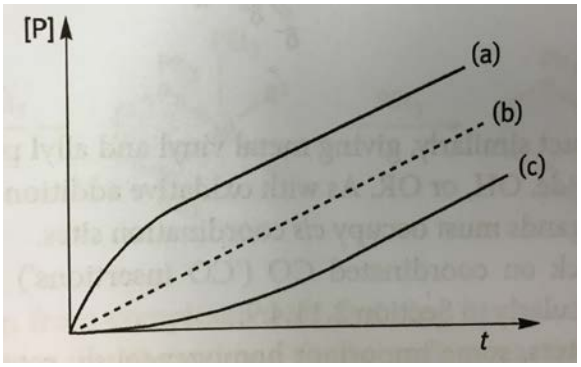
1. A chemical reaction in the presence of a catalyst is 1000 times faster than the uncatalysed reaction. What is the difference in energy barriers in these two cases?

2. Many catalytic reactions have an initiation period, during which the catalyst concentration increases. This reaction phase therefore operates under non-steady-state conditions. It can be shown that in such cases the formation of a product P from a substrate S in the presence of catalyst C follows the rate law:

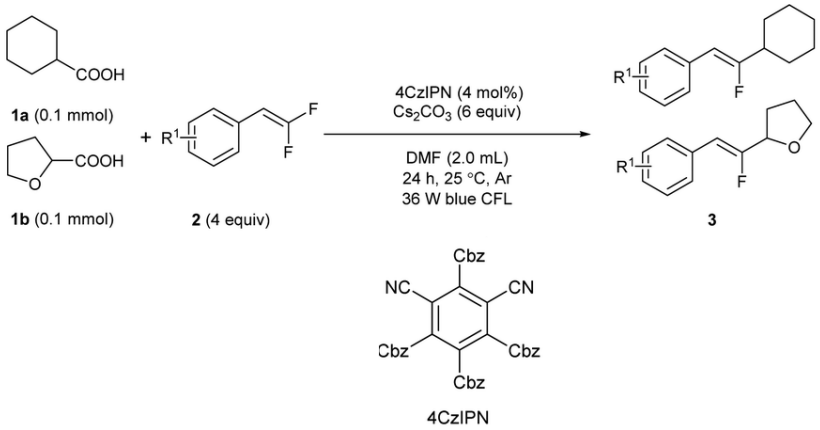
$$\frac{d[P]}{dt} = k_P[S][C] + (k_i - k_P)[S][C]\exp(-k_i[S]t)$$

Three different substrates give the following three conversion vs. time curves. What do these curves tell us concerning the kinetic behavior of the catalyst? In each case, determine the initial and the steady-state slopes of the reactions and identify which information these slopes provide.



3. (a) Hydroformylation of alkenes is usually carried out with rhodium catalysts. However, depending of the choice of ligand, the compound [Pd(PP)(OTf)2] (PP = bis-phosphine ligand) is also a hydroformylation catalyst in the presence of small amounts of an organic acid. Give a likely mechanism for hydroformylation of 1-butene by the catalyst; include electron count and oxidation state of the intermediates and name the reaction steps.
   (b) Depending of the ligands, palladium compounds are also good catalyst for hydrogenation and CO/alkene co-polymerization. Which byproducts ca be formed in the reaction mentioned under (a)?

4. Photoredox catalysis. Consider the reaction below:



Suggest a possible mechanism. Start with a SET to a carboxylate reactant.