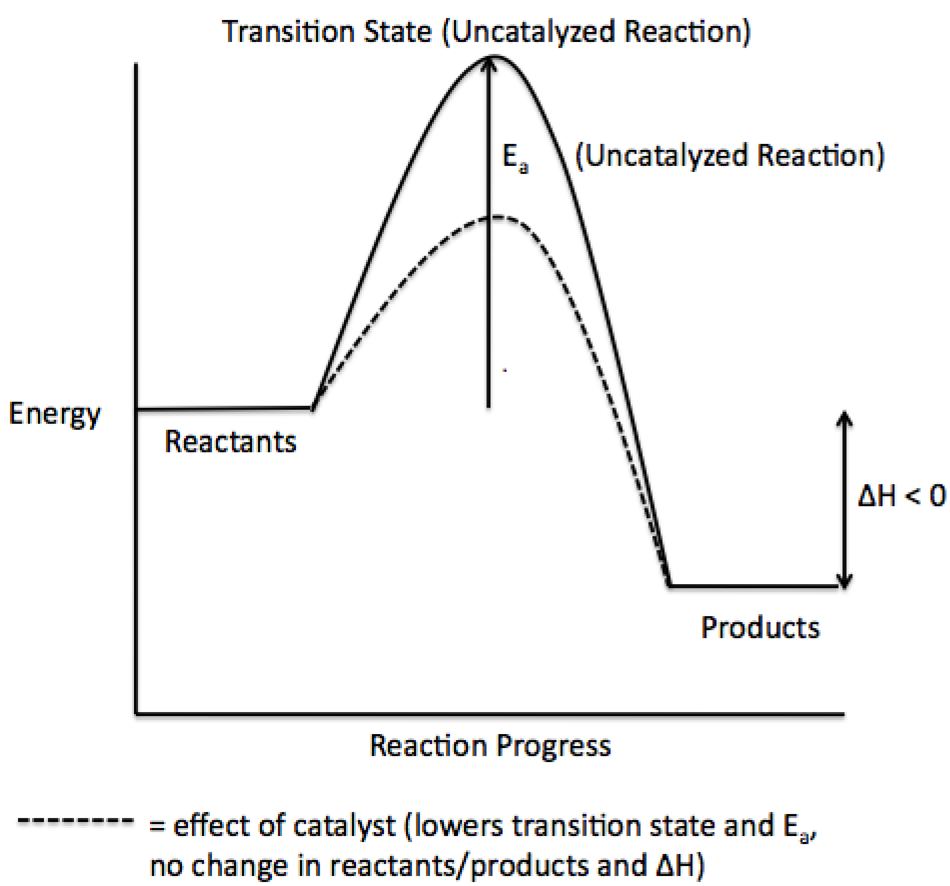
Non Sibi High School

Andover's Chem 550/580: Advanced Chemistry

Chapter 19, Review Quiz 1 Answers

1

Sketch a completely-labeled reaction energy profile (reaction progress diagram) for an exothermic reaction. Indicate any effects a catalyst would have the sketch.



2

The following mechanism has been proposed for a reaction:

Step 1: $NO_2 + NO_2 \longrightarrow NO_3 + NO$

Step 2: $NO_3 + CO \longrightarrow NO_2 + CO_2$

Identify the intermediate and write the overall balanced equation for the reaction.

NO_3 is formed in the first step but then consumed in the second step, so NO_3 is the intermediate that cancels out of the overall balanced equation $NO_2 + CO \longrightarrow NO + CO_2$.

3

If the rate of formation of hydrogen gas in the reaction $4PH_3(g) \longrightarrow 6H_2(g) + P_4(g)$ is found to be 0.0066 $M{\cdot}s^{-1}$, what is the rate of disappearance of PH_3 gas?

$$0.0066\,\mathrm{mol\cdot L^{-1}\cdot s^{-1}}\left(\frac{4\,\mathrm{mol\,PH_3}}{6\,\mathrm{mol\,H_2}}\right) = 0.0044\,\mathrm{mol\cdot L^{-1}\cdot s^{-1}}$$

$$\text{rate of disappearance of } \mathrm{PH_3} = 0.0044\,\mathrm{M\cdot s^{-1}}$$

4

For the reaction $\frac{1}{2}Cl_2(g) + NO(g) \longrightarrow NOCl(g)$, the following data were collected:

Experiment	$[Cl_2]$ (M)	[NO] (M)	Initial Rate ($M{\cdot}min^{-1}$)
1	0.12	0.12	0.0025
2	0.24	0.12	0.0050
3	0.48	0.48	0.16

Determine the overall order of the reaction, write the rate law, and calculate the value of k with units.

$$\mathrm{rate} = \mathrm{k[Cl_2]^x[NO]^y}$$

$$\mathrm{rate_1} = \mathrm{k(0.12\,M)^x(0.12\,M)^y} = 0.0025\,\mathrm{M\cdot min^{-1}}$$

$$\mathrm{rate_2} = \mathrm{k(0.24\,M)^x(0.12\,M)^y} = 0.0050\,\mathrm{M\cdot min^{-1}}$$

$$\mathrm{rate_3} = \mathrm{k(0.48\,M)^x(0.48\,M)^y} = 0.16\,\mathrm{M\cdot min^{-1}}$$

$$\frac{\mathrm{rate_2}}{\mathrm{rate_1}} = \frac{\mathrm{k(0.24\,M)^x(0.12\,M)^y}}{\mathrm{k(0.12\,M)^x(0.12\,M)^y}} = \frac{0.0050\,\mathrm{M\cdot min^{-1}}}{0.0025\,\mathrm{M\cdot min^{-1}}}$$

$$2^x = 2$$

$$x = 1$$

$$\frac{rate_3}{rate_2} = \frac{k(0.48\,M)^1(0.48\,M)^y}{k(0.24\,M)^1(0.12\,M)^y} = \frac{0.16\,M\cdot min^{-1}}{0.0050\,M\cdot min^{-1}}$$

$$(2)(4)^y = 32$$

$$y = 2$$

$$\text{overall order} = 1 + 2 = 3$$

$$rate = k[Cl_2]^1[NO]^2$$

$$k = \frac{0.0050\,M\cdot min^{-1}}{(0.24\,M)^1(0.12\,M)^2} = 1.4\,M^{-2}\cdot min^{-1}$$

5

Concentration versus time data were collected for the reaction $2N_2O_5(g) \longrightarrow O_2(g) + 4NO_2(g)$. Graphs of $[N_2O_5]_t$ v. t, $\ln[N_2O_5]_t$ v. t, and $1/[N_2O_5]_t$ v. t were plotted, and the data points on the graph of $\ln[N_2O_5]_t$ v. t were found to fit a straight line most closely. Is the reaction zero-order, first-order, or second-order?

Since the data points on the graph of $\ln[N_2O_5]_t$ v. t had the best straight line fit, the reaction is first-order.

6

For the reaction $2ICl + H_2 \longrightarrow I_2 + 2HCl$, consider the following proposed mechanism:

$$ICl + H_2 \xrightarrow{k_1} HI + HCl \quad \text{(slow)}$$

$$ICl + HI \xrightarrow{k_2} I_2 + HCl \quad \text{(fast)}$$

Deduce a rate law for the overall reaction that is consistent with the proposed mechanism above.

$$\text{overall rate} = \text{rate of slow step} = k_1[ICl]^1[H_2]^1$$

7

For the reaction $H_2 + I_2 \longrightarrow 2HI$, consider the following proposed mechanism:

$$I_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2\,I \quad \text{(fast)}$$

$$2I + H_2 \xrightarrow{k_2} 2HI \quad \text{(slow)}$$

Deduce a rate law for the overall reaction that is consistent with the proposed mechanism above.

$$\text{Step 1 : forward rate} = \text{reverse rate}$$
$$k_1[I_2] = k_{-1}[I]^2$$
$$[I]^2 = \frac{k_1}{k_{-1}}[I_2]$$
$$\text{overall rate} = \text{rate of slow step} = k_2[I]^2[H_2] = \frac{k_2 k_1}{k_{-1}}[I_2][H_2]$$

8

The activation energy for a reaction is 92 kJ/mol. If $k = 3.3 \times 10^{-5}\,s^{-1}$ at 75°C for the reaction, calculate k for the reaction at 35°C.

$$\ln\frac{k_2}{3.3 \times 10^{-5}\,s^{-1}} = \frac{9.2 \times 10^4\,J/mol \cdot K}{8.31\,J/mol \cdot K}\left(\frac{1}{348\,K} - \frac{1}{308\,K}\right)$$
$$k_2 = 5.3 \times 10^{-7}\,s^{-1}\,\text{at}\,35°C$$