Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, Dec 2019

Programme Name: B.Tech. CERP **Semester : V**
Course Name : Chemical Reaction Engineering I **Time : 03 hrs**
Course Code : CHCE3004 **Max. Marks: 100**
Nos. of page(s) : 02

Instructions: (i) This question paper has three sections- A, B and C. All questions of each section are compulsory. (iii) Attempt all the sub-parts of a question together.

SECTION A (20 Marks)

<table>
<tr><td>S. No.</td><td></td><td>Marks</td><td>CO</td></tr>
<tr><td>Q 1</td><td>The half-life periods for decomposition of PH_3 for different initial pressures are given below
Find out the order of reaction.
<table>
<tr><td>P,torr</td><td>707</td><td>79</td><td>37.5</td></tr>
<tr><td>t1/2, min</td><td>84</td><td>84</td><td>84</td></tr>
</table></td><td>5</td><td>CO5</td></tr>
<tr><td>Q 2</td><td>Define space time and space velocity.</td><td>5</td><td>CO4</td></tr>
<tr><td>Q 3</td><td>The pyrolysis of ethane proceeds with an activation energy of about 300 KJ/mol. How much faster is the decomposition at 650^{o}C than 500^{o}C.</td><td>5</td><td>CO5</td></tr>
<tr><td>Q 4</td><td>Substance 'A' in liquid reacts to produce R and S as follows:
A → R (First Order)
A → S (First Order)
A feed (C_{Ao} = 2, C_{Ro}= 0, C_{So}= 0) enters in two mixed flow reactors in series (τ_1= 2.5 min, τ_2= 5 min) knowing the composition in the first reactor (C_{A1}= 0.8, C_{R1}= 0.8, C_{S1}= 0.4). find the composition leaving the second reactor.</td><td>5</td><td>CO3</td></tr>
<tr><td colspan="4">SECTION B (60 Marks)</td></tr>
<tr><td>Q 5</td><td>The irreversible gas phase reaction A+B → C is to be carried out at 10 atm and 227 oC. In a reactor chain consist of A MFR and PFR. It is required to process 1 lt of feed per second. The feed contains 41 mole % A, 41 mole % B and 18 mole % inerts by volume. The rate of reaction in mol/(1.min) as a function of conversion is as follows:
<table>
<tr><td>$-r_{A}$, mol/lit</td><td>0.2</td><td>0.0167</td><td>0.00488</td><td>0.00286</td><td>0.00204</td></tr>
<tr><td>X_A</td><td>0</td><td>0.1</td><td>0.4</td><td>0.7</td><td>0.9</td></tr>
</table>
Calculate size of MFR and PFR required to achieve X_{A1}= 0.47 as a intermediate conversion (from reactor 1) and X_{A2}= 0.8 as final conversion. Suggest best arrangement.</td><td>12</td><td>CO4</td></tr>
</table>

<table>
<tr><td>Q 6</td><td>The reaction between H_2(gas) and I(gas) to produce HI(gas) proceeds with a rate
$$\frac{1}{2}\frac{d[HI]}{dt} = K[H_2]\,[I]^2$$
Suggest a two-step mechanism which is consistent with this rate.</td><td>12</td><td>CO 5</td></tr>
<tr><td>Q 7</td><td>Derive an integrated rate expression for third order reaction of the type 2A +B → products.</td><td>12</td><td>CO 2</td></tr>
<tr><td>Q 8</td><td>The decomposition of pure NH3 on tungsten wire at 856ºC gave the following results:
<table>
<tr><td>Total Pressure (mm of Hg)</td><td>228</td><td>250</td><td>273</td><td>318</td></tr>
<tr><td>Time (Sec)</td><td>200</td><td>400</td><td>600</td><td>1000</td></tr>
</table>
Determine the order of the reaction and calculate its rate constant in terms of moles, litres and seconds.</td><td>12</td><td>CO 5</td></tr>
<tr><td>Q 9</td><td>Find the first order reaction rate constant k, (referred to A) of the gas reaction 2A→ P, if by keeping the pressure constant, the volume of the reaction mixture, starting with 80 mole% A and 20 mole % inerts, decreases by 20 %in 3 min.</td><td>12</td><td>CO1</td></tr>
<tr><td colspan="4">SECTION-C (20 Marks)</td></tr>
<tr><td>Q 10</td><td>(a). Derive the design equation of ideal plug flow reactor from fundamentals, clearly stating the assumptions made.
(b). Substance ‘A’ reacts according to second order kinetics and conversion is 95% from a single flow reactor. We buy a second unit identical to the first for the same degree of conversion by how much is the capacity increased if we operate these two units in series:
(i) The reactors are both Plug Flow.
(ii) the reactors are both mixed flow.</td><td>20</td><td>CO4</td></tr>
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