Enzyme inhibition

A carboxypeptidase was found to have a Michaelis constant, K_M, of 2.00 μM and k_{cat} of 150 s^{-1} for its substrate, A.

a) what is the initial rate of reaction for a substrate concentration of 5.00 μM and an enzyme concentration of 0.01 μM? Give units.
b) The presence of 5.00 mM of a competitive inhibitor decreased the initial rate law above by a factor of 2. What is the dissociation constant for the enzyme-inhibitor complex, K_I, where $K_I = [E][I]/[EI]$?

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Solution: For the given data the initial rate is

$$V_0 = \frac{k_{cat}[E]_0[S]}{K_m + [S]} = \frac{(150)[0.01][5]}{2 + [5]} = 1.07\ \mu M s^{-1}$$

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Solution: The initial rate is decreased by a factor of 2. Therefore, $V_0 = 0.535$ mM s^{-1}. To find the K_I we need to solve for α.

$$V_0 = \frac{k_{cat}[E]_0[S]}{\alpha K_m + [S]}$$

Algebra to solve for α:

$$\alpha K_m V_0 + [S]V_0 = k_{cat}[E]_0[S]$$

$$\alpha = \frac{(k_{cat}[E]_0 - V_0)[S]}{K_m V_0}$$

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Now insert the values from the data and calculate α.

$$\alpha = \frac{(k_{cat}[E]_0 - V_0)[S]}{K_m V_0}$$

$$\alpha = \frac{(150(0.01) - 0.535)[5]}{(2)(0.535)} = 4.5$$

Use the definition of α to solve for K_I.

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The definition is:

$$\alpha = 1 + \frac{[I]}{K_I}$$

Finally, K_I is given by:

$$K_I = \frac{[I]}{\alpha - 1} = \frac{[5]}{4.5 - 1} = 1.42\, mM$$