Question

Calculate the overall order of a reaction which has the rate expression

a) $Rate = k[A]^{1/2}[B]^{3/2}$

b) $Rate = k[A]^{3/2}[B]^{-1}$

Answer

For rate law expression rate $= k[A]^x[B]^y$, order $= x + y$.

a) order $= \frac{1}{2} + \frac{3}{2} = 2$ (second order)

b) order $= \frac{3}{2} + (-1) = \frac{1}{2}$ (half order)

Question

Identify the reaction order from each of the following rate constants.

i) $k = 2.3 \times 10^{-5}\ L\,mol^{-1}s^{-1}$

ii) $k = 3 \times 10^{-4}\ s^{-1}$

Answer

Units of rate constant k are: $(concentration)^{1-n}\ time^{-1}$, where n is order of reaction.

i) The unit of second order $(n=2)$ rate constant $L\,mol^{-1}s^{-1}$, therefore, $k = 2.3 \times 10^{-5}\ L\,mol^{-1}s^{-1}$ represents a second order reaction.

ii) The unit of a first order $(n=1)$ rate constant is s^{-1}, therefore $k = 3 \times 10^{-4}\ s^{-1}$ represents a first order reaction.

Question

For a reaction, $A + B \rightarrow$ Products, the rate law is given by

$r = k[A]^{1/2}[B]^2$. What is the order of the reaction?

Answer:

For rate law expression, $rate = k[A]^x[B]^y$, order of reaction, is given by, order = $x+y$.

Thus for given reaction, order = $\frac{1}{2} + 2 = 2.5$

Question:

The conversion of molecules X to Y follows second order kinetics. If concentration of X is increased to three times, how will it affect the rate of formation of Y?

Answer:

For given second order reaction $X \rightarrow Y$, rate law expression is given by, rate of reaction $(r) = k[X]^2$

Thus $\frac{r_2}{r_1} = \frac{[X_2]^2}{[X_1]^2} = \frac{[3X_1]^2}{[X_1]} = 9$

Hence reaction rate becomes 9 times.

rate of reaction = $\frac{1}{\text{Stoichiometric coeffient of Y}} \times$ Rate of formation of Y

$= \frac{1}{1} \times$ Rate of formation of Y

= Rate of formation of Y

Since rate of formation of Y is equal to rate of reaction, rate of formation of Y also becomes 9 times.

Question

The decomposition of NH_3 on platinum surface is zero order reaction. What are the rates of production of N_2 and H_2 if $k = 2.5 \times 10^{-4}$ mol $L^{-1}s^{-1}$?

Answer: $2NH_3 \rightarrow N_2 + 3H_2$

rate of reaction $(r) = \frac{1}{2}$ Rate of decomposition of NH_3 (r_{NH_3})

$= \frac{1}{1}$ Rate of formation of N_2 (r_{N_2})

$= \frac{1}{3}$ Rate of formation of H_2 (r_{H_2})

For zero order reaction, $r = k$

Thus $k = \frac{1}{2} r_{NH_3} = \frac{1}{1} r_{N_2} = \frac{1}{3} r_{H_2}$

$r_{H_2} = 3k = 3 \times 2.5 \times 10^{-4} = 7.5 \times 10^{-4}\ mol\ L^{-1} s^{-1}$

$r_{N_2} = 1k = 1 \times 2.5 \times 10^{-4} = 2.5 \times 10^{-4}\ mol\ L^{-1} s^{-1}$

Question

The decomposition of dimethyl ether leads to the formation of CH_4, H_2 and CO and the reaction rate is given by

Rate = $k\ [CH_3OCH_3]^{3/2}$

The rate of reaction is followed by increase in pressure in a closed vessel, so that rate can also be expressed in terms of the partial pressure of dimethyl ether i.e

Rate = $k\ P_{CH_3OCH_3}^{3/2}$

If the pressure is measured in bar and time in minutes, then what are the units of rate and rate constant?

Answer:

i) Rate is defined as change in pressure per unit time, thus the units of rate, $r = \frac{\text{Units of change in pressure}}{\text{Units of time}}$

$= \frac{bar}{min} = bar\ min^{-1}$

ii) $r = k\ (\text{pressure of reactant})^{order}$

units of $k = \frac{\text{Units of rate}}{(\text{Unit of pressure})^{order}}$

$= \frac{bar\ min^{-1}}{(bar)^{3/2}} = bar^{-1/2}\ min^{-1}$

Question

Mention the factors that affect the rate of a chemical reaction

Answer:

Rate of reaction depends upon the experimental conditions such as :

i) concentration of reactants (pressure in case of gases)

ii) temperature

iii) Catalyst

Question

A reaction is second order with respect to a reactant. How is the rate of reaction affected if the concentration of the reactant is i) doubled ii) reduced to half ?

Answer:

If reaction is second order w.r.t a reactant then

rate of reaction, $r \propto [C]^2$

where C is concentration of reactant

i) When concentration of reactant is doubled,

$\frac{r_2}{r_1} = \frac{[C_2]^2}{[C_1]^2} = \frac{[2C_1]^2}{[C_1]^2} = 4$, Reaction rate becomes 4 times

ii) $\frac{r_2}{r_1} = \frac{[C_2]^2}{[C_1]^2} = \frac{[0.5C_1]^2}{[C_1]^2} = 0.25$, Reaction rate becomes $\frac{1}{4}$ times