The irreversible gas-phase nonelementary reaction

\[ A + 2B \rightarrow C \]

is to be carried out isothermally in a constant-pressure batch reactor. The feed is at a temperature of 227°C, a pressure of 1013 kPa, and its composition is 33.3% A and 66.7% B. Laboratory data taken under identical conditions are as follows (note that at \( X = 0 \), \( -r_A = 0.00001 \)):

<table>
<thead>
<tr>
<th>( X )</th>
<th>0.010</th>
<th>0.005</th>
<th>0.002</th>
<th>0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_A ) (mol/dm(^3)·s) \times 10^3</td>
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</tbody>
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(a) Estimate the volume of a plug-flow reactor required to achieve 30% conversion of A for an entering volumetric flow rate of 2 m\(^3\)/min.

(b) Estimate the volume of a CSTR required to take the effluent from the plug-flow reactor (PFR) above and achieve 50% total conversion (based on species A fed to the PFR).

(c) What is the total volume of the two reactors?

(d) What is the volume of a single plug-flow reactor necessary to achieve 60% conversion? 80% conversion?

(e) What is the volume of a single CSTR necessary to achieve 50% conversion?

(f) What is the volume of a second CSTR necessary to raise the conversion from 50% to 60%?

(g) Plot the rate of reaction and conversion as a function of PFR volume.

(h) Give a critique of the answers to this problem.