Chemical Kinetics: Temperature Dependence of Reaction Rates

Chemistry 126

1. The rate constant of a reaction is 0.001 s^{-1} at 298 K with an activation energy of 50 kJ/mol. What is the value of the reaction rate constant at 325 K?

2. The rate constant of a reaction is 0.03 L $mole^{-1}$ s^{-1} at 220 °C and 0.29 L $mole^{-1}$ s^{-1} at 282 °C. What is the activation energy of the reaction?

3. The decomposition of nitrogen dioxide, $2NO_2 \rightarrow 2NO + O_2$, follows the rate equation Reaction Rate = $k[NO_2]^2$ (Bodenstein, M., Z. Phys. Chem., 1922, 100, 106) over a narrow temperature range. a.) Graph the data below in an Arrhenius plot. b.) Deduce the values A and E_a in the Arrhenius equation from your graph.

T/K	k/L mol^{-1} s^{-1}
592.0	0.522
603.2	0.755
627.0	1.70
651.5	4.02
656.0	5.03

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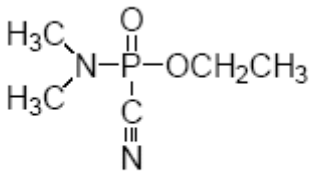
4. Tabun is the first and still one of the most toxic nerve agents ever discovered. (See http://www.emedicine.com/emerg/topic898.htm or http://www.opcw.org/resp/html/nerve.html for more information). First synthesized in 1936 by G. Schrader of I. G. Farben in Germany as a potential pesticide, tabun's biochemistry involves inhibiting the action of acetylcholinesterase, an important enzyme involved in nerve signal transmission. Tabun reacts with water to form hydrocyanic acid (HCN) as a byproduct in a pseudo-first-order reaction. The table below lists the half-life of tabun as a function of temperature in salt-water (Epstein, J.; Rosenblatt, D. H.; Gallacio, A.; McTeague, W. F., *Summary report on a data base for predicting consequences of chemical disposal operations*, EASP 1200-12, January 1973, AD-B955399)



Tabun

T/Celsius	$t_{1/2}$/min.
15	475
20	267
25	175

a.) Calculate the rate constant at each temperature.
b.) Make an Arrhenius plot and determine the activation energy for tabun hydrolysis. (Careful! Check those units!)
c.) Using this information, what is the half-life of tabun in boiling water (at 100 °C)?

5. If the activation energy of a chemical reaction is 75 kJ/mol, how much faster is the ***reaction rate*** at 35 °C than at 25 °C? [HINT: What can you get with Ea and two temperatures?]