Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.TECH(FT)/SEM-2/MFT-202/2012

2012

ADVANCED FOOD ENGINEERING

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) Pervaporation differs from the other membrane separation processes because
      a) it is less expensive
      b) it involves phase change in permeate
      c) commercially it is always supplemented to a conventional separation process
      d) very high pressure is applied in the upstream side of the membrane.

   ii) *Waterogen* is an Atlanta based water purifying company that manufactures water purifiers which combine antimicrobial activity and another membrane separation process that can remove mineral salts from the water. Which of the following may be the membrane separation process adopted by *Waterogen* ?
      a) Pervaporation b) Dialysis
      c) Reverse osmosis d) Electrodialysis.

iii) It is proposed to purify benzene from a small volume of non-volatile solutes by subjecting it to distillation with saturated steam under atmospheric pressure of 745 mm of Hg. Calculate the temperature at which the distillation will proceed.

	Temp. (°C)	VP of water in mm Hg	VP of benzene in mm Hg
a)	60	150	390
b)	65	190	460
c)	68	215	510
d)	69	225	520

iv) In azeotropic mixture, the equilibrium vapour composition is
   a) more than liquid composition
   b) less than liquid composition
   c) same as liquid composition
   d) independent of pressure.

v) Drying refers to an operation where
   a) non-volatile liquid is removed from water
   b) volatile liquid is removed from a solid or semi-solid medium by means of thermal energy
   c) volatile liquid is removed from water
   d) volatile liquid is removed from a solid by molecular vibration.

vi) Boiling point diagram is
   a) not affected by pressure
   b) affected by pressure
   c) a plot of temperature *vs* liquid composition
   d) a plot of temperature *vs* vapour composition.

vii) For incompressible cakes in cake filtration

$$\alpha = \frac{K_2(1-e)}{(\phi_s D_p)^2 \varepsilon^3 \rho_p}$$

Dimension of α will be

a) L^{-1} b) $ML^{-1}T^2$

c) LM^{-1} d) $\frac{M}{L}$.

viii) Relative centrifugal field (RCF) is defined as

a) $\frac{g}{\omega^2 R}$ where g = acceleration due to gravity, ω = angular velocity

b) $(1.118.10^{-2})(\text{revmin}^{-1})^3.R$

c) $(1.118.10^{-5})(\text{revmin}^{-1})^2.R$

d) $(1.118)(\text{revmin}^{-1})$.

ix) In a fluidized bed, when the supercritical velocity increases

a) there is increased pressure drop

b) there is increase in porosity of the bed

c) there is increase in heat transfer rate

d) none of these.

x) Minimum air velocity needed to convey particles at the time of fluidization is given by

a) $V_g = \frac{d_p^2 (\rho_p - \rho) g}{18\mu}$ b) $V_g = \sqrt{\frac{4d(\rho_p - \rho) g}{3c_D \rho}}$

c) $V_g = \sqrt{\frac{3c_D \rho}{4d(\rho_p - \rho) g}}$ d) $V_g = \sqrt{\frac{3c_D \rho}{4d(\rho - \rho_p) g}}$.

xi) In case of ultra-rapid freezing the rate of freezing is

a) 2-5 mm/hr b) 10-20 mm/hr

c) 100-1000 mm/hr d) 50-100 mm/hr.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) The rejection co-efficient of an ultra-filter is denoted by R = ...

b) What is the difference between cross flow and dead-end flow ?

c) "All membrane foulings are preceded by concentration polarization but all concentration polarizations do not lead to membrane fouling." Justify. 1 + 2 + 2

3. The temperature of air in a room is 40·2°C and the total pressure is 101·3 kPa. The air containing water vapour with a partial pressure pA is 3·74 kPa. Calculate (i) the humidity, (ii) the saturation humidity & % humidity, (iii) the % relative humidity. 1 + 2 + 2

4. A loaf of bread having a surface temperature of 373 K is being baked in an oven whose walls and air are at 477·4 K. The bread moves continuously through the large oven on an open chain belt conveyor. The emissivity of the bread is estimated as 0·85 and the loaf can be assumed a rectangular solid 114·3 mm high × 114·3 mm wide × 330 mm long. Calculate the radiation heat-transfer rate to the bread, assuming that it is small compared to the oven and neglecting natural convection heat transfer.

5. Peas which have average diameter of 6 mm and density of 880 kg/m^3 are dried in a fluidized bed drier. The minimum void age is 0·4 and the cross-sectional area of bed is 0·25 m^2. Calculate the minimum air velocity to fluidize the bed if air density is 0·96 kg/m^3 and air viscosity is $2{\cdot}15 \times 10^{-5}$ N/sm^2. Calculate the minimum air velocity needed to convey the particles.

6. a) Calculate the osmotic pressure of a solution having 0·35 g mol NaCl/1000g water at 25°C. Density of water is 997 kg/m^3 at 25°C.

   b) A reverse osmosis membrane to be used at 25°C for a NaCl feed solution containing 2·5 g NaCl/L (density = 999 kg/m^3) has permeability constants = A_w = $2{\cdot}405 \times 10^{-4}$ kg/s-m^2-atm and a

solute permeability constant $A_s = 8 \cdot 84 \times 10^{-7}$ m/s. Calculate the water flux through the membrane using $\Delta P = 27 \cdot 2$ atm and the solute rejection R. Also calculate C_2 of the solution product. The following table relates values of gm-mol NaCl/kg of water with the corresponding Osmotic Pressure (OP) at 25°C :

gm mol NaCl/kg of water	Density (kg/m^3)	OP (atm)
0	997·0	0·00
0·01	997·4	0·47
0·10	1001·1	4·56
0·50	1017·2	22·55
1·00	1036·2	45·80
2·00	1072·3	96·20

2 + 3

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Define the terms 'free' and 'bound' moisture content.

   b) A continuous counter-current drier is used to dry 425·6 kg dry solid/h containing 0·035 kg total moisture/kg dry solid to a value of 0·0017 kg total moisture/kg dry solid. The granular solid enters at 25°C & leaves at 60°C. The heating medium is air which enters at 84·2°C, has a humidity of 0·0175 kg water/kg dry air & leaves at 32·8°C. Calculate the air flow rate & the outlet humidity, assuming the heat losses from the drier to be 9300 kJ/h. 3 + 12

8. a) What is cavitation of a centrifugal pump ?

   b) A centrifugal pump takes brine from the bottom of a supply tank and delivers it into the bottom of another

tank. The brine level in the discharge tank is 50 m above the supply tank. The line between the tank is 200 m of 10 mm pipe. The flow rate is 100 m^3/h. In this line there are two gate valves, three standard tees and four elbows. What is the energy cost for running the pump for 24 hrs/day ?

Take ρ = 1180 kg/m^3, $\mu = 1 \cdot 2\,mp\text{-}s$, Energy cost Re. 0·80 kW/h. Overall efficiency of the pump is 60%, $F = 0{\cdot}079\ (Re)^{-0{\cdot}25}$, L/D ratio of gate valve = 7, Standard tees = 90, Elbow = 32.

c) Write a note on selected grades of stainless steel in manufacturing pipeline in food processing plant.

2 + 8 + 5

9. An ultrafiltration plant is required to treat 50 m^3/day of a protein containing waste stream. The waste contains 0·5 kg/m^3 of protein, which has to be concentrated to 20 kg/m^3, so as to allow recycling of the process stream. The tubular membranes to be used are available as 30 m^2 modules. Pilot plant studies show that the flux J through the membrane is given by $J = 0{\cdot}02\ ln\ (30/cf)$ m/h, where cf is the concentration of protein in kg/m^3. Due to fouling the flux never exceeds 0·04 m/h. Estimate the minimum module required for the operation of this process —

a) as single feed and bleed stage

b) as two feed and bleed stages in series operation, for 20 h/day.

10. a) What are the bases for designing a continuous sterilizer ?

b) A fluid food product has a viscosity of 5 *cp* and density of 1009 kg/m^3. It is to be pasteurized in a continuous system that involves heating to 82·2°C holding in a

1·5 inch nominal sanitary pipe and cooled. A SV value 12 for *S. aureus* D82·2°C = 0·0063 min is desired. Calculate the length of the holding tube for a flow rate of 181/min. 7 + 8

11. a) How can you estimate refrigeration load in a cold storage ?

b) Delicious apples of 70 mm dia and 85% water content initially at uniform temperature of 30°C are to be cooled by refrigerated air at –5°C flowing at a velocity of 1·5 m/s. The average heat transfer coefficient between the apples and the air is 21 w/m^2 °C. Determine how long it will take for the centre temperature of apples to drop to 6°C. Also determine if any part of the apples will freeze during this process.

Thermal conductivity of apples = 0·418 w/m °C

Thermal diffusivity of apples = $0 \cdot 13 \times 10^{-6}$ m^2/s

Given, $1/B_i = 0 \cdot 57$, $Y = 0 \cdot 314$, $F_o = 0 \cdot 46$.

c) The browning reaction in milk has been shown to have a Q10 value of 1·5. If the product is processed at 285°F and 260°F to an F_o^{22} of 15 in the holding tube of an aseptic canning system, compare the extent of formation of brown pigments between the products processed at these two temperatures. 5 + 5 + 5

12. a) It is wished to freeze 15 tonnes of fish per day from an initial temperature of 10°C to a final temperature of –8°C using a stream of cold air. Estimate the maximum capacity of the refrigeration plant required, if it is

assumed that the maximum rate of heat extraction from the product is twice the average rate. If the heat transfer coefficient from air to evaporator coils, which form the heat exchanger between air and boiling refrigerant is 22 J/m^2 s °C. Calculate the surface area of evaporator coil required if the logarithmic mean temperature drop across the coil is 12°C.

b) To meet the requirements, calculate the speed at which it would be necessary to run a six cylinder reciprocating ammonia compressor with each cylinder having a 10 cm bore diameter and 12 cm stroke (length of the piston travel), assuming the volumetric efficiency of 80% and the evaporating temperature of the boiling refrigerant needed is –15°C.

Given the heat extracted by ammonia at its boiling temperature 1·11 MJ/kg.

Given, specific volume of refrigerant 0·49 m^3/kg.

C_p of fish = 3·18 kJ/kg °C above freezing and 1·67 kJ/kg °C below freezing and the latent heat is 276 kJ/kg. 8 + 7

13. a) What are the different types of flows in an extruder barrel ? Show it diagrammatically.

b) What will be flow profile in an extruder in screw and die combined operation ?

c) What are the bases of extruder scale up ? 5 + 5 + 5

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