GATE 2023 CH-58

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Question: A fresh catalyst is loaded into a reactor before the start of the following catalytic reaction:

$$A \rightarrow \text{Products}$$

The catalyst gets deactivated over time. The instantaneous activity $a(t)$, at time t, is defined as the ratio of the rate of reaction $-r_A(t)'$ (mol.$(g_{cat})^{-1}$hr^{-1}) to the rate of reaction with fresh catalyst. Controlled experimental measurements led to an empirical correlation:

$$-r_A(t)' = -0.5t + 10$$

where t is in hours. The activity of the catalyst at $t = 10$ hours is given by (rounded off to one decimal place):
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Solution:

Values	Parameters	Description
$-r_A(t)'$	$-0.5t + 10$	Rate of reaction at time t
$-r_A(0)'$	10	Rate of fresh catalyst
$a(t)$	$\frac{-r_A(t)'}{-r_A(0)'}$	Activity of a catalyst at time t

TABLE 0
GIVEN PARAMETERS

$$-r_A(t)' = -0.5t + 10 \tag{1}$$

The rate of reaction for fresh catalyst ,at $t = 0$;

$$-r_A(0)' = 10 \tag{2}$$
$$-r_A(10)' = -0.5(10) + 10 \tag{3}$$
$$= -5 + 10 \tag{4}$$
$$= 5 \tag{5}$$

The activity of a catalyst at a time 't' is given by :

$$a(t) = \frac{-0.5t + 10}{10} \tag{6}$$
$$a(10) = \frac{-r_A(10)'}{-r_A(0)'} \tag{7}$$
$$= \frac{-0.5(10) + 10}{10} \tag{8}$$
$$= \frac{5}{10} \tag{9}$$
$$= 0.5 \tag{10}$$

The activity of the catalyst at $t = 10$ hours is given by 0.5

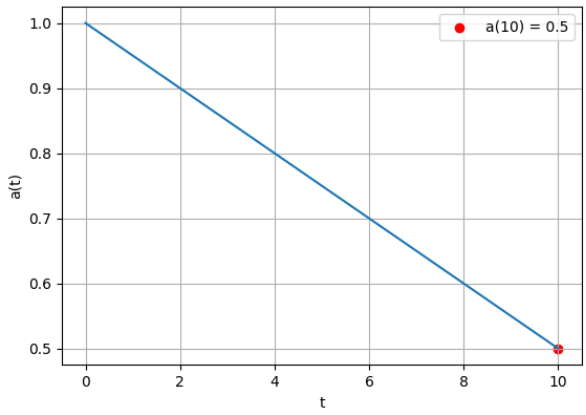

Fig. 0. Activity of catalyst vs time