Part 1:

1. Explain the terms (a) Boiling Point (b) Vapor Pressure (c) Equilibrium (d) Driving Force (d) Equilibrium stage (e) Vapor-Liquid equilibrium (f) Constant pressure vapor liquid equilibria (g) Boiling point diagram (h) Bubble point and Dew point (i) Raoult's law (j) Dalton's law (k) Relative volatility
2. Explain relative volatility. Show that for ideal systems obeying Raoult's law, the vapour liquid equilibrium data for a binary system may be represented by the equation, $y = \frac{\alpha x}{1+(\alpha-1)x}$, Where $\alpha =$ relative volatility.
3. Define distillation with neat flow diagram.
4. Explain T-x,y boiling point diagram.
5. Methods or classification of distillation.
6. Explain differential or Simple distillation with neat flow diagram.
7. Explain Flash or Equilibrium distillation with neat flow diagram.
8. Explain Rectification or Fractionation distillation with neat flow diagram.
9. Prove that $ln\frac{Fx_F}{Wx_W} = \alpha \ln \frac{F(1-x_F)}{W(1-x_W)}$ (Assume constant relative volatility)
10. Explain terms feed plate and Feed Line with neat diagrams and expressions.
11. Explain the terms using material balance diagrams for (a) Total condenser and (b) Partial condenser (c) Reboilers.
12. Explains the following terms
    (a) Reflux ratio (b) Infinite or total reflux ratio (c) Minimum reflux ratio (d) Optimum reflux ratio
13. Explain the calculation procedure of minimum reflux ratio
14. Discuss about the McCabe-Thiele method for obtaining theoretical plates. (Including Assumptions, stepwise procedure and Limitations)
15. Discuss about the Ponchen-Savarit method for obtaining theoretical plates. (Including Assumptions, stepwise procedure and Limitations)
16. Azeotropes (a) Minimum boiling azeotropes (b) Maximum boiling azeotropes
17. Discuss about (a) Extractive distillation with neat diagram (b) Steam distillation with neat diagram
18. Types of plate efficiency (a) Overall efficiency or Overall plate efficiency (b) Murphree efficiency (c) Murphree local or point efficiency
19. Discuss briefly the simple distillation process and state its applications.
20. Derive Rayleigh's equation and explain its usefulness of distillation calculations.
21. A liquid mixture of 20 mole percent acetone and 80 mole percent methanol is to be continuously flash vaporized at the 1 atm pressure to vaporize 40 mole percent feed. Calculate composition of the products. x and y are mole fractions of acetone in liquid and vapour respectively. Equilibrium data

x	0	0.1	0.2	0.4	0.6	0.8	1.0
y	0	0.19	0.32	0.51	0.66	0.8	1.0

22. Describe in detail about azeotropic distillation with a neat sketch.

25.	Define the terms minimum reflux, total reflux and optimum reflux ratio, how to determine the optimum reflux ratio.

27.	A reboiler is considered as a theoretical plate but a total condenser is not. Justify.
28.	Compare azeotropic and extractive distillation. Which is the most preferred one among two?
29.	Under what circumstances vacuum distillation is preferred over normal distillation.
30.	Why reflux stream is necessary for a continuous distillation column?
31.	Define plate, Murphree and point efficiency with respect to plate columns.
32.	State and explain the assumptions of McCabe Thiele method.
33.	Explain the concept of optimum reflux ratio with a graph.

37.	Tabulate different conditions of feed along with their q values (or) formula. Represent q lines for different feed conditions on the equilibrium diagram.
38.	Draw a continuous distillation column. Indicate the parts and sections in the continuous distillation column. Explain the constructional features, working principle and application of it.
39.	A feed containing 50mol% benzene and 50 mol% toluene is to be distilled in a fractionating column to produce a distillate containing 90 mol% benzene and bottoms containing 90 mol% toluene. Feed rate to the column is 10000 kg/h and feed is at its bubble point. The operating reflux ratio is 1.5 times the minimum and the overall plate efficiency is 0.75. Determine the actual number of plates required. The relative volatility is 2.28.

Part 2:

Humidification and drying

1. The following data were obtained during a test run of a packed cooling tower of 0.4 m dia and 1 m packed height, operating at atmospheric pressure. Calculate the humidity of the exit air by means of an enthalpy balance. Average temperature of entering and leaving air is 38°C and 39°C respectively. Average temperature of water entering and leaving is 46°C and 35°C respectively.

   Rate of entering air = 13.6 m^3/min

   Rate of entering water = 1000 kg/hr

   Humidity of entering air = 0.0175 kg water vapor / kg dry air

   Latent heat of evaporation of water = 589 kcal/kg

   Specific heat of air = 0.245 kcal/kg°C

   Specific heat of water vapor = 0.45 kcal/kg°C

2. A wet solid material is dried from 0.7 kg water/kg dry solid to 0.08 kg water/kg dry solid in a continuous counter-current drier from which the product flows out at the rate of 500 kg/hr. The inlet air to the drier is at 54°C with an initial humidity of 0.015 kg water/kg of dry air and the exit air is at 32.2°C with 80% saturated humidity. Calculate the inlet air rate in m^3/hr and the heat supplied by the preheater if the atmospheric temperature is 24°C.

   Data:

   Saturated humidity at 32.2°C = 0.025 kg water/kg dry air

   Specific volume of dry air at 54°C = 0.925 m^3/kg

   Saturated volume = 1.09 m^3/kg

   Humid heat 0.015 humidity = 0.243 cal/gm°C

   Humid heat at 32.2°C and at 80% saturated humidity = 0.250 cal/gm°C

   a.

3. A mixture of oxygen and acetone vapor at a total pressure of 1050 mm Hg at 25°C has a percentage saturation of 75%. Calculate:

   a. The molal humidity
   b. Absolute humidity
   c. Relative humidity
   d. Volume percent acetone
   e. Molal humid volume and
   f. Molal humid heat.

4. Describe with a neat s sketch the types of cooling towers used in process industries. (b) Derive Lewis relation and explain its significance

5.A drum dryer is designed for drying a product from an initial TS of 12 % and a final moisture content of 4 %. An average temperature difference between the roller surface and the product of 65 °C will be used and the overall heat transfer coefficient is 1.74 kw / m^2 -K. Determine the surface area of the roller required to provide a production rate of 50 kg product / hr.

6. It takes 9 hours for a porous solid to reduce the moisture content from 45 to 10% when dried in a batch dryer under constant frying conditions. The critical moisture content was found to be 25% and the equilibrium moisture 3%. All moisture contents are on dry basis. Assuming that the rate of drying during the falling rate period is proportional to the free moisture content , how long should it take to dry a sample of the same solid from 35 to 5% under the same drying conditions

7.

Example 24.1. A filter cake 24 in. (610 mm) square and 2 in. (51 mm) thick, supported on a screen, is dried from both sides with air at a wet-bulb temperature of 80°F (26.7°C) and a dry-bulb temperature of 120°F (48.9°C). The air flows parallel with the faces of the cake at a velocity of 3.5 ft/s (1.07 m/s). The dry density of the cake is 120 lb/ft^3 (1922 kg/m^3). The equilibrium-moisture content is negligible. Under the conditions of drying the critical moisture is 9 percent, dry basis. (*a*) What is the drying rate during the constant-rate period? (*b*) How long would it take to dry this material from an initial moisture content of 20 percent (dry basis) to a final moisture content of 10 percent? Equivalent diameter D_e is equal to 2 ft.

8. A 32.5% solution of MgSO4 at 120oF (48.9oC)is cooled without appreciable evaporation to 70oF (21.1oC) in a batch water cooled crystallizer. How much heat must be removed from the solution per 1000kg of crystals?

9.

At 293 K, a supersaturated solution of sucrose contains 2.45 kg sucrose/kg water. If the equilibrium saturation value is 2.04 kg/kg water, what is the supersaturation ratio in terms of kg/kg water and kg/kg solution?

10. Find an expression for obtaining the total drying time for the drying of a wet solid material under constant drying conditions of to a final moisture content well below the critical moisture content.

11.Discuss in detail each one of the following processes separately giving an example.

a. Direct fractional crystallization
b. Extractive fractional crystallization
c. Adductive fractional crystallization

12. How does the super-saturation theory explain the phenomenon of crystallization?

13.What is L law? How is crystal growth controlled in continuous crystallizers?

14. List and explain the different ways in which the drying rate of a given substance in the constant rate period may be increased.

15. Giving reasons, indicate the type of dryer that can be used for the following purpose:

a. Removal of the last 6 percent moisture from salt
b. Drying of cakes of soap
c. Drying of heat sensitive materials like pharmaceuticals
d. Drying of paddy

Part 3:

Mixed units 3 to 5

1. Define humidity
2. What is meant by percentage humidity?
3. How the cooling effect in a cooling tower can be increased?
4. Define Dew point
5. Define the term Equilibrium moisture and free moisture content of solid
6. What is freeze-drying?
7. Which drier is suitable for handling fragile crystals?
8. During drying operation, critical moisture content varies with _____.
9. Write down the sequence of stages in the evolution of a crystal
10. Write down the three methods used to produce super-saturation
11. What is magma?
12. What is the purpose of agitator in a crystallizer?
13. (a) (i) Describe the methods available for estimating humidity of a sample of air.

    (ii) What are the different types of cooling towers used in industries? Briefly explain them.

    (b) The temperature of air in a room is 40.2°C and the total pressure is 101.3 kPa abs. The air contains water vapor with a partial pressure P_A = 3.74 kPa. Calculate

    (i) the humidity

    (ii) the saturation humidity and percentage humidity

    (iii) the percentage relative humidity

    14. (a) Find an expression for the determination of total time of drying of a wet solid material under constant drying conditions to a final moisture content well below the critical moisture content.

    15. (a) (i) Discuss the working of a continuous vacuum crystallizer with the help of a neat sketch.

    (ii) What are the parameters controlling the crystal size distribution in a crystallizer? Explain them briefly.

(b) A solution of sodium sulfate in water is saturated at a temperature of 40°C. Calculate the weight of crystals and the percentage yield obtained by cooling this solution to a temperature of 5°C.The solubilities are as follows:

at 40°C: 32.6% Na_2SO_4
at 5°C: 5.75% Na_2SO_4

Note: At a temperature of 5°C the decahydrate will be the stable crystalline form

1. Explain the theory of humidification
2. What is meant by wet bulb temperature approach?
3. What is the principle of 'recirculating liquid gas humidifier'?
4. Define Dew point
5. Define the term "Bound moisture"
6. Explain the effect of temperature and mass flow rate of air on the constant rate of drying, N_C.
7. What is meant by holdup in a rotary dryer?
8. Which type of drier is used in the manufacture of (a) tablets (b) Paraffin wax?
9. What is crystallization?
10. What is the purpose of agitator in the crystallizer?
11. Give examples of batch crystallizer and continuous crystallizer.
12. (a) Explain the theory of adiabatic saturation curves and wet bulb temperature theory
13. (a) Explain a typical drying rate curve and bring out its salient features.

    (b) A time of 5 hr was taken to dry a material from an initial moisture of 30% to a final moisture of 7%. Critical and equilibrium moisture are found to be 15% and 2% respectively. How much further time would be required to dry the material to a final moisture of 4%. All moisture contents are on wet basis.

14. (a) (i) Explain the crystallizers classification.

    (ii) Explain with neat sketch, working of a Swenson-Walker crystallizer.

    (b) 5000 kg of KCl solution at a temperature of 80°C is cooled to 20°C in an open tank. The solubilities of KCl at 80°C and 20°C are 55 parts and 35 parts per 100 parts of water. Estimate the yield of KCl crystals by

    (i) Assuming 5% water is lost by evaporation

    (ii) Assuming no loss of water by evaporation.