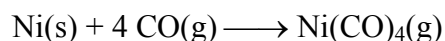


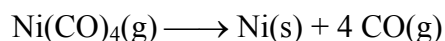
CHEM 111 Challenge Problem Two

The first step in the purification of crude nickel metal is the reaction with carbon monoxide gas.

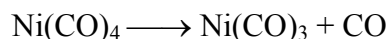


- a) If you have 3.05 g of CO, and you combine it with 1.25 g of nickel metal, what is the maximum quantity of Ni(CO)₄ (in grams) that can be formed?

The pure gaseous nickel carbonyl is easily separated from its solid impurities and then is decomposed in a vacuum at a little above room temperature to give pure nickel.



Kinetic studies* of this first order decomposition reaction have been carried out between 47.3°C and 66.0°C. In hexane solution, the reaction is proposed to occur in four steps, the first of which is:

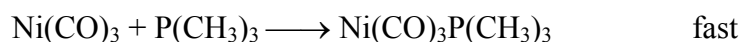


The data in the table below were obtained for this reaction step at different temperatures.

Temperature (°C)	Rate Constant (s ⁻¹)
47.3	0.263
50.7	0.354
54.9	0.606
59.9	1.022
66.0	1.873

- b) Determine the activation energy of this reaction step.

The kinetics[#] of the replacement of CO by another molecule in Ni(CO)₄ was also studied and the following mechanism proposed:



- c) Tell whether each step in the reaction is unimolecular or bimolecular.
d) When the steps of the mechanism are added together, show that the result is the balanced equation of the observed reaction.
e) Is there an intermediate in the reaction? If so, what is its formula?
f) It was found that doubling the concentration of Ni(CO)₄ led to an increase in the reaction rate by a factor of two. Doubling the concentration of P(CH₃)₃ had no effect on the reaction rate. Based on this information write the rate law for the reaction.
g) Does the experimental rate law support the proposed mechanism? Why or why not?

*J. P. Day, F. Basolo, and R.G. Pearson, J. Am. Chem. Soc. 90, 6927 (1968)

[#]J. P. Day, F. Basolo, and R.G. Pearson, J. Am. Chem. Soc. 90, 6943 (1968)