OpenStax: Determination of Activation Energy

Example 12.11 Determination of Ea

The variation of the rate constant with temperature for the decomposition of HI(g) to H_2(g) and I_2(g) is given here.

What is the activation energy for the reaction?

$2HI(g) \longrightarrow H_2(g) + I_2(g)$

T(K)	k (L/mol*s)	1/T (K^{-1})	ln k
555	3.52×10^{-7}	1.80×10^{-3}	−14.860
575	1.22×10^{-6}	1.74×10^{-3}	−13.617
645	8.59×10^{-5}	1.55×10^{-3}	−9.362
700	1.16×10^{-3}	1.43×10^{-3}	−6.759
781	3.95×10^{-2}	1.28×10^{-3}	−3.231

slope = Δ(ln k)/Δ(1/T) = − Ea/R

$Ea = -\text{slope} \times R = -(-2.2 \times 10^4 \text{ K} \times 8.314 \text{ J mol}^{-1} \text{ K}^{-1}) = 1.8 \times 10^5$ J/mol

Or

$Ea = -R\{(\ln k_2 - \ln k_1) / ((1/T_2) - (1/T_1))\}$ = 185,900 J/mol

The rate constant for the rate of decomposition of N_2O_5 to NO and O_2 in the gas phase is 1.66 L/mol*s at 650 K and 7.39 L/mol/s at 700 K:

$2N_2O_5(g) \longrightarrow 4NO(g) + 3O_2(g)$

Assuming the kinetics of this reaction are consistent with the Arrhenius equation, calculate the activation energy for this decomposition.

Answer: 113,000 J/mol

63. Hydrogen iodide, HI, decomposes in the gas phase to produce hydrogen, H_2, and iodine, I_2. The value of the rate constant, k, for the reaction was measured at several different temperatures and the data are shown here:

Temperature (K)	k (M^{-1} s^{-1})	1/T (K^{-1})	ln k
555	6.23 × 10−7		
575	2.42 × 10−6		
645	1.44 × 10−4		
700	2.01 × 10−3		

What is the value of the activation energy (in kJ/mol) for this reaction?

64. The element Co exists in two oxidation states, Co(II) and Co(III), and the ions form many complexes. The rate at which one of the complexes of Co(III) was reduced by Fe(II) in water was measured. Determine the activation energy of the reaction from the following data:

T (K)	k (s^{-1})	1/T (K^{-1})	ln k
293	0.054		
298	0.100		