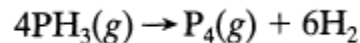**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**
DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER EXAMINATIONS – APRIL 2009
REACTOR TECHNOLOGY – SCH 4208
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

Answer **four** questions only. Total marks are 100.

$R = 82.06$ atm cm^{3}gmol^{-1} K^{-1}. also $R = 8.314$Jmol^{-1}K^{-1}

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1.   (a)   The homogeneous gas decomposition of phosphine;

$$4PH_3(g) \rightarrow P_4(g) + 6H_2$$

proceeds at 649°C with the first-order rate;

$$-r_{PH_3} = (10/hr)\, C_{PH_3}$$

What size of plug flow reactor operating at 649°C and 460 kPa can produce 80% conversion of a feed consisting of 40 mol of pure phosphine per hour?
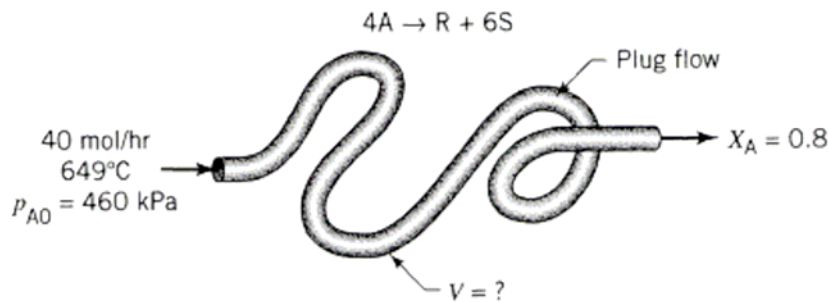
Figure E5.5

(10 marks)

   (b)   Milk is pasteurized if it is heated to 63°C for 24min, but if it is heated to 74°C it only needs 12s for the same result. Find the activation energy of this sterilization process. $R = 8.314$J/mol.K

(10 marks)

   (c)   What type of reactor is preferred if the rate of heat of evolution is very high, support your answer.

(5 marks)

2. (a) Continuous stirred tank reactor and a plug flow reactor are two types of continuous flow reactors. Discuss the advantages and limitations of each type of reactor.

(8 marks)

(b) With reference to gas-solid non-catalytic reactors, discuss:

(i) The shrinking core reaction model   (7 marks)

(ii) Progressive conversion reaction model.   (7 marks)

(c) State the three types of information needed to predict what a reactor can do.

(3 marks)

3. (a) Consider a feed $C_{Ao} = 100$, $C_{Bo} = 200$, $C_{io} = 100$ to a steady-flow reactor. The isothermal gas-phase reaction is:

A + 3B → 6R

$\varepsilon_B = (\varepsilon_A C_{Bo})/(bC_{Ao})$

If $C_A = 40$ at the reactor exit, what is C_B, X_A and X_B there?

(10 marks)

(b) What is the advantages and disadvantages of a Batch Reactor.

(10 marks)

4. (a) 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

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

from air   breathed out

Find man's metabolic rate (the rate of living, loving, and laughing) in terms of moles of oxygen used per m^3 of person per second.

(10 marks)

(b) Consumption of reactants to give unwanted and unmarketable byproducts is wasteful and affects negatively the operating expenses of a chemical production process. Using suitable examples where possible, explain why it is of utmost importance to ascertain the exact nature and amount of byproducts formed in a reaction when designing a reactor.

(10 marks)

(c) State and explain the three reasons why a semi-batch reactor may be a suitable choice for a chemical reactor.   (5 marks)

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5. (a) Explain two complicating factors that must be accounted for in heterogeneous non-catalytic systems but not considered in homogeneous systems.

(10 marks)

(b) (i) Name and explain any two Industrial Reactions in which the solid does not appreciably change in size during reaction.

(6 marks)

(ii) Name and explain two Industrial Reactions in which the solid change in size during reaction.

(6 marks)

(c) State the material balance of an ideal batch reactor for an element volume of the reactor. (3 marks)

END OF QUESTION PAPER!!!