I/L/1X

# Final Assessment Test – November 2024

VIT
Vellore Institute of Technology

Course: BBIT201L - Principles of Chemical Engineering
Class NBR(s): 1092 / 1094 Slot: F1+TF1
Time: Three Hours Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

**Answer ALL Questions**
**(10 X 10 = 100 Marks)**

1. a) Calculate the molarity of a solution containing 40 g of sugar ($C_{12}H_{22}O_{11}$) in 200 mL of solution. [5]

   b) 2000 mL solution of strength 0.5 N $H_2SO_4$ is to be prepared in laboratory by adding 98% $H_2SO_4$ (specific gravity 1.84) to water. Calculate the volume in ml of 98% $H_2SO_4$ to be added to get solution of required strength. [5]

2. a) A 150 L cylinder contains oxygen at 300 K and 10 bar. What is the mass of oxygen in the cylinder? [5]

   b) An ideal gas mixture contains 40% $N_2$, 30% CO and 30% $H_2$ by volume at P= 202.65 kPa and T = 338 K. Calculate [5]

   i) partial pressure of each component.

   ii) mass fraction of nitrogen.

   iii) average molecular weight of the gas.

   iv) the density of gas (g/L)

3. The label has come off a cylinder in your laboratory. You know that only the species of gas is contained in the cylinder, but you do not know whether it is hydrogen, oxygen or nitrogen. To find out, you evacuate a 5 litres flask, seal it and weight it, then let the gas to flow from the cylinder into the flask until a pressure gauge reads 101.325 kPa. The flask is reweighted, and the mass of the added gas is found to be 13 g. The temperature is 300 K (27°C), and barometric pressure is 101.325 kPa, Identify the gas?

4. In production of $SO_3$, 100 kmol of $SO_2$ and 100 kmol of $O_2$ are fed to the reactor. If the percentage conversion of $SO_2$ is 80, calculate the composition of product stream on mole basis.

5. Describe how the heat added to the system is equivalent to change in internal energy and enthalpy of the system under constant volume and pressure conditions respectively.

6. Air containing 21% (mole) $O_2$ and 79% (mole) $N_2$ is to be heated from 300 K to 450 K. Calculate the heat required if the air flow rate is 5 $m^3$ per minute using data given below.

$Cp,O_2 = 26.01 + 11.76 \times 10^{-3}T - 2.35 \times 10^{-6}T^2$, kJ/kgmol K

$Cp, N_2 = 29.60 - 5.15 \times 10^{-3}T + 13.19 \times 10^{-6}T^2$, kJ/kgmol K

7. Explain the Rayleigh's method in detail and write the selection of repeating variables in Buckingham's π theorem.

8. The pressure difference ΔP in a pipe of diameter "D" and length "L" due to viscous flow depends on the velocity "v", viscosity"μ" and density "ρ". Using Buckingham's π theorem, develop an expression for ΔP. (Select D, v and ρ as repeating variable)

9.a) A 30 cm diameter pipe, conveying water, branches into two pipes of diameters 20 cm and 15 cm respectively. If the average velocity in the 30 cm diameter pipe is 2.5 m/s. find the discharge in this pipe. Also determine the velocity in 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/s.

**OR**

9.b) Derive the equation for the calculation of discharge in Orifice meter by using the Bernoulli's equation

10.a) A spent dye sample obtained from a soap making unit contains 9.6% glycerol and 10.3% salt. It is concentrated at the rate of 5000 kg/h in an evaporator until the solution contains 80% glycerol and 6% salt. Assume that 4.5% glycerol is lost by evaporation, find the amount of evaporation taking place in the system.

**OR**

10.b) In downstream processing of gluconic acid, concentrated fermentation broth containing 20% (w/w) gluconic acid is cooled in a heat exchanger prior to crystallisation. 2000 kg $h^{-1}$ liquid leaving an evaporator at 90 °C must be cooled to 6 °C. Cooling is achieved by heat exchange with 2700 kg $h^{-1}$ water initially at 2 °C. If the final temperature of the cooling water is 50 °C, what is the rate of heat loss from the gluconic acid solution to the surroundings? Assume the heat capacity of gluconic acid is 0.35 cal $g^{-1}$ °$C^{-1}$.

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