1. Penicillinase is an enzyme that inactivates penicillin. Penicillinase has a molecular weight of 30,000 g/mol, \( k_{\text{cat}} = 2000 \text{ sec}^{-1} \) and \( K_M = 5 \times 10^{-5} \text{ M} \). The inactivation of penicillin by penicillinase follows Michaelis-Menten kinetics.

In response to treatment with \( 2 \times 10^{-5} \text{ M} \) penicillin, bacteria in a 1 mL culture secrete some penicillinase into the culture.

a) The rate of inactivation of penicillin in this culture is found to be \( 1 \times 10^{-5} \text{ M/sec} \). What is the value of \( V_{\text{max}} \) for the penicillinase-catalyzed reaction?

b) What is the concentration of penicillinase in the 1 mL culture?

c) What is the fraction of penicillinase that is bound to penicillin under these conditions?

d) Suppose a drug company has produced an analog of penicillin, \( P^* \), that is also inactivated by penicillinase. Penicillinase has the same \( k_{\text{cat}} \) for the \( P^* \) as it does for regular penicillin, but \( P^* \) binds ten times less well to penicillinase than does penicillin. At a substrate concentration of \( 5 \times 10^{-5} \text{ M} \), will penicillin or \( P^* \) be inactivated more rapidly?
2. Suppose a bare proton comes into contact with an electron. The electron “falls” into the most stable energy state of the newly formed hydrogen atom.

a) If the electron had no energy of its own (kinetic or potential) before it “fell” into the H atom, how much energy is liberated during this process?

b) If the energy liberated in a) is converted to kinetic energy of the newly formed H atom, what will the velocity of the H atom be? (Note: kinetic energy = \( \frac{1}{2} mv^2 \)).

c) Which would have a longer wavelength: the H atom of part b) or an electron that had the same kinetic energy (from part b)? Explain your answer.