Evaporation

1. Heat sensitive materials can be concentrated in an evaporator employing
   a. vacuum c. high pressure
   b. high residence time d. none of these

2. kg of liquid evaporated per hour in an evaporator is defined as its
   a. capacity c. economy
   b. steam load d. none of these

3. The number of kg vaporized per kg of steam fed to the evaporator is defined as
   a. capacity c. rate of evaporation
   b. economy d. rate of vaporization

4. What is the steam economy in case of a single effect evaporator system?
   a. 1 c. >1
   b. < 1 d. 0.1

5. Evaporation of 1kg of water from a solution in a single effect evaporator requires about _____ kg of steam.
   a. 0.4 - 0.6 c. 1 - 1.3
   b. 1.8 - 2 d. 2 - 2.4

6. The rate of heat transfer is a product of overall heat transfer co-efficient, the difference in temperature and the
   a. heating volume c. heat transfer area
   b. Nusselt number d. none of these

7. Increasing the liquor level in the evaporator results in the
   a. decreased capacity.
   b. increase in liquor film co-efficient.
   c. decreased effect of hydrostatic head.
   d. increased true temperature drop.

   For numbers 8 to 10:
   4500 kg/h of a 10% wt sugar solution is to be concentrated to 30% wt using single effect evaporator. Feed enters at 21°C. Saturated steam at 110°C is available and the temperature in the condenser is 43°C. Specific heat of the solutions may be taken as constant at 4 J/g-°C. The over-all heat transfer coefficient is 2840 W/m^2-^{0}C.

8. Determine the steam consumption, in kg/h.
   a. 3400 kg/h c. 5800 kg/h
   b. 4700 kg/h d. 6500 kg/h

9. How many square meters of heating surface are required?
   a. 15 m^2 c. 11 m^2
   b. 9 m^2 d. 13 m^2

10. What is the steam economy?
    a. 0.82 c. 0.90
    b. 0.88 d. 0.92

11. An evaporator having an area of 83.6 m^2 and U = 2270 W/m^2-K is used to produce distilled water for a boiler feed. Tap water having 400 ppm is dissolved solids at 15.6^{0}C is fed to the evaporator operating at 1 atm pressure abs. Saturated steam at 115.6^{0}C is available for use. Calculate the amount of distilled water produced per hour if the outlet liquid contains 800 ppm solids.
    a. 3595 kg/h c. 4215 kg/h
    b. 7191 kg/h d. 6543 kg/h

12. It is not preferable to use superheated steam in evaporators, because of its very
    a. high temperature c. high pressure
    b. low film coefficient d. none of these

13. Small scale evaporation is done in a
    a. heat exchange
    b. multiple effect evaporator
    c. condenser
    d. steam jacketed kettle

14. Viscous and heat sensitive liquids are concentrated in _____ evaporators.
    a. open pan c. long tube
    b. agitated film d. none of these

15. Forced circulation evaporators are useful for the concentration of viscous, salting and scale forming liquors. Which of the following is a forced circulation evaporator?
    a. Long vertical evaporator
    b. Horizontal tube evaporator
    c. Agitated film evaporator
    d. Calandria vertical tube evaporator

16. A _____ evaporator employs an annular down take.
    a. basket type c. horizontal
    b. long tube vertical d. none of these

17. Which is the most suitable for the concentration of foamy and frothy liquors?
    a. Agitated film evaporator
    b. Long tube vertical evaporator
    c. Open pan evaporator
    d. None of these

18. A single effect evaporator concentrates 1 MT of 10 wt% sucrose solution to 50%. The feed enters the evaporator at 20^{0}C and has a specific heat of 1.0. The evaporator is maintained at a vacuum of 600 mmHg. The heat is provided by saturated steam at 8.8 kg/cm^2 gage. Assuming that no sensible heat is recovered in the evaporator, calculate the weight of heating steam, in kg, needed for concentrating the sucrose solution.
    a. 1020 kg c. 2860 kg
    b. 2100 kg d. 1430 kg

19. Boiling point elevation for a strong and concentrated solution is found by Duhring's rule, which states that at the same pressure, the boiling point of a solution is a linear function of the _____ of pure water.
    a. boiling point c. dynamic viscosity
    b. kinematic viscosity d. density

20. Boiling point of a solution according to Duhring's rule is a linear function of the _____ of water.
    a. boiling point (at the same pressure)
    b. viscosity
    c. density
    d. thermal conductivity

    For numbers 21 to 22:
    Determine the boiling point rise for the following solutions in water.

21. A 30 wt% solution of citric acid in water boiling at 220^{0}F.
    a. 3.4 ^{0}F c. 2.2 ^{0}F
    b. 1.8 ^{0}F d. 4.5 ^{0}F

22. What is the boiling point elevation of a 30% NaOH solution boiling in an evaporator at a pressure of 172.4 kPa?
    a. 15 ^{0}C c. 10 ^{0}C
    b. 13 ^{0}C d. 17 ^{0}C

    For numbers 23 to 25:
    A single effect evaporator is to concentrate 20000 lb/hr of a 20% solution NaOH to 50% solids. Saturated steam is available at 20 psig. The absolute vapor pressure in the vapor space is to be 100 mmHg. The overall coefficient is to be estimated to be 250 BTU/hr-ft^2-^{0}F. The feed temperature is 100^{0}F. Calculate the following:

23. The amount of steam consumed
    a. 15400 lb/h c. 12800 lb/h
    b. 13500 lb/h d. 19100 lb/hr

24. The steam economy
    a. 0.72 c. 0.78
    b. 0.88 d. 0.90

25. The heating surface required.
    a. 930 ft^2 c. 810 ft^2
    b. 670 ft^2 d. 550 ft^2

26. In case of vertical tube evaporator, with increase in liquor level, the overall heat transfer coefficient
    a. increases
    b. decreases
    c. is not affected
    d. may increase or decrease; depends on the feed

27. In case of evaporators, liquid entrainment results primarily due to
    a. high vacuum in the evaporator.
    b. high evaporation rate.
    c. foaming of the solution.
    d. high heat transfer rate.

28. Multiple effect evaporation is generally recommended, when the
    a. large scale evaporation of liquor is needed.
    b. corrosive liquids are to be concentrated.
    c. fuel is cheaply available.
    d. evaporation on small scale is to be done.

29. A dilute aqueous solution is to be concentrated in an evaporator system. High pressure steam is available. Multiple effect evaporator system is employed, because
    a. total heat transfer area of all the effects is less than that in a single effect evaporator system.
    b. total amount of vapor produced per kg of feed steam in a multiple effect system is much higher than in a single effect.
    c. boiling point elevation in a single effect system is much higher than that in any effect in a multi effect system.
    d. heat transfer coefficient in a single effect is much lower than that in any effect in a multi-effect system.

30. In a backward feed multiple effect evaporator
    a. feed is introduced in the first effect.
    b. feed flows from low pressure to high pressure.
    c. no pumps are required between successive effects.
    d. none of these.

31. For evaporation of viscous solution in a multiple effect evaporator, the preferred feeding scheme is
    a. forward c. backward
    b. parallel d. none of these

32. In a forward feed multiple effect, the pressure build up will be
    a. least at the inlet of the first effect.
    b. least at the outlet of the last effect.
    c. highest at the inlet of the last effect.
    d. highest at the outlet of the last effect.

33. For the same heat transfer area and the terminal conditions, the ratio of the capacities of a single effect evaporator to a triple effect evaporator is
    a. 3 c. 0.33
    b. 1 d. 1.33

34. Black liquor generated during paper manufacture is concentrated in a
    a. single effect evaporator.
    b. single effect evaporator followed by a crystallizer.
    c. multiple effect evaporator.
    d. multiple effect evaporators followed by a crystallizer.

35. Which of the following accessories is provided in the vapor line of an evaporator for removing the entrained liquid?
    a. Bleed point c. Vent
    b. Catchall d. Baffle

For numbers 36 to 38:
A solution with a negligible boiling point rise is being evaporated in a triple effect evaporator using saturated steam at 121.1°C. The pressure in the vapor of the last effect is 25.6 kPa abs. The heat transfer coefficients are U_1 = 2840, U_2 = 1988, and U_3 = 1420 $W/m^2 \cdot K$ and the areas are equal. Estimate the boiling point in each of the evaporators.

36. T_1
    a. 381.7 K c. 286.2 K
    b. 592.3 K d. 440.9 K

37. T_2
    a. 289.1 K b. 363.8 K
    b. 501.5 K d. 411.1 K

38. T_3
    a. 210.5 K c. 495.2 K
    b. 338.7 K d. 526.2 K

39. Consider a four-effect standard vertical tube, each effect has 140 m^2 of heating surface, is to be used to concentrate, from 4% to 35% percent solids, the total boiling point elevation is 10^0C. Forward feed is to be used. Saturated steam is available at 120^0C, and the vacuum in the las effect corresponds to a boiling temperature of 40^0C. the overall coefficients, in W/m^2-K are 2950 in I, 2670 in II, 2070 in III and 1360 in IV, all specific heats may be taken as 4.2 J/g-^{0}C and radiation is negligible. Calculate the boiling point of solution in effect number 1.
    a. 107.7^0C c. 101.5^0C
    b. 112.3^0C d. 116.4^0C

Crystallization

For numbers 40 to 42:
A solution of sodium nitrate in water at a temperature of 40^0C contains 49% $NaNO_3$ by weight.

40. Calculate the percentage saturation of this solution.
    a. 92% c. 96%
    b. 84% d. 88%

41. Calculate the lb of $NaNO_3$ that crystallized from 1000 lb of this solution by cooling it to 10^0C.
    a. 94 lb c. 82 lb
    b. 76 lb d. 63 lb

42. Calculate the percentage yield of the process.
    a. 15.2% c. 18.1%
    b. 16.7% d. 17.5%

43. The driving potential for the crystal growth during crystallization is the _____ of the solution.
    a. concentration c. viscosity
    b. super-saturation d. density

44. A solution of Na_2SO_4 in water is saturated at 50 ^{0}C. When a saturated solution of Na_2SO_4 is cooled, crystals of Na_2SO_4 x $10H_2O$ separate from the solution. If 1000 kg of this solution is cooled to 10 ^{0}C, the percentage yield obtained is

Temperature, ^{0}C	Solubility of Na_2SO_4 (g per 100g water)
50	46.7
10	9

    a. 91% c. 55%
    b. 86% d. 73%

For numbers 45 to 46:
A saturated solution containing 1500 kg of potassium chloride at 360 K is cooled in an open tank to 290 K. If the specific gravity of the solution is 1.2, the solubility of potassium chloride per 100 parts water is 53.55 at 360 K and 34.5 at 290 K.

45. What is the capacity of the tank?
a. 4.56 m^3 c. 2.99 m^3
b. 3.58 m^3 d. 5.71 m^3

46. Calculate the mass of the crystals obtained, neglecting loss of water by evaporation.
a. 489 kg c. 112 kg
b. 653 kg d. 534 kg

47. A tank holds 10000 kg of a saturated solution of Na_2CO_3 at 30^0C. You want to crystallize from this solution 3000 kg Na_2CO_3 x 10 H_2O without any accompanying water. To what temperature must the solution be cooled?

Temperature (^{0}C)	Solubility (g Na_2CO_3/100 g H_2O)
0	7
10	12.5
20	21.5
30	38.8

a. 26^0C c. 10^0C
b. 18^0C d. 15^0C

48. Crystallization of solids from a homogeneous solution is a/an _____ process.
a. exothermic c. mildly endothermic
b. highly endothermic d. none of these

For numbers 49 to 51:
Ammonium sulfate is to be crystallized from a solution containing 48% $(NH_4)_2SO_4$ by cooling it in a counter flow crystallizer from 85 to 35^0C. During cooling the amount of water that evaporates is 5% of the mass of the feed solution.
Data:
Feed rate = 1000 kg/h
Solubility of $N(H_4)_2SO_4$ at 35^0C = 75 kg /100 kg of water
Specific heat of 48% $(NH_4)_2SO_4$ at solution = 2.97 kJ/kg-K
Heat of crystallization of $(NH_4)_2SO_4$ = 75.2 kJ/kg

49. Calculate the rate of formation of crystals.
a. 127.5 kg/h c. 822.5 kg/h
b. 678.3 kg/h d. 321.7 kh/h

50. What is the cooling water rate, if it is heated from 18 to 29^0C?
a. 764 kg/h c. 810 kg/h
b. 505 kg/h d. 427 kg/h

51. Determine the required cooling surface, if the overall heat transfer is 125 W/m^2-K.
a. 3.13 m^2 c. 1.95 m^2
b. 2.52 m^2 d. 4.02 m^2

For numbers 52 to 54:
Glauber's salt, $Na_2SO_4x10H_2O$, is to be produced in a Swenson–Walker crystallizer by cooling to 290 K a solution of anhydrous Na_2SO_4 which saturates between 300 K and 290 K. Cooling water enters and leaves the unit at 280 K and 290 K respectively and evaporation is negligible. The solubilities of anhydrous Na_2SO_4 in water are 40 and 14 kg/100 kg water at 300 K and 290 K respectively, the mean heat capacity of the liquor is 3.8 kJ/kgK and the heat of crystallization is 230 kJ/kg. For the crystallizer, the available heat transfer area is 3 m^2/m length, the overall coefficient of heat transfer is 0.15 kW/m^2-K.

52. Calculate the amount of feed in kg/s
a. 0.559 c. 0.342
b. 0.643 d. 0.488

53. The total heat to be removed is
a. 76 kW c. 92 kW
b. 51 kW d. 88 kW

54. How many sections of crystallizer, each 3 m long, will be required to process 0.25 kg/s of the product?
a. 4 c. 2
b. 1 d. 6

55. In most of the vacuum crystallizer, vacuum is generally produced by means of a
a. suction pump
b. compressed air jet
c. steam jet ejector with a barometric condenser
d. none of these

56. What is the yield of sodium acetate crystals (CH_3COONa x $3H_2O$) obtainable from a vacuum crystallizer operating at 1.33 kN/m^2 when it is supplied with 0.56 kg/s of a 40 percent aqueous solution of the salt at 353 K? The boiling point elevation of the solution is 11.5 K.
Data:
Heat of crystallization, q = 144 kJ/kg trihydrate
Heat capacity of the solution, Cp = 3.5 kJ/kg deg K
Latent heat of water at 1.33 kN/m^2, λ = 2.46 MJ/kg
Boiling point of water at 1.33 kN/m^2 = 290.7K
Solubility of sodium acetate product = 0.539 kg/kg water.
a. 0.15 kg/s c. 0.18 kg/s
b. 0.12 kg/s d. 0.16 kg/s

Humidification

57. At a fixed pressure, the humidity depends upon the partial pressure of vapor in the mixture. Humidity of a vapor free gas is _____ percent.
a. 100 c. 0
b. 50 d. between 0 and 100

For numbers 58 to 61:
The vapor pressure of styrene is 100 mmHg at 82^0C and 200 mmHg at 100^0C. A gas that consists of 10 mol% styrene and 90 mol% non-condensable is contained in a tank at 100^0C and 1000 mmHg. Calculate:

58. The dew point of the gas
a. 77^0C c. 82^0C
b. 100^0C d. 96^0C

59. The relative saturation
a. 20% c. 30%
b. 40% d. 50%

60. The molal saturation
a. 0.111 c. 0.087
b. 0.206 d. 0.150

61. The percentage saturation
a. 33.3% c. 44.4%
b. 55.5% d. 66.6%

For numbers 62 to 65:
In a vessel at 101.325 kN/m^2 and 300K, the percentage relative humidity of the water vapor in the air is 25. If partial pressure of water vapor when air is saturated with vapor at 300K is 3.6 kN/m^2, calculate:

62. The partial pressure of the water vapor in the vessels
a. 0.2 c. 0.7
b. 0.5 d. 0.9

63. The humidity of the air
a. 0.006 c. 0.001
b. 0.003 d. 0.008

64. The humid volume
a. 0.352 m^3/kg c. 0.857 m^3/kg
b. 0.109 m^3/kg d. 0.264 m^3/kg

65. The percentage humidity
a. 31% c. 10%
b. 46% d. 25 %

66. _____ is the temperature at which a gas-vapor mixture becomes saturated, when cooled at constant total pressure out of contact with a liquid.
a. Dew point c. Bubble point
b. Dry bulb temperature d. Wet bulb temperature

67. Weight of 1 m^3 of humid air as compared to 1 m^3 of dry air, under the same conditions, is
a. less c. more
b. same d. unpredictable

For numbers 68 to 70:
A stream of air at 100^0C and 5260 mmHg contains 10% water by volume.

68. Calculate the dew point.
a. 90^0C c. 83^0C
b. 72^0C d. 65^0C

69. Calculate the percentage of the vapor condenses and the final composition of the gas phase if the air is cooled to 80^0C at constant pressure.
a. 20% c. 25%
b. 30% d. 35%

70. Calculate the percent condensation if, instead of being cooled, the air is compressed isothermally to 8500 mmHg.
a. 12% c. 15%
b. 18% c. 13%

71. Condensation of a vapor-gas mixture just begins, when (where, p = partial pressure of the vapor P = vapor pressure of the liquid)
a. p = P c. p >>P
b. p < P d. p << P

For numbers 72 to 75:
The absolute humidity of a carbon dioxide–water vapor mixture at 310 K and 100 kPa is measured to be 0.022 kg water per kg dry carbon dioxide. Calculate the following:

72. The molal saturation
a. 0.0267 c. 0.0537
b. 0.0336 d. 0.0011

73. The percent relative saturation
a. 82.42% c. 81.48%
b. 80.36% d. 84.90%

74. The percent saturation
a. 82.42% c. 81.48%
b. 80.36% d. 84.90%

75. The temperature to which the gas is to be heated at constant pressure to reduce its percent saturation to 30 percent
a. 337.5 K c. 345.5 K
b. 327.5 K d. 461.5 K

76. When an unsaturated air-water mixture is heated at constant pressure, then
a. the partial pressure of water vapor increases.
b. the specific humidity decreases.
c. the relative humidity increases.
d. the relative humidity decreases.

For 77 to 79:
A gas mixture contains 0.0083 mol of water vapor per mol of dry methane at a temperature of 27^0C and a total pressure of 200 kPa.

77. Percent relative saturation of the mixture
a. 46% c. 58%
b. 33% d. 60%

78. Percent saturation of the mixture
a. 65% c. 46%
b. 77% d. 50%

79. Temperature to which the mixture must be heated at 200 kPa in order that the relative saturation will be 0.20.
a. 53^0C c. 37^0C
b. 64^0C d. 42^0C

80. In a process in which it is used as a solvent, benzene is removed into dry nitrogen. At 297 K and 101.3 kN/m^2, the resulting mixture has a percentage relative humidity of 60. It is required to recover 80 per cent of the benzene present by cooling to 283 K and compressing to a suitable pressure. What should this pressure be? The vapor pressure of benzene is 12.2 kN/m^2 at 297 K and 6.0 kN/m^2 at 283 K.
a. 392 kPa c. 345 kPa
b. 353 kPa d. 386 kPa

81. Air initially at 101. 3 kPa and 40°C and with a relative humidity of 50%, is cooled at constant pressure to 30°C. The cooled air has a
a. higher dew point.
b. higher absolute (specific) humidity.
c. higher relative humidity
d. higher wet bulb temperature.

For numbers 82 to 87:
The air supply for a dryer has a dry-bulb temperature of 70^0F and a wet bulb temperature of 60^0F. It is heated to 200^0F by coils and blown into the dryer. In the dryer it cools along an adiabatic cooling line and leaves the dryer fully saturated.

82. What is the dew point of the initial air?
a. 62^0F c. 40^0F
b. 35^0F d. 54^0F

83. What is its humidity?
a. 0.0066 c. 0.0087
b. 0.0090 d. 0.0052

84. What is its percentage relative humidity?
a. 33% c. 55%
b. 44% d. 66%

85. How much heat is needed to heat 100 ft^3 to 200^0F?
a. 235 BTU c. 168 BTU
b. 107 BTU d. 240 BTU

86. How much water will be evaporated per 100 ft^3 of entering air?
a. 0.262 lb c. 0.185 lb
b. 0.333 lb d. 0.497 lb

87. At what temperature does the air leave the dryer?
a. 86^0F c. 72^0F
b. 93^0F d. 61^0F

88. Steady state temperature reached by a small amount of liquid evaporating into a large amount of unsaturated vapor-gas mixture is
a. dry-bulb temperature
b. wet bulb temperature
c. dew point
d. adiabatic saturation temperature

89. Which of the following remains constant during evaporative cooling process with recirculated water supply?
a. Relative humidity c. Partial pressure of vapor
b. Wet bulb temperature d. None of these

90. When the temperature and humidity of air is low, we usually use _____ draft cooling tower.
a. natural c. forced
b. induced d. none of these

91. The semiconductor plant at the Food Terminal Export Zone, an adiabatic dryer is used where air enters at 160°F. If the air has a dew point of 68°F and it picked up 0.08 lb water per 100 ft^3, how saturated is the air coming out of the dryer?
a. 50% c. 60%
b. 70% d. 80%

For numbers 92 to 93:
It is desired to condition saturated atmospheric air at 70°F with entrained 0.0008 lb water per cu ft air to hot air at 200°F dry bulb and 115°F wet bulb temperatures. The air is passed thru a heater, then thru an adiabatic humidifier, then thru a reheater. The air, as it leaves the adiabatic humidifier, has a humidity of 90%. Calculate the temperature of the air as it leaves the

92. Adiabatic humidifier
a. 106^{0}F c. 137^{0}F
b. 115^{0}F d. 124^{0}F

93. Heater
a. 228^{0}F c. 183^{0}F
b. 191^{0}F d. 215^{0}F

For numbers 94 to 95:
1000 cfm of air (A) at 95^{0}F dry bulb, 74^{0}F wet bulb is mixed with 2000 cfm of air (B) at 65^{0}F dry bulb, 54^{0}F wet bulb. Determine for the mixed stream:

94. The dry bulb temperature
a. 83^{0}F c. 75^{0}F
b. 90^{0}F d. 85^{0}F

95. The wet bulb temperature
a. 61^{0}F c. 50^{0}F
b. 55^{0}F d. 68^{0}F

96. If 100 lb of dry air at 50^{0}F db and 50^{0}F wb is mixed with 300 lb of dry air at 110^{0}F db and 80^{0}F wb, the resulting mixture will have a dry bulb temperature of
a. 80^{0}F c. 85^{0}F
b. 90^{0}F d. 95^{0}F

97. What is the wet bulb temperature of the resulting mixture for the mixed air of Problem 97?
a. 85^{0}F c. 65^{0}F
b. 73^{0}F d. 70^{0}F

For numbers 98 to 100:
Air in an amount 1000 cfm at 150^{0}F, 20% RH is passed over a refrigerated coil and thereby brought to 60^{0}F, 90% RH with the condensed moisture withdrawn at 55^{0}F. The air is then reheated by means of an electric heating coil to 150^{0}F.

98. Compute the moisture removed in lb/min.
a. 1.44 c. 3.67
b. 2.08 d. 4.19

99. Compute the heat removed by the refrigerated coil, expressed as tons of refrigerated coil, expressed as tons of refrigeration.
a. 11 c. 17
b. 15 d. 13

100. Calculate the wattage of the heating coil required.
a. 38 kW c. 25 kW
b. 16 kW d. 44 kW

Drying

101. Moisture contained by a substance in excess of the equilibrium moisture is called
a. unbound moisture c. free moisture
b. critical moisture d. bound moisture

102. Moisture in a substance exerting an equilibrium vapor pressure less than that of pure liquid at the same temperature is called the _____ moisture.
a. bound c. unbound
b. critical d. none of these

103. Drying operation under vacuum is carried out to
a. dry those materials which have very high unbound moisture content.
b. reduce drying temperature.
c. increase drying temperature.
d. dry materials having high bound moisture content.

104. A wet solid is dried in a batch drier under constant drying conditions from 25% db to 10% db in 4.17 hours. The critical moisture content is 15% db and its equilibrium moisture content is 5% db. How long will it take to dry the solid from 30% db to 8% db under the same drying conditions?
a. 6.66 hours c. 4.44 hours
b. 2.65 hours d. 1.44 hours

105. A solid material shows case hardening properties while drying. Which of the following should be controlled to control the drying process?
a. Flow rate of inlet air c. Relative humidity of outlet air
b. Humidity of inlet air d. Temperature of the solid

106. Wet solid is dried in a batch dryer under constant drying conditions from 35% to 10% in 7 hours. The critical moisture content is 20% and the equilibrium moisture is 4%. All moisture contents are on dry basis. How long should it take to dry the same solid from 10% to 5% moisture under the same drying conditions.
a. 6.5 hrs c. 5.1 hrs
b. 3.3 hrs d. 4.8 hrs

107. Wet solid is to be dried from 40 to 10% in 5 hours under constant drying conditions. The critical moisture is 20% and the equilibrium moisture content is 7%. All moisture contents are on a dry basis. The time needed to dry from 15% to 5% free moisture under the same drying conditions is
a. 4.28 hrs c. 1.85 hrs
b. 2.67 hrs d. 2.03 hrs

108. A porous material dries in the open air at a rate approximately proportional to its moisture content. If a sheet hangs in the wind losses half its free moisture in the first hour, when will it have lost 99%, weather conditions remaining the same?
a. 6.6 hrs c. 4.7 hrs
b. 7.5 hrs d. 8.1 hrs

109. The initial moisture content of a food product is 77% (wet basis), and the critical moisture content is 30% (wet basis). If the constant drying rate is 0.1 kg H_2O / m^2-s, compute the time required for the product to begin the falling rate drying period. Neglect equilibrium moisture content. The product has a cube shape with 5 cm sides, and the initial product density is 950 kg/m^3.
a. 23.4 s c. 34.6 s
b. 48.5 s d. 53.2 s

For numbers 110 to 112:
Ipil-ipil leaves will be dried in a moving train of trays dryers. The wet leaves containing 75 % water (wet basis) is to be dried to 15% (wet basis) in tray containing 1 m x 1.5 m. The wet leaves are spread out in the tray to a uniform thickness of 8 cm. Calculate:

110. The number of trays needed to produce 1 MT of the dried leaves
a. 20 c. 45
b. 38 d. 17

111. The amount of water removed/MT of product. The density of the leaves is 0.75 g/cc
a. 2400 kg c. 3300 kg
b. 5800 kg d. 4700 kg

112. If hot air at 20% RH and a dry bulb temperature of 110^0F is blown into the dryer and moist air leaves at 105^0F dry bulb and 86^0F wet bulb temperatures, how many ft^3 of hot air will be needed per MT of product?
a. $8.05x10^6$ ft^3 c. $6.41x10^6$ ft^3
b. $4.98x10^6$ ft^3 d.$5.22x10^6$ ft^3

113. An adiabatic tunnel dryer handles 100 kg of banana chips per batch reducing the moisture content from 50% and 12% wet basis. Drying takes 10 hours to complete by flowing air at 82 ^{0}C and 5% R.H. The air leaves the dryer saturated. Assuming that the rate of drying is constant, calculate the volume of air blown in m^3/hr.
a. 222 c. 250
b. 267 d. 208

114. Milk is dried usually in a _____ dryer.
a. freeze c. spray
b. tray d. rotary

115. Heat sensitive materials like certain pharmaceuticals and food stuff can be dried
a. in indirect tray dryer c. in spray dryer
b. by freeze drying d. festoon dryer

116. Large scale drying of sugar is done in a _____ dryer.
a. spouted bed c. tray
b. rotary d. truck

117. Free flowing granular materials can be best dried in a _____ drier.
a. rotary c. cylinder
b. drum d. freeze

118. Pick out the wrong statement pertaining to the rotary dryer.
a. Flights (located in the inside shell of rotary dryer) lift the material being dried and shower it down through the current of hot air/gases. It extends from the wall to a distance which is about 8-12% of the inside diameter of shell.
b. Hold up of a rotary drier is defined as the fraction of the dryer volume occupied by the solid at any instant. The best performance for rotary drier is obtained, when the holdup is in the range of 0.05 to 0.15.
c. Rotary dryer is suitable for drying sticky material.
d. Recommended peripherial speed of a rotary drier is in the range of 10 to 30 meters/minute.

119. Flights in a rotary dryer are provided to
a. lift and shower the solids thus exposing it thoroughly to the drying action of the gas.
b. reduce the residence time of solid.
c. increase the residence time of the solid.
d. none of these.

120. Which of the following is not a continuous drier?
a. Drum drier c. Spray drier
b. Tunnel drier d. Tray drier