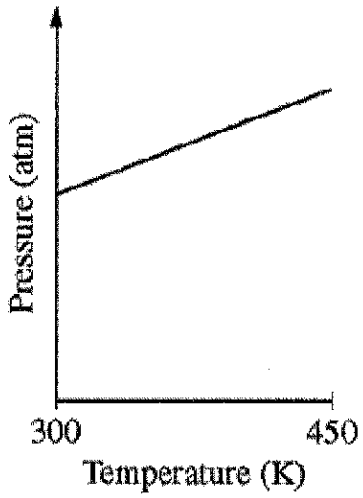
~~42~~ 49 #4

Unit 5: AP Free Response Practice ~~#3~~ [2013 #5, 8 points]

3. A sample of $C_2H_4(g)$ is placed in a previously evacuated, rigid 2.0 L container and heated from 300 K to 450 K. The pressure of the sample is measured and plotted in the graph below.



a. Describe TWO reasons why the pressure changes as the temperature of the C2H4(g) increases. Your descriptions must be in terms of what occurs at the molecular level. [2 points]

C_2H_4 ✓

$C_2H_4(g)$ reacts readily with HCl(g) to produce C2H5Cl(g), as represented by the following equation.

$$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g) \qquad \Delta H^\circ = -72.6 \text{ kJ/mol}_{rxn}$$

b. When HCl(g) is injected into the container of $C_2H_4(g)$ at 450 K, the total pressure increases. Then, as the reaction proceeds at 450 K, the total pressure decreases. Explain this decrease in total pressure in terms of what occurs at the molecular level. [1 point]

It is proposed that the formation of $C_2H_5Cl(g)$ proceeds via the following two-step reaction mechanism.

$$\text{Step 1: } C_2H_4(g) + HCl(g) \rightarrow C_2H_5^+(g) + Cl^-(g) \qquad \textit{rate-determining step}$$
$$\text{Step 2: } C_2H_5^+(g) + Cl^-(g) \rightarrow C_2H_5Cl(g) \qquad \textit{fast step}$$

c. Write the rate law for the reaction that is consistent with the reaction mechanism above. [1 point]

d. Identify an intermediate in the reaction mechanism above. [1 point]

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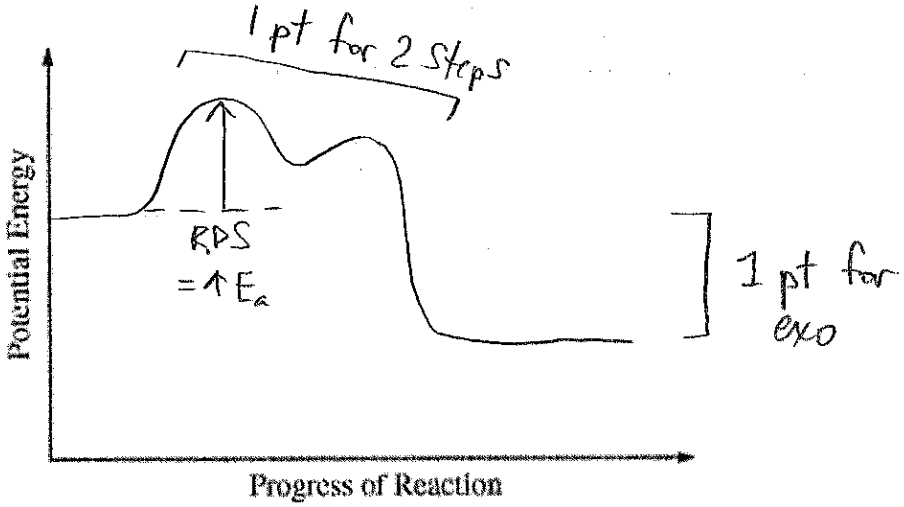
e. Using the axes provided below, draw a curve that shows the energy changes that occur during the progress of the reaction. The curve should illustrate both the proposed two-step mechanism and the enthalpy change of the reaction. [2 points]



f. On the diagram above, clearly indicate the activation energy, E_a, for the rate-determining step in the reaction. [1 point]

(a) #1: ↑T = ↑KE = ↑ speed of particles, which means particles collide more frequently with container walls. (1 pt)

#2: ↑ = ↑KE, which means particles strike the walls of the container w/ greater force. (1 pt)

(b) This rxn produces fewer gas molecules than it consumes (2 mol reactants(g) → 1 mol products(g)). As products are made, fewer gas particles are present, so there are fewer collisions w/ container walls = ↓ P. (1 pt)

(c) rate = $k[C_2H_4][HCl]$ (1 pt) *no explanation required!*

(d) $C_2H_5^+(g)$ or $Cl^-(g)$ (1 pt)