Question

The initial concentration of N_2O_5 in the following first order reaction $N_2O_5(g) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$ was 1.24×10^{-2} M at 318K. The concentration of N_2O_5 after 60 minutes was 0.2×10^{-2} mol L^{-1}. Calculate rate constant of the reaction at 318K.

Ans:

For first order reactions, rate constant k is given by:

$$k = \frac{2.303}{t} \log \frac{a_0}{a_t}$$

$$= \frac{2.303}{60} \log \frac{1.24 \times 10^{-2}}{0.2 \times 10^{-2}}$$

$$= 0.0384 \log 6.2$$

$$= 0.0304 \text{ min}^{-1}$$

Question

A first order reaction has a rate constant $1.15 \times 10^{-3}\ s^{-1}$. How long will 5 g of this reactant take to reduce to 3 g?

Ans:

For first order reaction, rate constant k is given by:

$$k = \frac{2.303}{t} \log \frac{a_0}{a_t}$$

$$1.15 \times 10^{-3} = \frac{2.303}{t} \log \frac{5}{3}$$

$$t = \frac{2.303 \log(5/3)}{1.15 \times 10^{-3}}$$

$$= \frac{2.303 (\log 5 - \log 3)}{1.15 \times 10^{-3}}$$

$$= 2.303\ (0.7 - 0.48)$$

$\log 2 = 0.3$

$\log 3 = 0.48$

$\log 5 = 0.7$

$$= \frac{2.303\,(0.7-0.48)}{1.15\times10^{-3}}$$

$$= 440.6\,s$$

$\log 3 = 0.48$

$\log 5 = 0.7$

$\log 7 = 0.85$

$\log 10 = 1$

$\log ab = \log a + \log b$

$\log \frac{a}{b} = \log a - \log b$

$\log a^b = b \log a$

Question

The rate constant for a first order reaction is $60\,s^{-1}$. How much time will it take to reduce the initial concentration of the reactant to its $\frac{1}{16}$th value.

Answer:

For first order reaction, rate constant k is given by:

$$k = \frac{2.303}{t}\log\frac{a_0}{a_t}$$

For given problem $a_t = \frac{1}{16}a_0$, $\frac{a_0}{a_t} = 16$

thus

$$k = \frac{2.303}{t}\log 16$$

$$t = \frac{2.303}{k}\log 16$$

$$= \frac{2.303}{60}\log 2^4$$

$$= \frac{2.303}{60}\,4\log 2$$

$$= \frac{2.303}{60}\,4\,(0.3)$$

$$= 0.04606\,s$$

Question

For a first order reaction, show that time required for 99% completion is twice the time required for the completion of 90% of reaction.

Answer:

For first order reaction, rate constant k is given by:

$$k = \frac{2.303}{t} \log \frac{a_0}{a_t}$$

When reaction is 99% complete, 1% reactants are left i.e.

$$a_t = \frac{1}{100} a_0 \quad , \quad \frac{a_0}{a_t} = 100$$

$$\text{Thus } k = \frac{2.303}{t_{99\%}} \log 100 \quad \text{— } \underline{I}$$

When reaction is 90% complete, 10% reactants are left

$$\text{i.e. } a_t = \frac{10}{100} a_0 \quad , \quad \frac{a_0}{a_t} = 10$$

$$\text{Thus } k = \frac{2.303}{t_{90\%}} \log 10 \quad \text{— } \underline{II}$$

Equate I and II

$$\frac{2.303}{t_{99\%}} \log 100 = \frac{2.303}{t_{90\%}} \log 10$$

$$\frac{1}{t_{99\%}} (2) = \frac{1}{t_{90\%}} (1)$$

$$t_{99\%} = 2 \times t_{90\%}$$

Question

Consider a certain reaction $A \rightarrow$ Products with $k = 2.0 \times 10^{-2}$

s^{-1}. Calculate the concentration of A remaining after 100 s, if the initial concentration of A is 1.0 mol L^{-1}.

Answer:

For first order reaction, rate constant k is given by:

$$k = \frac{2.303}{t} \log \frac{a_0}{a_t}$$

$$2.0 \times 10^{-2} = \frac{2.303}{100} \log \frac{1}{a_t}$$

$$\log \frac{1}{a_t} = 0.8684$$

$$\log a_t = -0.8684$$

$$a_t = \text{antilog}(-0.8684) = 0.135 \text{ mol } L^{-1}$$

$\log 7 = 0.85$

$\frac{1}{a_t} = 7$

$a = \frac{1}{7}$

$= 0.14.$