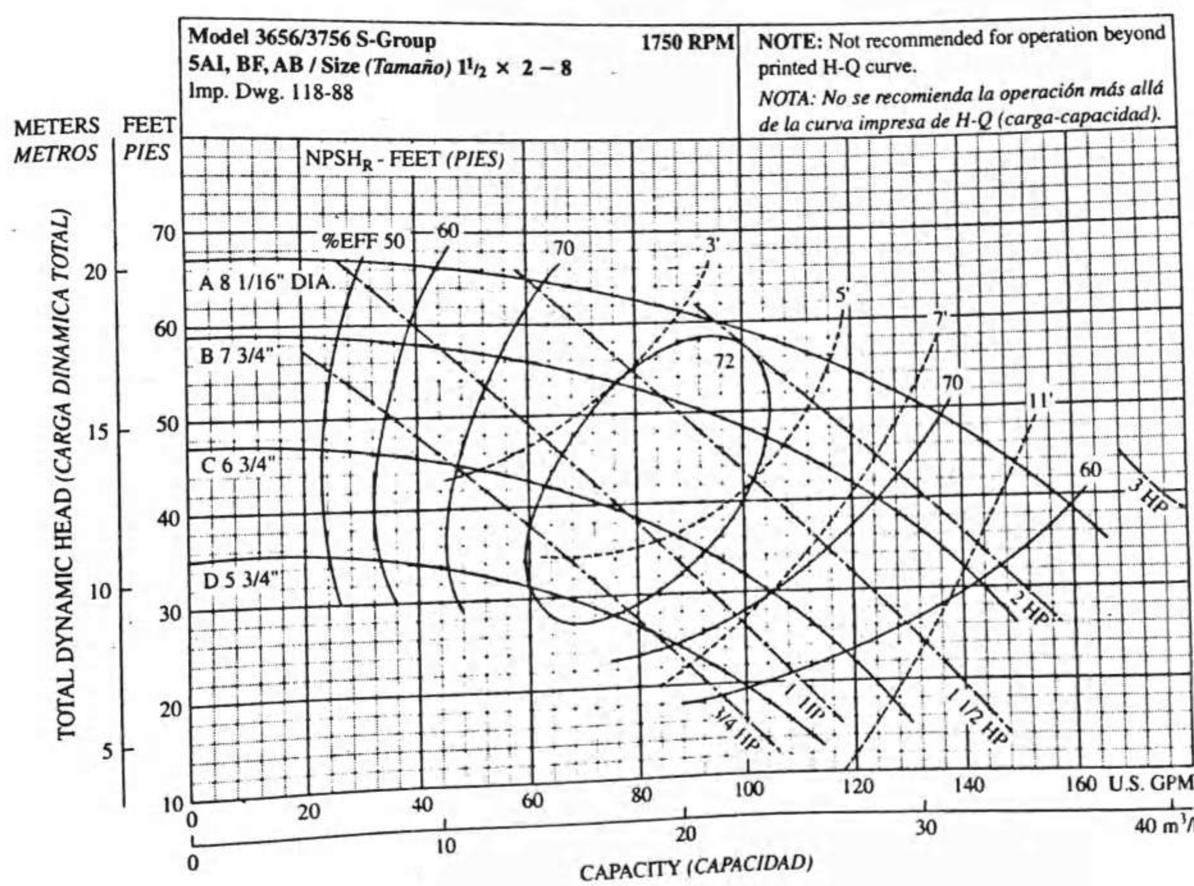

Fig. 4: Pump map.

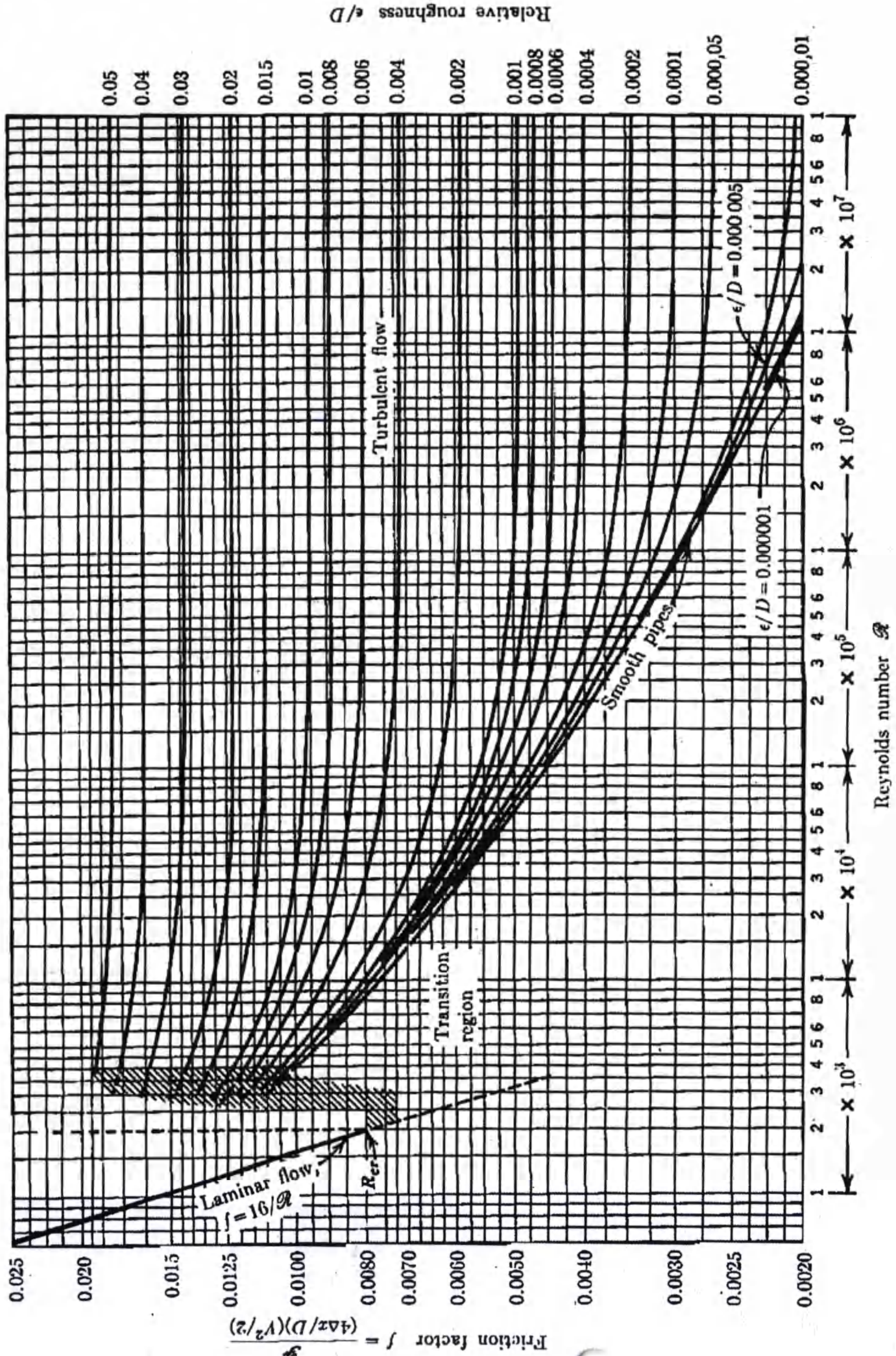

Fig. 5: Friction factor plot for circular pipes.

Conversion Factors, and Common Units and Values

Length:

1 ft = 0.3048 m = 12 in = mile / 5280 = nautical mile / 6076 = km / 3281

1 m = 3.281 ft = 39.37 in = 100 cm = 1000 mm = 10^6 micron = 10^{10} Å

= km / 1000

Mass:

1 lbm = 0.45359 kg = short ton / 2000 = long ton / 2240 = 16 oz (av.)

= 14.58 oz (troy) = metric ton (tonne) / 2204.63 = 7000 grains

= slug / 32.2

1 kg = 2.2046 lbm = 1000 g = (metric ton or tonne or Mg) / 1000

Force:

1 lbf = 4.4482 N = 32.2 lbm · ft / s^2 = 32.2 poundal = 0.4536 kgf

1 N = 0.2248 lbf = kg · m / s^2 = 10^5 dyne = kgf / 9.81

Volume:

1 ft^3 = 0.02831 m^3 = 28.31 L = 7.48 U.S. gal = 6.23 Imperial gal

= acre-ft / 43,560

1 U.S. gallon = 231 in^3 ≐ barrel (petroleum) / 42 = barrel (beer, U.S.A.) / 31

= 4 U.S. quarts = 8 U.S. pints

= 3.785 L = 0.003785 m^3

1 m^3 = 35.29 ft^3 = 1000 L

Energy:

1 Btu = 1055 J = 1.055 kW · s = $2.93 \cdot 10^{-4}$ kWh = 252 cal = 777.97 ft · lbf

= $3.93 \cdot 10^{-4}$ hp · h

1 J = 1 N · m = 1 W · s = 1 V · C = $9.48 \cdot 10^{-4}$ Btu = 0.239 cal = 10^7 erg

Power:

1 hp = 0.746 kW = 550 ft · lbf / s = 33,000 ft · lbf / min = 2545 Btu / h

1 W = $1.34 \cdot 10^{-3}$ hp = J / s = N · m / s = V · A = 0.239 cal / s

= $9.49 \cdot 10^{-4}$ Btu / s

Pressure:

1 atm = 101.3 kPa = 1.013 bar = 14.696 lbf / in^2 = 33.89 ft of water

= 29.92 in of mercury = 1.033 kgf / cm^2 = 10.33 m of water

= 760 mm of mercury = 760 torr

1 psi = atm / 14.696 = 6.89 kPa = 27.7 in H_2O = 51.7 torr

1 Pa = N / m^2 = kg / m · s^2 = 10^{-5} bar = $1.450 \cdot 10^{-4}$ lbf / in^2

= 0.0075 torr = 0.0040 in H_2O = 10 dyne / cm

Conversion Factors, and Common Units and Values

Viscosity:

$$1\ \mathbf{cP} = 0.01\ \text{poise} = 0.01\ \text{g / cm} \cdot \text{s} = 0.001\ \text{kg / m} \cdot \text{s} = 0.001\ \text{N} \cdot \text{s / m}^2$$

$$= 0.001\ \text{Pa} \cdot \text{s} = 0.01\ \text{dyne} \cdot \text{s / cm}^2$$

$$= 6.72 \cdot 10^{-4}\ \text{lbm / ft} \cdot \text{s} = 2.42\ \text{lbm / ft} \cdot \text{h} = 2.09 \cdot 10^{-5}\ \text{lbf} \cdot \text{s / ft}^2$$

Kinematic viscosity:

$$1\ \mathbf{cSt} = 0.01\ \text{Stoke} = 0.01\ \text{cm}^2/\text{s} = 10^{-6}\ \text{m}^2/\text{s} = 1\ \text{cP} / (\text{g / cm}^3)$$

$$= 1.08 \cdot 10^{-5}\ \text{ft}^2/\text{s} = \text{cP} / (62.4\ \text{lbm / ft}^3)$$

Temperature:

$$\mathbf{K} = °\text{C} + 273.15 = °\text{R} / 1.8 \approx °\text{C} + 273 \qquad \mathbf{°C} = (°\text{F} - 32) / 1.8$$

$$\mathbf{°R} = °\text{F} + 459.67 \approx °\text{F} + 460 = 1.8\ \text{K} \qquad \mathbf{°F} = 1.8°\text{C} + 32$$

Psia, psig:

Psia means pounds per square inch, absolute. Psig means pounds per square inch, gauge, i.e., above or below the local atmospheric pressure.

Force-mass conversion factor, g_c

This factor is equal to dimensionless 1.00. Any dimensioned quantity may be multiplied or divided by g_c without changing the value of that quantity.

$$g_c = \mathbf{1.0} = 32.2 \frac{\text{lbm} \cdot \text{ft}}{\text{lbf} \cdot \text{s}^2} = 1 \frac{\text{slug} \cdot \text{ft}}{\text{lbf} \cdot \text{s}^2} = 1 \frac{\text{lbm} \cdot \text{ft}}{\text{poundal} \cdot \text{s}^2} = 1 \frac{\text{kg} \cdot \text{m}}{\text{N} \cdot \text{s}^2}$$

The molecular weights (g / mol = lbm / lbmol) of common gases are, approximately, as follows: hydrogen, 2; helium, 4; methane, 16; carbon monoxide, 28; nitrogen, 28; air, 29; oxygen, 32; carbon dioxide, 44; propane, 44.

Other fluids should be assumed to be at 20°C = 68°F and 1 atm, for which the values in the following table should be used:

Fluid	Specific gravity (water = 1.00)	Viscosity, cP
Mercury	13.6	1.55
Typical gasoline	0.72	0.6
Sea water	1.03	1.0

The acceleration of gravity is $g = 32.17\ \text{ft / s}^2 = 9.81\ \text{m / s}^2$

The surrounding atmospheric pressure is the "standard atmospheric pressure", $P_{\text{surroundings}} = P_{\text{atmospheric}} = 1\ \text{atm} = 14.696 \approx 14.7\ \text{lbf / in}^2 = 33.89$ ft of water = 10.33 m of water = 29.92 in of mercury = 760 mm of mercury = 760 torr = 101.3 kPa = 1.013 bar = 1.033 kgf / cm^2.

If the fluid in the problem or example is water, then it is water at 1 atm pressure and 20°C = 68°F = 293.15 K = 528°R, for which

$$\rho = 62.3\ \text{lbm / ft}^3 = 998.2\ \text{kg / m}^3 = 3.46\ \text{lbmol / ft}^3 = 55.5\ \text{kgmol / m}^3$$

$$= 55.5\ \text{mol / L}$$

$$\mu = 1.002\ \text{cP} = 1.002 \cdot 10^{-3}\ \text{Pa} \cdot \text{s} = 6.73 \cdot 10^{-4}\ \text{lbm / ft} \cdot \text{s}$$

$$= 2.09 \cdot 10^{-5}\ \text{lbf} \cdot \text{s / ft}^2$$

$$\nu = \mu / \rho = 1.004 \cdot 10^{-6}\ \text{m}^2/\text{s} = 1.004\ \text{cSt} = 1.077 \cdot 10^{-5}\ \text{ft}^2/\text{s}$$

$$M = 18\ \text{g / mol} = 18\ \text{lbm / lbmol}$$

$$\sigma = 0.000415\ \text{lbf / in} = 72.74\ \text{dyne / cm} = 0.07274\ \text{N / m}$$

If the fluid in the problem or example is air, then it is air at 1 atm pressure and 20°C = 68°F = 293.15 K = 528°R for which

$$\rho = 0.075\ \text{lbm / ft}^3 = 1.20\ \text{kg / m}^3 = 2.59 \cdot 10^{-3}\ \text{lbmol / ft}^3 = 41.6\ \text{mol / m}^3$$

$$\mu = 0.018\ \text{cP} = 1.8 \cdot 10^{-5}\ \text{Pa} \cdot \text{s}$$

$$\nu = \mu / \rho = 1.488 \cdot 10^{-5}\ \text{m}^2/\text{s} = 14.88\ \text{cSt} = 1.613 \cdot 10^{-4}\ \text{ft}^2/\text{s}$$

$$C_P = 3.5\,R = 6.95\ \text{Btu / lbmol °R} = 6.95\ \text{cal / mol K} = 29.1\ \text{J / mol K}$$

$$M = 29\ \text{g / mol} = 29\ \text{lbm / lbmol}$$

$$k = 1.40$$

$$R = \frac{10.73 (\text{lbf / in}^2)\text{ft}^3}{\text{lbmol} \cdot °\text{R}} = \frac{0.7302\ \text{atm} \cdot \text{ft}^3}{\text{lbmol} \cdot °\text{R}}$$

$$= \frac{8.314\ \text{m}^3 \cdot \text{Pa}}{\text{mol} \cdot \text{K}} = \frac{0.08206\ \text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = \frac{0.08314\ \text{L} \cdot \text{bar}}{\text{mol} \cdot \text{K}}$$

$$= \frac{1.987\ \text{Btu}}{\text{lbmol} \cdot °\text{R}} = \frac{1.987\ \text{cal}}{\text{mol} \cdot \text{K}} = \frac{1.987\ \text{kcal}}{\text{kgmol} \cdot \text{K}} = \frac{8.314\ \text{J}}{\text{mol} \cdot \text{K}}$$