University of Baghdad - College of Engineering
Chemical Engineering Department
Ph. D. Entry Examination

Reactor Design

September, 2014

Q1: A human being (75 kg) consumes about 6000 kJ of food per day. Assume that the food is all glucose and that the overall reaction is

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \qquad -\Delta H_r = 2816 \text{ kJ}$$

If the average "human" density is 1000 kg/m^3, then the metabolic rate (the rate of living, loving, and laughing) in terms of moles of oxygen used per m^3 of person per second is:

1. $-r_{O2}$= 0.002
2. $-r_{O2}$= 2.13
3. $-r_{O2}$= 159.8
4. $-r_{O2}$= 209.3

Q2: Milk I pasteurized if it is heated to 63 °C for 30 minutes, but if it is heated to 74 °C it only needs 15 seconds for the same results. Then the activation energy of the sterilization process is:

1. 422 kJ/mole
2. 138 kJ/mole
3. 73 kJ/mole
4. 18 kJ/mole

Q3: It is favor to get the best product distribution for the parallel reactions that the desired product has the lowest reaction order:

1. Keep C_A high.
2. Keep C_A low.
3. Use recycle for the reactor.
4. None of the above!

Q4: A designer made some calculation mistakes by ignoring the fractional change of volume in certain first order gas reaction (which equal to 1.7). What is your prediction for the conversion of the limiting reactant (x_A) that flow out from this reactor?

1. Conversion increasing.
2. Conversion decreasing.
3. Conversion did not affected.
4. Reactor never works!

Q5: Explain briefly the effect of the contacting patterns on the product distribution of decomposition of A through parallel reactions into desired product (R) and undesired product (S).

Q6: The activation energies of two reactions (1 and 2) are $E_1=E_2/10$. This means that:

1. Rate 1 is more affected by temperature.
2. Rate 2 is more affected by temperature.
3. Rate 1 is larger ten times than rate 2.
4. None of the above!

Q7: In quantitative analysis of a certain reaction ($A \rightarrow R$), instantaneous fractional yield of R can be defined as:

1. Moles of R formed/reacted moles of A.
2. Moles of R formed/final moles of A only.
3. Moles of R formed/initial moles of A only.
4. Moles of R formed/final moles of A+R.

Q8: The favorable contacting pattern for reactions in series that gives maximum amount of intermediate component is:

1. Mixed flow reactor.
2. Plug flow reactor with high recycle ratio.
3. Plug flow reactor and batch.
4. Maximum amount of intermediate component does not affected by reactor type.

Fluid Flow PhD

Q.1 Select the right answer for the followings:

1. At high Reynolds number

a. viscous forces predominate.

b. inertial forces are unimportant and viscous forces control.

c. inertial forces control and viscous forces are unimportant.

d. none of these.

2. The fluid property, due to which, mercury does not wet the glass is

a. viscosity b. adhesion c. surface tension d. cohesion

3. The velocity profile for laminar flow of a viscous fluid in a cylinder, where μ is the coefficient of viscosity, dp/dx is the pressure gradient in the axial direction, r is the radial distance from the axis and a is the radius of the cylinder, is of the form

a. $u = \frac{1}{4\mu}\frac{dp}{dx}(a-r)^2$ b. $u = \frac{1}{4\mu}\frac{dp}{dx}r(a-r)$ c. $u = \frac{1}{4\mu}\frac{dp}{dx}(a^2-r^2)$

4. Mass velocity is independent of temperature & pressure, when the flow is

a. unsteady through unchanged cross-section.

b. steady through changing cross-section.

c. steady and the cross-section is unchanged.

d. unsteady and the cross-section is changed.

5. The flow of a liquid through tapering pipe at a constant rate is an example of __________ flow.

a. steady uniform b. steady non uniform

c. unsteady uniform d. unsteady non uniform

6. If in a flow field, between any two points, then the flow must be

a. steady, incompressible, irrotational. b. steady, compressible, irrotational.

c. steady, compressible and along a streamline. d. unsteady, incompressible, irrotational.

7. Forces acting on a particle settling in fluid are __________ forces.

a. gravitational & buoyant. b. centrifugal & drag.

c. gravitational or centrifugal buoyant drag. d. external, drag & viscous.

8. Navier-Stokes equation is useful in the analysis of __________ fluid flow problems.

a. non-viscous b. viscous c. turbulent d. rotational

9. The distribution of shear stress in a stream of fluid in a circular tube is

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Chemical Engineering Department

Ph.D. Qualifying Examination

Subject: Modeling

Examiner: Dr.Hasan F. Makki

Date : 07/09/ 2014

Q.1 Answer the following with examples:

a. What is the difference between "Macro" and "Micro" Models?

b. Define "lumped Model".

c. Briefly explain "Finite difference calculus".

d. Compare between "linear" and "Non-linear" differential equations.

e. What is $\pounds\,(t+1)^2$

Q.2

A glass tube of cross sectional (S) is filled with volatile liquid to a certain level. The level is kept constant. Its open end is subjected to a stream of air.

1) Find the equation describing the rate of diffusion.
2) Solve the equation above with suggested boundary conditions.

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Ph.D. Qualifying Examination

Subject: Mass Transfer

Examiner: Dr. Wadood T. Mohammed

Date : 07/09/ 2014

Q1: Answer the following:

1) Mass transfer rate between two fluid phases does not necessarily depends on the ___________ of the two phases.
   a. Chemical properties.
   b. Physical properties.
   c. Degree of turbulence.
   d. Interfacial area.

2) Which of the following is the most suitable for extraction in a system having very low density difference?
   a. Mixer – settler extractor.
   b. Centrifugal extractor.
   c. Pulsed extractor.
   d. Packed extraction tower.

3) 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.

4) The mass diffusivity, the thermal diffusivity and the eddy momentum diffusivity are same for $N_{Pr} = N_{Sc} =$ _____.
   a. 1.
   b. 0.50.
   c. 10.
   d. Zero.

5) Which of the following plays an important role in problems of simultaneous heat and mass transfer?
   a. Lewis number.
   b. Schmidt number.
   c. Prandtl number.
   d. Sherwood number.

6) Physical Absorption is___________.
   a. An irreversible phenomenon.
   b. A reversible phenomenon.
   c. Accompanied by evolution of heat.
   d. Both B and C .

Q2) A gas is being transferred across a stagnant air film at a total pressure of 100 kN/m^2 .The partial pressure of the gas is 40 kPa at one boundary of the film and 10 kPa at the other. If the partial pressures remain constant, calculate the total pressure to double the transfer rate of the gas.

5 The value of the overall heat transfer coefficient depends on:
a. The mechanism by which heat is transferred, and the properties of materials through which heat must pass.
b. The mechanism by which heat is transferred, dynamics of both heated and cooled fluids and the properties of materials through which heat must pass.
c. Neither of the above.

6 Heat is transferred from one fluid stream to another across a heat transfer surface. If the film coefficients for the two fluids are, 1.0 and 1.5 k?W/m^{2}K, the metal is 6 mm thick, thermal conductivity is 20 W/mK and the scale coefficient is 850 W/m^{2}K, the overall heat transfer coefficient
a. 0.318 W/m^{2}K
b. 300 W/m^{2}K
c. 318 kW/m^{2}K

7 By dimensional analysis, derive a relationship for the heat transfer coefficient h for natural convection between a surface and a fluid on the assumption that the coefficient is a function of: thermal conductivity of fluid, specific heat of fluid, density of fluid, viscosity of fluid, temperature difference between fluid and surface, a characteristic dimension of the surface and (βg) the product of acceleration and coefficient of cubical expansion of fluid with dimension of $L/T^2\ \theta^{-1}$.

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Heat Transfer

1 The basic differential equation for the unidirectional flow of heat in a continuous medium is:

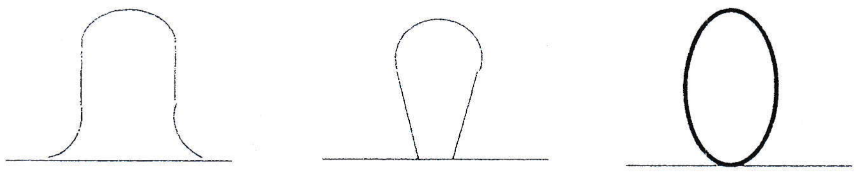
a. $\dfrac{\partial \theta}{\partial t} = D_H \dfrac{\partial^2 \theta}{\partial x^2}.$

b. $\dfrac{\partial \theta}{\partial t} = D_H \left(\dfrac{\partial^2 \theta}{\partial x^2} + \dfrac{\partial^2 \theta}{\partial y^2} + \dfrac{\partial^2 \theta}{\partial z^2}\right).$

c. $\dfrac{\partial \theta}{\partial t} = \dfrac{\partial^2 \theta}{\partial x^2}.$

2 If a vapour contains a proportion of non-condensable gas is cooled below its point;
a. A layer of condensate is formed on the surface with mixture of the non-condensable gas and vapour above it and the heat flow from vapour to surface is done only by sensible heat.
b. No heat flow occurs.
c. A layer of condensate is formed on the surface with mixture of the non-condensable gas and vapour above it and the heat flow from vapour to surface is done only by sensible heat and latent heat of condensing vapour bubbles.

3 In the figure given, the shapes of the bubble formed due to boiling:



(1) (2) (3)

a. (1) Non-wettable surface (2) Entirely wetted surface (3) Partially wettable surface
b. (1) Non-wettable surface (2) Partially wettable surface (3) Entirely wetted surface
c. (1) Partially wettable surface (2) Entirely wetted surface (3) Non-wettable surface

4 A 6 m long horizontal steam pipe of 50 mm internal diameter and 60 mm is carrying steam at 443 K, the temperature of atmosphere and surroundings is 290 K , the convective heat transfer coefficient = 1.64 W/m^{2}K and the emissivity of the pipe = 0.85. The rate of heat loss equals to:
a. 2712 W.
b. 3000 W
c. 2712 kW.

Thermodynamics

1 For a closed system undergoing same change in state by several processes, experiments showed that:

a. Q + W is the same for all processes.

b. Q + Δu is the same for all processes.

c. ΔU + W is the same for all processes.

2 Work is zero if:

a. Process occurs at constant pressure.

b. Process occurs at constant temperature.

c. Process occurs at constant volume.

3 A reversible process:

a. Is frictionless and can be reversed at any point by a differential change in the external conditions.

b. Needs forces in differential magnitude.

c. When reversed, it restores the initial state of system and surroundings.

d. All of the above.

4 When different phases are present at the same temperature and pressure:

a. The magnitude of chemical potential varies depending on their quantities.

b. The magnitude of their enthalpies are equal.

c. The magnitude of chemical potential are equal for all the phases.

5 The partial molar property of species I can be represented by:

a. $\overline{M_\iota} = \left[\frac{\partial(nM)}{\partial ni}\right]_{P,T,nj}$

b. $\overline{M_\iota} = \left[\frac{\partial(nM)}{\partial ni}\right]_{T,nj}$

c. Neither of the above.

6 For an ideal solution:

a. $G^{id} = \sum_i x_i G_i + RT\sum_i x_i \ln x_i$ and $S^{id} = \sum_i x_i S_i - R\sum_i x_i \ln x_i$

b. $G^{id} = \sum_i x_i G_i + RT\sum_i x_i \ln x_i$

c. $G^{id} = \sum_i x_i G_i + RT\sum_i x_i \ln x_i$, a. $S^{id} = \sum_i x_i S_i - R\sum_i x_i \ln x_i$, $V^{id} = \sum_i x_i V$ and $H^{id} = \sum_i x_i H_i$

7 Draw the P-V diagram for a Carnot cycle with the necessary notations.