**Part One: Choose the correct answer of the following: (60% , 30 questions, 2 marks per each question)**

1. The volume percentage of O₂ in air is 21%, and the weight percentage of O₂ in air is about:
a) 21% b) 22% c) 23% d) 24%
2. The weight percentage of chlorine in common salt NaCl is about : (Na=23, Cl=35.5)
a) 61% b) 62% c) 63% d) 64%
3. The rate of heat transfer (kW) to methanol evaporator at its boiling point to generate 1500 g/min saturated vapor is about: [heat of vaporization is 35.8 kJ/mol , Mw=32]
a) 26 b) 27 c) 28 d) 29
4. The number 0.0000055 is equivalent to :
a) 5.5×10^7 b) 5.5×10^{-7} c) 55×10^7 d) 55×10^{-7}
5. The power of the pump required (kW) for water flowrate of 20 m³/h, 70 m head, and 64% efficiency is about:
a) 5 b) 6 c) 7 d) 8
6. The extreme limit of the absolute vacuum pressure (atm) is:
a) 1 b) 0 c) -1 d) -2
7. The flowrate (m³/h) from a 5 mm nozzle at a bottom of a tank containing water of constant 5 m height, neglecting friction loss is about:
a) 0.4 b) 0.5 c) 0.6 d) 0.7
8. The pressure drop (N/m²) in a horizontal pipe of oil flowrate =53 m³/h, pipe diameter d=100 mm, and length L=10 m is about: [oil density =800 kg/m³ and viscosity= 100 cP]
a) 60 b) 600 c) 6000 d) 60000
9. Air flow in a pipe d=100 mm at 25 °C and 1 atm. A pitot tube at the center show a manometer reading 100 mm H₂O, CD=0.98. Air flow rate (m³/hr) is about:
a) 90 b) 900 c) 9000 d) 90000
10. LPG containing mainly:
a) Methane & Ethane b) Ethane & Propane c) Propane & Butane d) Butane & pentane
11. The molecular weight of heavy crude oil (API = 30, Mean average b.pt=642 °F) is about:
a) 50-100 b) 100-200 c) 200-300 d) 300-400
12. The viscosity (cst) of heavy crude oil (API = 30, Mean average b.pt=642 °F) is about:
a) 1-10 b) 10-20 c) 20-30 d) 30-40
13. The Heat transfer coefficient is important parameter in:
a) conduction b) convection c) radiation d) all
14. The more Efficient heat transfer rate is in:
a) laminar b) turbulent c) transition d) same
15. Air at 20°C blows over a hot plate 50 by 75 cm maintained at 250°C. The convection heat-transfer coefficient is 25 W/m² · °C. The heat transfer (kW) is about:
a) 216 b) 21.6 c) 2.16 d) 0.216

16. One face of a copper plate 3 cm thick is maintained at 400°C, and the other face is maintained at 100°C. The heat transfer (kW/m²) through the plate is about: [$k_{\text{copper}}=370 \text{ W/m } ^\circ\text{C}$]
a) 73000 b) 3700 c) 37000 d) 7300

17. A cylindrical resistor (d=4 mm, L=15 mm) on a circuit board dissipates 0.6 W of power, The heat flux (W/m²) on the surface of the resistor is about:
a) 4810 b) 3810 c) 2810 d) 1810

18. By what percentage would the rate of absorption be increased or decreased by increasing the total pressure from 100 to 200 kN/m² in the case of the absorption of ammonia from a mixture of ammonia and air containing 10% of ammonia by volume, using pure water as solvent. Assume that all the resistance to mass transfer lies within the gas phase.

a) unchanged b) doubled c) 50% reduced d) 50% increased

19. If a five-component mixture A–B–C–D–E is to be distilled,

Feed	Top product	Bottom product
A	A	
B	B	
C	C	C
D	D	D
E		E

the light and heavy keys components respectively are:

a) A & B b) B & C c) C & D d) D & E

20. If a centrifuge is 0.9 m diameter and rotates at 20 Hz, at what speed (Hz) should a laboratory centrifuge of 150 mm diameter be run if it is to duplicate the performance of the large unit:

a) 29 b) 39 c) 49 d) 59

21. If A rotary filter, operating at 1.8 rpm, filters at the rate of 0.0075 m³/s. Operating under the same vacuum and neglecting the resistance of the filter cloth, at what speed (rpm) must the filter be operated to give a filtration rate of 0.0160 m³/s?:

a) 7.2 b) 8.2 c) 9.2 d) 10.2

22. Two litres of an ideal gas at a pressure of 10 atm expands isothermally into vacuum until its total volume becomes 100 litres. The amount of heat (J) absorbed in the expansion is:

a) 2.303 b) 100 c) 90 d) None

23. Ten litres of an ideal gas at a pressure of 10 atm expands isothermally against a constant pressure of 1 atm. until its total volume becomes 100 litres. The work done in the expansion is:

a) -90 L-atm b) -10 L-atm c) -23.03 L-atm d) -230.3 L-atm

24. In a process, 800 J of heat is absorbed by a system and 350 J of work is done by the system. The change in internal energy (J) for the process is:

a) -350 b) -450 c) 350 d) 450

25. The density of O₂ at 30 °C and 10 atm is about (kg/m³) :

a) 1.3 b) 13 c) 130 d) 1300

26. The amount of heat absorbed by one mole of an ideal gas in an isochoric process to raise the temperature from 1.1 °C to 11.1 °C is 120 kJ/mol. The Cv and Cp values of the gas in kJ/mol K will be:

a) 12 kJ & 3.7 kJ b) 10 kJ & 12 kJ c) 12 kJ & 20.3 kJ d) 20.3 kJ & 12 kJ

27. The second law of thermodynamics says that:

a) energy cannot be created or destroyed b) heat flows from a hotter to a colder surface
c) for action there is an opposite and equal reaction d) systems tend to gravitate toward a condition of greater order

28. The rangeability is the ratio of :

a) maximum flow to minimum flow b) maximum controllable flow to minimum controllable flow
c) normal flow to minimum flow d) maximum controllable flow to normal flow.

29. The element in process control loop that regulate the manipulating variable is;

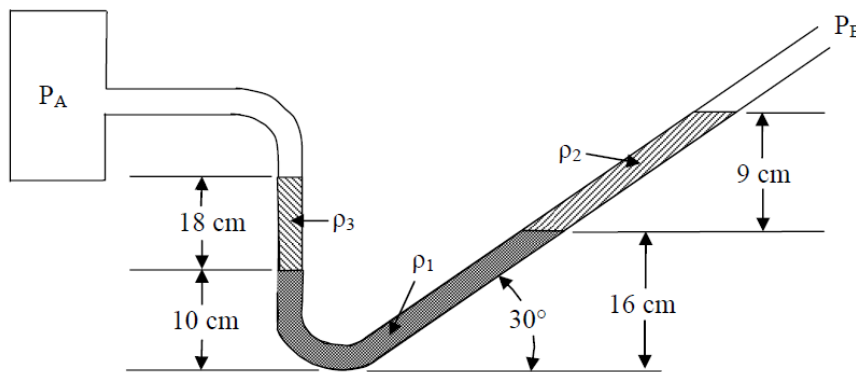
a) Control valve b) Sensor c) Controller d) Transmitter

30. The outlet signal from current/ pneumatic (I/P) convertor in process control loop is equal to :

a) 0 to 10 volt b) 3 to 15 psig c) 4 to 20 mA d) 0 to 100 mV

Part two: Answer of the following questions : (40% , 10 questions, 4 marks per each question)

1. A distillation column is used to separate benzene and toluene mixtures (50 wt% benzene) at 80 ton/hr feed flowrate. The top product is 95 wt% benzene. The benzene recovery is 95 wt%. Calculate the top flowrate and bottom flowrate and composition.
2. Water-free Oxygen flowrate of 6.00 L/min at 25°C and 1.00 atm is input to humidifier. The humidified oxygen leaving the humidifier is at 25°C and 1 atm and relative humidity 60%. How much water will be evaporated during a day to humidify the oxygen (g/day)? What is the rate of heat transfer (W) to (or from) the humidifier in order that both the oxygen and the humidifier remain at 25°C?
[vapor pressure of water at 25°C is 23.756 mm Hg, heat of vaporization at 25°C is 2442.5 kJ/kg]
3. The manometer shown below contains three liquids. The densities of the three are: $\rho_1 = 2.0 \text{ g/cm}^3$, $\rho_2 = 1.0 \text{ g/cm}^3$, and $\rho_3 = 1.6 \text{ g/cm}^3$. The one end of the manometer is connected to a vessel filled with a gas; the other is open to the atmosphere (P_B) in Pullman, where the ambient pressure is 710 mm Hg. The inclined leg of the manometer is inclined at an angle of 30° from the horizontal. What is the pressure (P_A) inside the vessel?



4. Draw a typical flow diagram of modern petroleum refinery plant.
5. How can you design a Heat Exchanger? Put the main equations, describe briefly?
6. Oxygen bubble of 1 mm diameter is injected into stirred water. After 7 minutes, the bubble is 0.54 mm in diameter. What is the mass transfer coefficient? [for sphere $V = \frac{4\pi r^3}{3}$, $A = 4\pi r^2$]
7. Calculate the terminal velocity of a material ball, 0.1 mm diameter and of density 1500 kg/m³ in an oil of density 900 kg/m³ and viscosity 50 mNs/m². Assuming Stokes' law is valid
8. Explain with equations the adiabatic and isothermal processes.
9. Draw the first order plus time delay system, with its transfer function
10. Draw the temperature control loop of a heat exchanger.