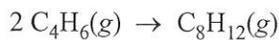
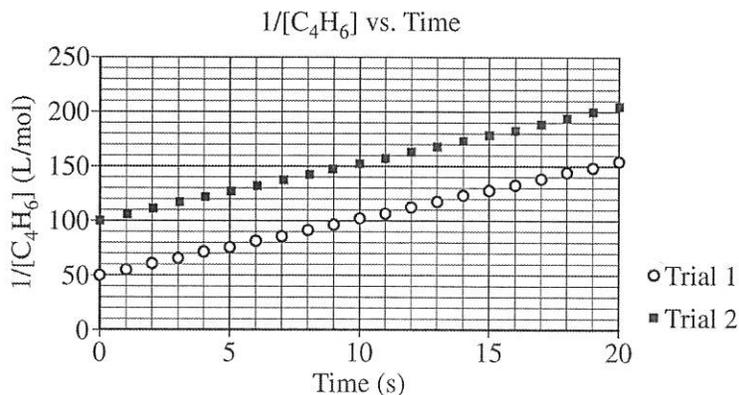
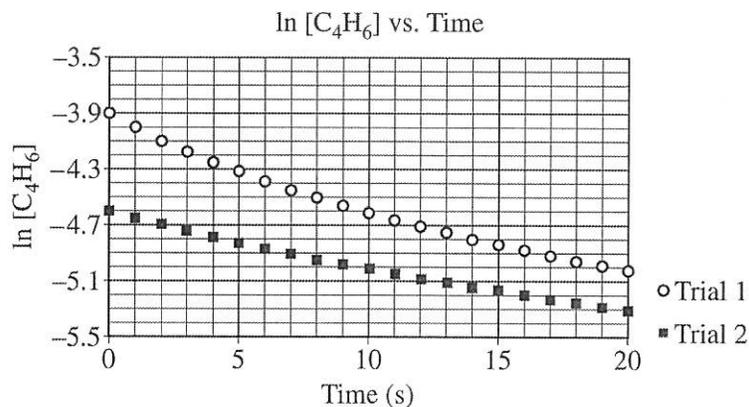
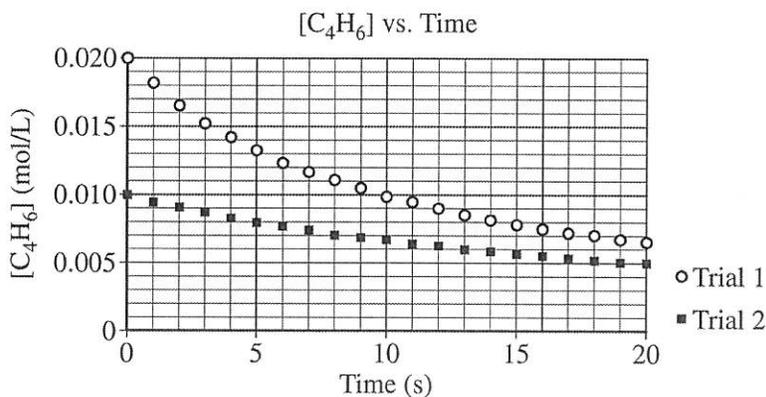


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**Question 5**



At high temperatures the compound  $\text{C}_4\text{H}_6$  (1,3-butadiene) reacts according to the equation above. The rate of the reaction was studied at 625 K in a rigid reaction vessel. Two different trials, each with a different starting concentration, were carried out. The data were plotted in three different ways, as shown below.



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**Question 5 (continued)**

- (a) For trial 1, calculate the initial pressure, in atm, in the vessel at 625 K. Assume that initially all the gas present in the vessel is C<sub>4</sub>H<sub>6</sub>.

<p>For trial 1, <math>\frac{n}{V} = 0.020 \text{ mol/L}</math> (or assume the volume of the vessel is 1.0 L; the number of moles of C<sub>4</sub>H<sub>6</sub> in the vessel would then be 0.020 mol).</p> <p><math>PV = nRT</math></p> <p><math>P = \frac{nRT}{V} = \frac{(0.020 \text{ mol})(0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1})(625 \text{ K})}{1.0 \text{ L}} = 1.0 \text{ atm}</math></p>	<p>1 point is earned for a correct setup.</p> <p>1 point is earned for the correct answer.</p>
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- (b) Use the data plotted in the graphs to determine the order of the reaction with respect to C<sub>4</sub>H<sub>6</sub>.

Second order (because the plot of $1/[C_4H_6]$ is a straight line).	1 point is earned for the correct order.
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- (c) The initial rate of the reaction in trial 1 is 0.0010 mol/(L·s). Calculate the rate constant,  $k$ , for the reaction at 625 K.

<p>From the second-order rate law (differential form): <math>\text{rate} = k[C_4H_6]^2</math></p> <p><math>\Rightarrow k = \frac{\text{rate}}{[C_4H_6]^2} = \frac{0.0010 \text{ mol}/(\text{L}\cdot\text{s})}{(0.020 \text{ mol/L})^2} = 2.5 \text{ L}/(\text{mol}\cdot\text{s})</math></p> <p>OR</p> <p>From the second-order rate law (integrated form):</p> $\frac{1}{[C_4H_6]_t} = 2kt + \frac{1}{[C_4H_6]_0}$ <p>The coefficient of <math>t</math> is equal to <math>2k</math> because of the reaction stoichiometry.</p> <p>The slope of the line in the plot of <math>\frac{1}{[C_4H_6]}</math> versus time is <math>2k</math>.</p> <p>Thus slope = <math>5.0 \text{ L}/(\text{mol}\cdot\text{s}) = 2k</math>, therefore <math>k = 2.5 \text{ L}/(\text{mol}\cdot\text{s})</math>.</p> <p><u>Note:</u> Students who choose the second method of determining <math>k</math> but omit the factor of 2, thereby getting an answer of <math>5.0 \text{ L}/(\text{mol}\cdot\text{s})</math>, still earn the point.</p>	<p>1 point is earned for the correct value.</p>
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