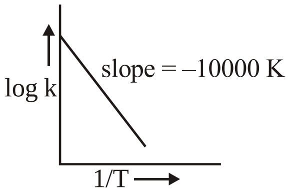
CHEMICAL KINETICS

1. Sucrose hydrolyses in acid solution into glucose and fructose following first order rate law with a half-life of 3.33 h at 25°C. After 9 h, the fraction of sucrose remaining is f. The value of $\log_{10}\left(\frac{1}{f}\right)$ is _______ $\times 10^{-2}$. (Rounded off to the nearest integer)
[Assume : ln 10 = 2.303, ln 2 = 0.693]

2. For the reaction, $aA + bB \rightarrow cC + dD$, the plot of log k vs $\frac{1}{T}$ is given below :



The temperature at which the rate constant of the reaction is 10^{-4} s^{-1} is _______ K.
(Rounded-off to the nearest integer)
[Given : The rate constant of the reaction is 10^{-5} s^{-1} at 500 K.]

3. The rate constant of a reaction increases by five times on increase in temperature from 27°C to 52°C. The value of activation energy in kJ mol^{-1} is _______ (Rounded-off to the nearest integer)
[R = 8.314 J K^{-1} mol^{-1}]

4. An exothermic reaction X → Y has an activation energy 30 kJ mol^{-1}. If energy change ΔE during the reaction is –20 kJ, then the activation energy for the reverse reaction in kJ is _______.(Integer answer)

5. If the activation energy of a reaction is 80.9 kJ mol^{-1}, the fraction of molecules at 700 K, having enough energy to react to form products is e^{-x}. The value of x is _______.
(Rounded off to the nearest integer)
[Use R = 8.31 J K^{-1} mol^{-1}]

6. Gaseous cyclobutene isomerizes to butadiene in a first order process which has a 'k' value of 3.3×10^{-4}s^{-1} at 153°C. The time in minutes it takes for the isomerization to proceed 40% to completion at this temperature is _____.
(Rounded off to the nearest integer)

7. The decomposition of formic acid on gold surface follows first order kinetics. If the rate constant at 300 K is 1.0×10^{-3} s^{-1} and the activation energy E_a = 11.488 kJ mol^{-1}, the rate constant at 200 K is _______ $\times 10^{-5}$ s^{-1}. (Round of to the Nearest Integer).
(Given : R = 8.314 J mol^{-1} K^{-1})

8. A and B decompose via first order kinetics with half-lives 54.0 min and 18.0 min respectively. Starting from an equimolar non reactive mixture of A and B, the time taken for the concentration of A to become 16 times that of B is ______ min. (Round off to the Nearest Integer).

9. For a certain first order reaction 32% of the reactant is left after 570 s. The rate constant of this reaction is _______ $\times 10^{-3}$ s^{-1}. (Round off to the Nearest Integer).
[Given : $\log_{10}2$ = 0.301, ln10 = 2.303]

10. The reaction $2A + B_2 \rightarrow 2AB$ is an elementary reaction.
For a certain quantity of reactants, if the volume of the reaction vessel is reduced by a factor of 3, the rate of the reaction increases by a factor of _____. (Round off to the Nearest Integer).

11. $2\,NO(g) + Cl_2(g) \rightleftharpoons 2\,NOCl(s)$

This reaction was studied at –10°C and the following data was obtained

run	$[NO]_0$	$[Cl_2]_0$	r_0
1	0.10	0.10	0.18
2	0.10	0.20	0.35
3	0.20	0.20	1.40

$[NO]_0$ and $[Cl_2]_0$ are the initial concentrations and r_0 is the initial reaction rate.
The overall order of the reaction is ______.
(Round off to the Nearest Integer).

$2\,NO(g) + Cl_2(g) \rightleftharpoons 2\,NOCl(s)$

12. A reaction has a half life of 1 min. The time required for 99.9% completion of the reaction is ______ min. (Round off to the Nearest integer)

[Use : ln 2= 0.69, ln 10 = 2.3]

13. The inactivation rate of a viral preparation is proportional to the amount of virus. In the first minute after preparation, 10% of the virus is inactivated. The rate constant for viral inactivation is ________ $\times 10^{-3}$ min^{-1}.

(Nearest integer)

[Use : ln 10 = 2.303 ; $\log_{10} 3 = 0.477$;

property of logarithm : $\log x^y = y \log x$]

14. $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

In the above first order reaction the concentration of PCl_5 reduces from initial concentration 50 mol L^{-1} to 10 mol L^{-1} in 120 minutes at 300 K. The rate constant for the reaction at 300 K is x $\times 10^{-2}$ min^{-1}. The value of x is _______. [Given log5 = 0.6989]

$PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

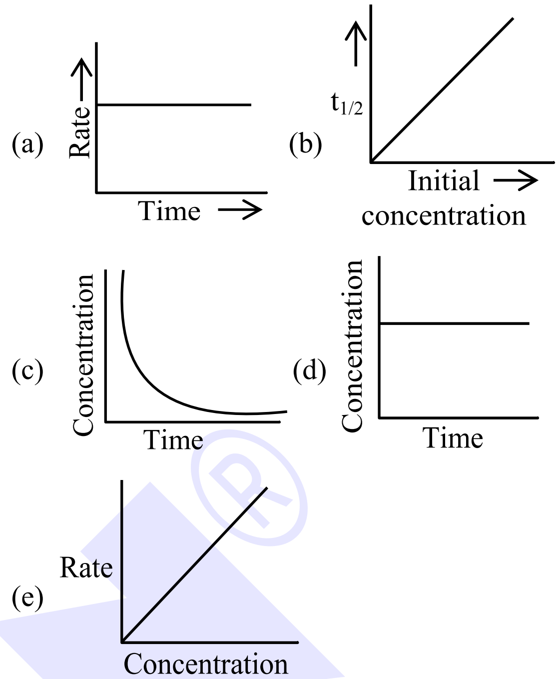
15. $N_2O_{5(g)} \rightarrow 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$

In the above first order reaction the initial concentration of N_2O_5 is 2.40×10^{-2} mol L^{-1} at 318 K. The concentration of N_2O_5 after 1 hour was 1.60×10^{-2} mol L^{-1}. The rate constant of the reaction at 318 K is _________ $\times 10^{-3}$ min^{-1}. (Nearest integer)

[Given : log 3 = 0.477, log 5 = 0.699]

$N_2O_{5(g)} \rightarrow 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$

16. For the following graphs,



Choose from the options given below, the **correct** one regarding order of reaction is :

(1) (b) zero order (c) and (e) First order

(2) (a) and (b) Zero order (e) First order

(3) (b) and (d) Zero order (e) First order

(4) (a) and (b) Zero order (c) and (e) First order

17. For a chemical reaction A $\rightarrow$ B, it was found that concentration of B is increased by 0.2 mol L^{-1} in 30 min. The average rate of the reaction is ________ $\times 10^{-1}$ mol L^{-1} h^{-1}.

(in nearest integer)

18. The number of neutrons and electrons, respectively, present in the radioactive isotope of hydrogen is :-

(1) 1 and 1

(2) 3 and 1

(3) 2 and 1

(4) 2 and 2

19. In a solvent 50% of an acid HA dimerizes and the rest dissociates. The van't Hoff factor of the acid is _____ $\times 10^{-2}$.

(Round off to the nearest integer)

20. For the first order reaction $A \rightarrow 2B$, 1 mole of reactant A gives 0.2 moles of B after 100 minutes. The half life of the reaction is ...... min. (Round off to the nearest integer).

[Use : $\ln 2 = 0.69$, $\ln 10 = 2.3$

Properties of logarithms : $\ln x^y = y \ln x$;

$\ln\left(\frac{x}{y}\right) = \ln x - \ln y$]

(Round off to the nearest integer)

21. The reaction that occurs in a breath analyser, a device used to determine the alcohol level in a person's blood stream is

$2K_2Cr_2O_7 + 8H_2SO_4 + 3C_2H_6O \rightarrow 2Cr_2(SO_4)_3 + 3C_2H_4O_2 + 2K_2SO_4 + 11H_2O$

If the rate of appearance of $Cr_2(SO_4)_3$ is 2.67 mol min^{-1} at a particular time, the rate of disappearance of C_2H_6O at the same time is _______ mol min^{-1}. (Nearest integer)

22. The first order rate constant for the decomposition of $CaCO_3$ at 700 K is $6.36 \times 10^{-3} s^{-1}$ and activation energy is 209 kJ mol^{-1}. Its rate constant (in s^{-1}) at 600 K is $x \times 10^{-6}$. The value of x is ___. (Nearest integer)

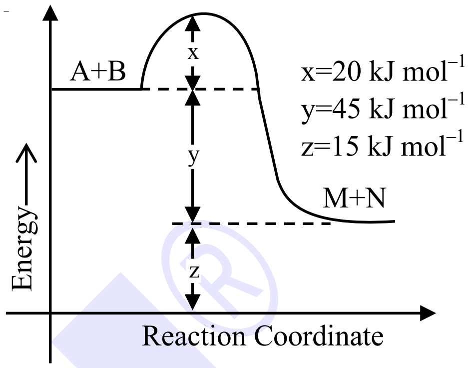
[Given R = 8.31 J K^{-1} mol^{-1}; $\log 6.36 \times 10^{-3} = -2.19$, $10^{-4.79} = 1.62 \times 10^{-5}$]

23. For a first order reaction, the ratio of the time for 75% completion of a reaction to the time for 50% completion is _______. (Integer answer)

24. According to the following figure, the magnitude of the enthalpy change of the reaction

$A + B \rightarrow M + N$ in kJ mol^{-1}

is equal to _________. (Integer answer)



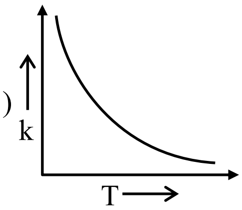
25. For the reaction $A \rightarrow B$, the rate constant k(in s^{-1}) is given by

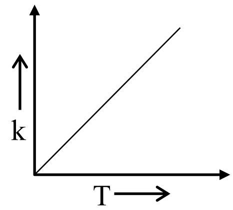
$$\log_{10} k = 20.35 - \frac{(2.47 \times 10^3)}{T}$$

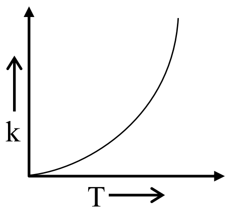
The energy of activation in kJ mol^{-1} is _______. (Nearest integer)

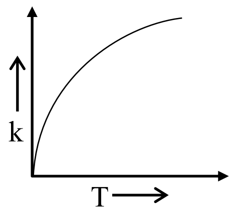
[Given : R = 8.314 J K^{-1} mol^{-1}]

26. Which one of the following given graphs represents the variation of rate constant (k) with temperature (T) for an endothermic reaction ?

(1)


(2)


(3)


(4)


SOLUTION

1. Official Ans. by NTA (81)

Sol. Given :

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow[t_{1/2}=\frac{10}{3}hr]{\text{I order}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$t = 0 \quad a = [A]_0$

$t = 9hr \quad a - x = [A]_t$

from I order kinetic : $\frac{k \times t}{2.303} = \log \frac{|A|_0}{|A|_t}$

$$\Rightarrow \frac{\ell n2 \times 9}{\frac{10}{3} \times 2.303} = \log\left(\frac{1}{f}\right)$$

$$\Rightarrow \frac{0.693 \times 9 \times 3}{23.03} = \log\left(\frac{1}{f}\right)$$

$$\Rightarrow \log\left(\frac{1}{f}\right) = 0.81246 = 81.24 \times 10^{-2}$$

$\Rightarrow x = 81$

2. Official Ans. by NTA (526)

Sol. $\log K = \log A - \frac{Ea}{2.303RT}$

$$|\text{Slope}| = \frac{Ea}{2.303R} = 10{,}000$$

$$\log\left(\frac{K_2}{K_1}\right) = \frac{Ea}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\log\left(\frac{10^{-4}}{10^{-5}}\right) = 10{,}000\left[\frac{1}{500} - \frac{1}{T_2}\right]$$

$T_2 = 526.31 \simeq 526K$

Hence answer is (526)

3. Official Ans. by NTA (52)

Sol. $T_1 = 300K, T_2 = 325K, K_2 = 5K,$

$$\ln\frac{K_2}{K_1} = \frac{Ea}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

or, $\ln 5 = \frac{Ea}{8.314}\left[\frac{1}{300} - \frac{1}{325}\right]$

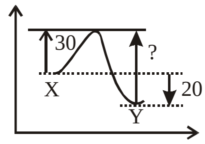
or, $Ea = 0.7 \times 2.303 \times 8.314 \times 12 \times 325$

$= 52271 \text{ J} = 52.271 \text{ kJ}$

Nearest integer answer will be 52 kJ

4. Official Ans. by NTA (50)

Sol. $X \longrightarrow Y$



5. Official Ans by NTA (14)

Sol. Fraction of molecules to have enough energy to react $= e^{-Ea/RT}$

So, $x = \frac{E_a}{RT}$

$$= \frac{80.9 \times 10^3}{8.31 \times 700}$$

$= 13.9$

6. Official Ans. by NTA (26)

Sol.  $\longrightarrow H_2C = HC–CH = CH_2$

$$Kt = \ell n\frac{[A]_0}{[A]_t}$$

$$3.3 \times 10^{-4} \times t = \ell n\left(\frac{100}{60}\right)$$

$t = 1547.956$ sec

$t = 25.799$ min

26 min

7. Official Ans. by NTA (10)

Sol. $K_{300} = 10^{-4}$ $\qquad K_{200} = ?$

$E_a = 11.488$ KJ/mole $\qquad R = 8.314$ J/mole-K

$$\text{so } \ell n\left(\frac{K_{300}}{K_{200}}\right) = \frac{E_a}{R}\left(\frac{1}{200} - \frac{1}{300}\right)$$

$$\ell n\left(\frac{K_{300}}{K_{200}}\right) = \frac{11.488 \times 1000 \times 100}{8.314 \times 200 \times 300}$$

$= 2.303$

$= \ell n10$

$$\text{so } \frac{K_{300}}{K_{200}} = 10$$

$$K_{200} = \frac{1}{10} \times K_{300} = 10^{-4}$$

$= 10 \times 10^{-5} \text{ sec}^{-1}$

8. Official Ans. by NTA (108)

Sol. Given t_2 = 54 min $T_{1/2}$ = 18 min

A   B

t = 0 'x' M   t = 0 'x' M

$\Rightarrow$ To calculate : $[A_t] = 16 \times [B_t]$ ....(1) time =?

$\Rightarrow$ For I order kinetic : $\boxed{[A_t] = \frac{A_0}{(2)^n}}$

n $\rightarrow$ no of Half lives

$\Rightarrow$ Now from the relation (1)

$[A_t] = 16 \times [B_t]$

$\Rightarrow \frac{x}{(2)^{n_1}} = \frac{x}{(2)^{n_2}} \times 16 \Rightarrow (2)^{n_2} = (2)^{n_1} \times (2)^4$

$\Rightarrow n_2 = n_1 + 4 \qquad \Rightarrow \frac{t}{(t_{1/2})_2} = \frac{t}{(t_{1/2})_1} + 4$

$\Rightarrow t\left(\frac{1}{18} - \frac{1}{54}\right) = 4 \Rightarrow t = \frac{4 \times 18 \times 54}{36}$

$\Rightarrow \boxed{t = 108\,\text{min}}$

9. Official Ans. by NTA (2)

Sol. For 1st order reaction,

$$K = \frac{2.303}{t}.\log\frac{[A_0]}{[A_t]} = \frac{2.303}{570\,\text{sec}}.\log\left(\frac{100}{32}\right)$$

$= 1.999 \times 10^{-3}\ \text{sec}^{-1} \approx 2 \times 10^{-3}\ \text{sec}^{-1}$

10. Official Ans. by NTA (27)

Sol. Reaction : $2A + B_2 \longrightarrow 2AB$

As the reaction is elementary, the rate of reaction is

$r = K\,.\,[A]^2\,[B_2]$

on reducing the volume by a factor of 3, the concentrations of A and B_2 will become 3 times and hence, the rate becomes $3^2 \times 3 = 27$ times of initial rate.

11. Official Ans. by NTA (3)

Sol. $r = k[NO]^m\,[Cl_2]^n$

$= k(0.1)^m\,(0.1)^n$ .....(1)

$= k(0.1)^m\,(0.2)^n$ .....(2)

$= k(0.2)^m\,(0.2)^n$ .....(3)

n = 1

m = 2

m + n = 3

12. Official Ans. by NTA (10)

Sol. $$\frac{t_{99.9\%}}{t_{50\%}} = \frac{\frac{1}{K}\ln\frac{100}{0.1}}{\frac{1}{K}\ln 2}$$

$= \frac{\ln 1000}{\ln 2} \times t_{50\%}$

$= \frac{3\ln 10}{\ln 2} \times 1$

$= \frac{3 \times 2.3}{0.69} = 10$

13. Official Ans. by NTA (106)

Sol. As the unit of rate constant is min^{-1} so it must be a first order reaction

$K \times t = 2.303 \log A_0/A_t$

in 1 min 10% is in activated so tabing

$A_0 = 100$ $A_t = 90$ in 1 min

So $K \times 1 = 2.303 \times \log\frac{100}{90}$

$= 2.303 \times (\log 10 - 2\log 3)$

$= 2.303 \times (1 - 2 \times 0.477)$

$= 0.10593$

$= 105.93 \times 10^{-3}$

≈ 106

14. Official Ans. by NTA (1)

Sol. $PCl_{5(g)} \xrightarrow[300K]{I\ order} PCl_{3(g)} + Cl_{2(g)}$

$t = 0 \quad 50\ M$

$t = 120\ min \quad 10\ M$

$\Rightarrow K = \frac{2.303}{t}\log\frac{[A_0]}{[A_t]}$

$\Rightarrow K = \frac{2.303}{120}\log\frac{50}{10}$

$\Rightarrow K = \frac{2.303}{120}\times 0.6989 = 0.013413\ min^{-1}$

$= 1.3413 \times 10^{-2}\ min^{-1}$

$1.34 \Rightarrow$ Nearest integer = 1

15. Official Ans. by NTA (7)

Sol. $K = \frac{2.303}{t}\log\frac{[N_2O_5]_0}{[N_2O_5]_t}$

$= \frac{2.303}{60}\log\frac{2.4}{1.6} = 6.76\times10^{-3}\ min^{-1} \approx 7\times10^{-3}\ min^{-1}$

16. Official Ans. by NTA (4)

17. Official Ans. by NTA (4)

$A \longrightarrow B$

Sol. $t=0 \quad\quad 0$

$t = 30\,min \quad\quad 0.2M$

Av. rate of reaction $= -\frac{\Delta[A]}{\Delta t} = \frac{\Delta[B]}{\Delta t} = \frac{(0.2-0)}{\frac{1}{2}}$

$= 0.4 = 4 \times 10^{-1}\ mol / L \times hr$

18. Official Ans. by NTA (3)

Sol. Radioactive isotope of hydrogen is Tritium $({}^3_1T)$

No. of neutrons (A–Z) = 3 – 1 = 2

No. of electrons = 1

19. Official Ans. by NTA (125)

Sol. $2HA \rightleftharpoons H_2A_2 \quad HA \rightleftharpoons H^+ + A$

Initial moles $a\times\frac{50}{100} \quad 0 \quad a\times\frac{50}{100} \quad 0 \quad 0$

Final moles $0 \quad 0.25\ a \quad 0 \quad 0.5a \quad 0.5a$

Now, $i = \frac{\text{final moles}}{\text{initial moles}} = \frac{0.25a + 0.5a + 0.5a}{0.5a + 0.5a}$

$= 1.25 = 125 \times 10^{-2}$

20. Official Ans. by NTA (300)

Sol. $A \longrightarrow 2B$

$t = 0 \quad 1\ mole \quad 0$

$t = 100\ min \quad 1 - x \quad 2x$

$= 0.9mol \quad = 0.2mol$

Now, $t = \frac{t_{1/2}}{\ln 2}\times\frac{[A_0]}{[A_t]}$

$100 = \frac{t_{1/2}}{\ln 2} \times \ln\frac{1}{0.9} \Rightarrow t_{1/2} = 690$ min.

(taking ln 3 = 1.11)

21. Official Ans. by NTA (4)

Sol. $\left(\frac{\text{Rate of disappearance of } C_2H_6O}{3}\right)$

$= \left(\frac{\text{Rate of appearance of } Cr_2(SO_4)_3}{2}\right)$

$\Rightarrow \left(\frac{2.67 mol / min \times 3}{2}\right)$ = rate of disappearance of C_2H_6O.

$\Rightarrow$ Rate of disappearance of C_2H_6O = 4.005 mol/min

22. Official Ans. by NTA (16)

Sol. $K_{700} = 6.36 \times 10^{-3} s^{-1}$;

$K_{600} = x \times 10^{-6} s^{-1}$

$E_a = 209$ kJ/mol

Applying ;

$$\log\left(\frac{K_{T_2}}{K_{T_1}}\right) = \frac{-E_a}{2.303R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\log\left(\frac{K_{700}}{K_{600}}\right) = \frac{-E_a}{2.303R}\left(\frac{1}{700} - \frac{1}{600}\right)$$

$$\log\left(\frac{6.36 \times 10^{-3}}{K_{600}}\right) = \frac{+209 \times 1000}{2.303 \times 8.31}\left(\frac{100}{700 \times 600}\right)$$

$\log(6.36 \times 10^{-3}) - \log K_{600} = 2.6$

$\Rightarrow \log K_{600} = -2.19 - 2.6 = -4.79$

$\Rightarrow K_{600} = 10^{-4.79} = 1.62 \times 10^{-5}$

$= 16.2 \times 10^{-6}$

$= x \times 10^{-6}$

$\Rightarrow$ x = 16

23. Official Ans. by NTA (2)

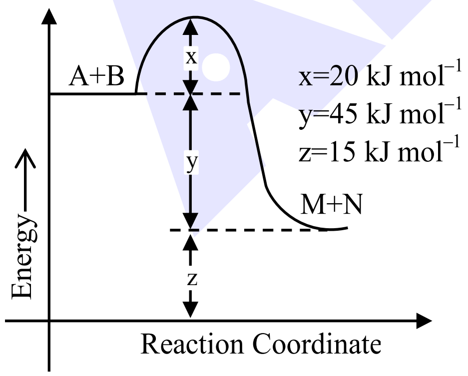
Sol. $k = \frac{2.303}{t} \log \frac{a}{a-x}$

$$\frac{2.303}{t_{50\%}} \log \frac{100}{100-50} = \frac{2.303}{t_{75\%}} \log \frac{100}{100-75}$$

$t_{75\%} = 2\ t_{50\%}$

24. Official Ans. by NTA (45)

Sol.



$\Delta H = E_{a_f} - E_{a_b}$

$= 20 - 65$

$= -45$ KJ/ mol

$|\Delta H| = 45$ KJ/mol

25. Official Ans. by NTA (47)

Sol. Given $\log K = 20.35 - \frac{2.47 \times 10^3}{T}$

We know $\log K = \log A - \frac{E_a}{2.303RT}$

$\Rightarrow \frac{E_a}{2.303RT} = 2.47 \times 10^3$

$E_a = 2.47 \times 10^3 \times 2.303 \times \frac{8.314}{1000}$ KJ / mole

$= 47.29 = 47$ (Nearest integer)

26. Official Ans. by NTA (3)

Sol. By observation we get this plot during measurable temperatures

Ans. 3rd Option.