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CHEMICAL ENGINEERING REFRESHER COURSE

UNIT OPERATION 1 PART 1

1. One mole each of A and B produces together one mole each of D and U in separate parallel non-elementary reactions. The reaction order of A to produce D is greater than its reaction order to produce U while the reaction order of B to produce U is greater than its reaction order to produce D. If D is the desired product, which of the following is the best configuration of reactor to increase the selectivity?
    a. high concentration of A at inlet with multiple side entries of B in PFR
    b. high concentrations of A and B at inlet in PFR
    c. low concentrations of A and B at start of CSTR
    d. high concentration of B and low concentration of A at start of CSTR

2. What makes the integral method different from the differential method of analyzing kinetic data?
    a. It is more useful in more complicated situations but requires more accurate data
    b. The rate expression is tested whether it fits to the data directly
    c. A particular form of the equation is guessed and predicts that the plot results in a straight line
    d. It is more difficult to use

3. Which of the following is true regarding Thiele modulus of porous catalyst pellets?
    a. Small values of the Thiele modulus indicate that the surface reaction is rapid and that the reactant is consumed very close to the external pellet surface and very little penetrates into the interior of the pellet
    b. The reaction rate is small compared to the diffusion rate for large Thiele modulus values
    c. The surface reaction is rate-limiting if Thiele modulus is large
    d. Internal diffusion limits the overall reaction when Thiele modulus is large

4. Which of the following continuous filters cannot be used if the cake growth rate is relatively slow?
    a. bottom-fed drum
    b. disc
    c. pan
    d. top-fed drum

5. Which of the following cannot form highly permeable filter cake in which flocs may be trapped?
    a. perlite
    b. diatomaceous earth
    c. ground wood pulp
    d. anatase

6. A slurry containing 40% wt solid is to be filtered on a rotary drum filter 2 m diameter and 2 m long, which operates with 40% of its surface immersed in the slurry and under a pressure of 17 kPa. A laboratory test on a sample of the slurry using a leaf filter of area 200 cm^2 and covered with a similar cloth to that on the drum produced 300 cm^3 of filtrate in the first 60 s and 140 cm^3 in the next 60 s when the leaf was under an absolute pressure of 17 kPa. The bulk density of the dry cake was 1500 kg/m^3 and the density of the filtrate was 1000 kg/m^3. The minimum thickness of cake which could be readily removed from the cloth was 5 mm. At what speed should the drum rotate for maximum throughput?
   a. 67.3 Hz
   b. 0.015 Hz
   c. 3.14 Hz
   d. 0.28 Hz

7. Which of the following flow meters can be used for slurries with a pressure of 1000 psig?
   a. Coriolis
   b. pitot
   c. ultrasonic doppler
   d. electromagnetic

Problems 8 and 9 are based on the following information:

A square-edged circular orifice with corner taps equipped is used to measure the flow rate of water at 15 °C through a 5 cm-diameter horizontal pipe. The diameter of the orifice is 3 cm, and the measured pressure drop is 0.111 kPa.

8. If the expansion factor is just 1, what is the discharge coefficient of the orifice?
   a. 0.86
   b. 0.66
   c. 0.68
   d. 0.58

9. Determine the average velocity through the pipe in m/s.
   a. 0.120
   b. 0.150
   c. 0.210
   d. 0.510

Problems 10 and 12 are based on the following information:

Your task is to select a plate exchanger from suppliers designed to cool 100,000 kg/hr of methanol from 95 °C to 40 °C with duty of 4,340 kW using brackish water. Cooling water inlet temperature is at 25 °C and outlet temperature at 40 °C. Flow rates of methanol and water are 27.8 and 68.9 kg/s, respectively. Titanium plates are specified to resist corrosion. The logarithmic mean temperature difference is 31 K with a correction factor of 0.96. The overall coefficient for light-organic water of 2,000 W/m-K.

10. What is the required total heat transfer area in m2?
    a. 70.79
    b. 72.92
    c. 79.29
    d. 76.22

11. Selecting an effective plate area of 0.75 m^2, length of 1.5 m, width of 0.50 m, plate spacing at 3 mm, and number of passes of 48; what is the channel velocity of methanol in m/s?
    a. 0.51
    b. 0.61
    c. 0.16
    d. 0.45

12. What is the channel velocity of brackish water in m/s?
    a. 1.06
    b. 0.69
    c. 0.88
    d. 0.96

Problems 13 and 15 are based on the following information:

A flat slab of rubber 1-in thick at an initial temperature of 70 °F is placed between two heated steel plates maintained at 280 °F. The heating is discontinued when the temperature at the midplane of the slab reaches 270 °F. The thermal conductivity of rubber is 0.092 BTU/h-ft-F° and thermal diffusivity of 0.0029 ft^2/hr, respectively. In the Gurney and Lurie chart, the Fourier number is X = 1.35.

13. How many hours is the heating period time?
    a. 1.80
    b. 0.18
    c. 0.81
    d. 8.10

14. What is the temperature in °F of the rubber if it is 0.25 in from the metal at the end of the run?
    a. 247.0
    b. 270.4
    c. 240.7
    d. 274.0

15. How long will it take in hours for the rubber to reach a temperature of 270 °F?
    a. 0.596
    b. 0.469
    c. 0.964
    d. 0.694

16. A basket-type short-tube vertical evaporator has 4-ft long steel tubes with an outside diameter of 2 in and wall gauge of 12. Its liquid level is maintained at the top tube sheet. Estimate the overall heat transfer coefficient in BTU/ft^2-hr-F°
    a. 525
    b. 505
    c. 495
    d. 545

17. A laboratory short-tube vertical evaporator with 1.75-in by 24-in tubes is used to boil sugar juices at 57°C with a temperature difference of 20 R°. Estimate the overall heat transfer coefficient in BTU/ft^2-hr-F° if the solution has a viscosity of 3.0 cP
    a. 500
    b. 400
    c. 550
    d. 450

Problems 18 and 20 are based on the following information:

4 kg/s of a liquor containing 10% wt solids is fed at 294 K to the first effect of a triple-effect unit. Liquor with 50% wt solids is to be withdrawn from the third effect, which is at a pressure of 13 kN/m^2. The liquor may be assumed to have a specific heat of 4.18 kJ/kg K and to have no boiling point rise. Saturated dry steam at 205 kN/m^2 is fed to the heating element of the first effect and the condensate is removed at the steam temperature in each effect. The three units are to have equal areas with heat transfer coefficients of 3.1, 2.0 and 1.1 kW/m^2-K for the first, second, and third effects, respectively.

18. What is the heat transfer surface area in m^2 of the first effect?
    a. 64.25
    b. 68.75
    c. 71.50
    d. 74.00

19. What is the temperature difference in the second effect?
    a. 69.96 K
    b. 34.57 K
    c. 18.06 K
    d. 17.32

20. What is the steam economy of the multi-effect system?
    a. 2.0
    b. 3.0
    c. 1.5
    d. 2.5

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