Chemical Kinetics MCQS TEST - 1

12th Standard

Chemistry

Chemical Kinetics

Total Mark : 60

Multiple Choice Question

30 × 1 = 30

1) Consider the reaction : Cl_2 (aq) + H_2S (aq) $\rightarrow$ S (s) + 2 H^+ (aq) +2 Cl^- (aq) The rate equation for this reaction is rate k [Cl_2] [H_2S] Which of these mechanisms is / are consistant with this rate equation ?
A. Cl_2+H_2S $\longrightarrow$ H^+ + Cl- + Cl^+ HS^- (slow) ; Cl+ Hs^- $\longrightarrow$ H^+ + Cl^- + S (fast)
B. $H_2S \rightleftharpoons H^+$ + HS - (fast equilibrium) ; Cl_2 + HS^- $\longrightarrow$ 2 Cl^- + H^+ S (slow)
(a) Neither A nor B (b) A only (c) B only (d) Both A and B

2) For the reaction R $\longrightarrow$ P, a graph of [R] against time is found to be a straight line with negative slope. What is the order of reaction ?
(a) Second order (b) Third order (c) First order (d) Zero order

3) The reaction A $\longrightarrow$ B follows first order kinetics. The time taken for 0.8 mole of A to produce 0.6 mole of B is 1 hour. What is the time taken for conversion of 9.9 mole of A to produce 0.675 mole of B ?
(a) 1 hour (b) 0.5 hour (c) 0.25 hour (d) 2 hours

4) The rate of a chemical reaction doubles for every 10°C rise of temperature. If the temperature is raised by 50°C, the rate the reaction increses by about :
(a) 24 times (b) 32 times (c) 64 times (d) 10 times

5) 75% of the first order reaction was completed in 32 min. 50% of the reaction was completed in
(a) 24 min (b) 8 min (c) 16 min (d) 4 min

6) 1[A] vs time is a straight line. The order of the reaction is
(a) 1 (b) 2 (c) 3 (d) 0

7) The rate constant, the activation energy and the Arrchenius parameter of a chemical reaction at 25°C are 3.0 $\times$ $10^{-4}s^{-1}$,104.4 kJ mol^{-1}, and 6.0 $\times$ 10^{14} s^{-1} respectively. The value of the rate constant as T $\longrightarrow$ ∞ is
(a) $2.0 \times 10^{18} s^{-1}$ (b) $6.0 \times 10^{14} s^{-1}$ (c) Infinity (d) $3.6 \times 10^{30} s^{-1}$

8) If a graph is plotted between ln k ad 1/T for the first order reaction. the slope of the straight line so obtained is given by
(a) - $\frac{E_a}{R}$ (b) - $-\frac{E_a}{2.303R}$ (c) $-\frac{2.303}{E_aR}$ (d) $-\frac{E_a}{2.303}$

9) A chemical reaction was carried out at 300 K and 280 K the rate constants were found to be K_1 and K_2 respectively. Then
(a) $K_2 = 4K_1$ (b) $K_2 = 2K_1$ (c) K_2 = 0.25 K (d) $K_2 = 0.5\ K_1$

10) Collision Theory is applicable to
(a) First order reactions (b) Zero order reactions (c) Bimolecular reactions (d) Intramolecular reactions

11) 10 g of a radioactive isotope is reduced to 1.25 g in 12 years, therefore half-life period of the isotope is
(a) 24 years (b) 4 years (c) 3 years (d) 8 years

12) The half-life period of a radioactive element is 20 days. What will be the remaining mass of 100 g of it after 60 days?
(a) 25 g (b) 50 g (c) 12.5 g (d) 20 g

13) The chemical reactions in which the reactions require high amount of activation energy are generally
(a) slow (b) fast (c) instantaneous (d) none of these

14) If the activatiopn energy for the forward reaction is 150 kJ mol^{-1} and that of the reserve reaction is 260 kJ mol^{-1}, what is the enthalpy change for the reaction ?
(a) 410 kJ mol^{-1} (b) -110 kJ mol^{-1} (c) 110 kJ mol^{-1} (d) -410 kJ mol^{-1}

15) When ethyl acetate was hydrolysed in presence of 0.1 N HCl, the rate constant was found to be 5.40 $\times$ 10^{-5} s^{-1} . From these values we can say that
(a) H_2SO_4 is stronger than HCl (b) H_2SO_4 is weaker than HCl (c) Both the acids have equal strength
(d) The data is insufficient to compare the strengths of HCl and H_2SO_4

16) The role of a catalyst is to change ..... .
(a) Gibbs energy of reaction (b) enthalpy of reaction (c) activation energy of reaction (d) equilibrium constant

17) In the presence of a catalyst, the heat evolved or absorbed during the reaction ..... .
(a) increases (b) decreases (c) remains unchanged (d) may increase or decrease

18) Activation energy of a chemical reaction can be determined by ..... .
(a) determining the rate constant at standard temperature (b) determining the rate constants at two temperatures
(c) determining probability of collision (d) using catalyst

19) Consider a first order gas phase decomposition reaction given below : A(g) $\longrightarrow$ B(g) + C(g) The initial pressure of the system before decomposition of A was pi . After lapse of time 't' , total pressure of the system increased by x the reaction is given as ..... .
(a) k = $\frac{2.303}{t} log \frac{p_i}{p_i - x}$ (b) k = $\frac{2.303}{t} log \frac{p_i}{2p_i - p_i}$ (c) k = $\frac{2.303}{t} log \frac{p_i}{2p_i + p_i}$ (d) k = $\frac{2.303}{t} log \frac{p_i}{p_i + x}$

20) Consider the Arrhenius equation given below and mark the correct option. k = $Ae^{-E_a/RT}$
(a) Rate constant increases exponentially with increasing activation energy and decreasing temperature
(b) Rate constant decreases exponentially with increasing activation energy and decreasing temperature
(c) Rate constant increases exponentially with decreasing activation energy and decreasing temperature
(d) Rate constant increases exponentially with decreasing activation energy and increasing temperature

bromide uions as follows :

(a) $\frac{d[Br_2]}{dt} = -\frac{5}{3}\frac{d[Br^-]}{dt}$ (b) $\frac{d[Br_2]}{dt} = \frac{5}{3}\frac{d[Br^-]}{dt}$ (c) $\frac{d[Br_2]}{dt} = \frac{3}{5}\frac{d[Br^-]}{dt}$ (d) $\frac{d[Br_2]}{dt} = -\frac{3}{5}\frac{d[Br^-]}{dt}$

22) Time required for 100 percent completion of a zero order reaction is

(a) $\frac{2k}{a}$ (b) $\frac{a}{2k}$ (c) $\frac{a}{k}$ (d) a k

23) For the reaction aA + bB $\longrightarrow$ cC, if -3 $\frac{d[A]}{dt} = +1.5\frac{d[C]}{dt}$, then a, b, and c respectively are

(a) 3, 1, 2 (b) 2, 1, 3 (c) 1, 3, 2 (d) 6, 2, 3

24) The rate of a gaseous reaction is given by the expression k [A][B]. If the volume of the reaction vessel is suddenly reduced to 1/4 th of the initial volume, the reaction rate relating to original rate will be

(a) 1/10 (b) 1/8 (c) 8 (d) 16

25) In a reaction $\longrightarrow$ B, the rate of reaction increases two times on increasing the concentration of the reactant four times, then order of reaction is

(a) 0 (b) 2 (c) 1/2 (d) 4

26) The rate of the reaction 2 NO + $Cl_2 \rightarrow$ 2NOCl is given by the rate equation : rate = k $[NO]_2$ $[Cl_2]$. The value of the rate constant can be increased by

(a) increasing the temperature (b) increasing the concentration of NO (c) increasing the concentration of Cl_2 (d) doing all of these

27) The unit of rate constant for a zero order reaction is

(a) mol L^{-1} s^{-1} (b) L mol^{-1} s^{-1} (c) L^2mol^{-1} s^{-1} (d) s^{-1}

28) A first order reaction has a half-life period of 34.65 seconds. Its rate constant is

(a) 2×10^{-2} sec^{-1} (b) 4×10^{-4} sec^{-1} (c) 20 sec^{-1} (d) 2×10^{-4} sec^{-1}

29) Rate constant of a reaction (k) is 175 $litre^2$ mol^{-2} sec^{-1}. What is the order of reaction?

(a) first (b) second (c) third (d) zero

30) The molecularity and order of the reaction 2 NO (g) + O_2 (g) $\rightarrow$2NO_2 (g) are respectively

(a) one and one (b) two and two (c) three and three (d) two and three

Fill up / 1 Marks

5 × 1 = 5

31) For a gaseous reaction, the units of the reaction are.....

32) In the plot of concentratiuon of reactant versus time, the tangent at any instant of time has a..... slope (opositive or negative or zero).

33) If the rate of reaction, 4 NH_3 + O_2 $\longrightarrow$ 2 NO + 5 H_2O at any instant of time is 9×10^{-4} mol L^{-1} s^{-1}, then rate of disapperance of NH_3 is ..... .

34) The rate of reaction when the concentration of each reactant is taken as unity is called ..... .

35) In the reaction, 2 NO_2 (g) + F_2 (g) $\longrightarrow$ 2 NO_2 F (g) , order with respect to NO_2 is..... and that with respect to F_2 is ..... .

Match the following

7 × 1 = 7

36) 2 HI $\longrightarrow$ H_2 + I_2	(1) 2
37) 2 NH3 $\longrightarrow$ N_2 + 3 H_2	(2) 0
38) 2 H_2O_2 $\longrightarrow$ 2H_2O + O_2	(3) 1
39) $COCl_2$ $\longrightarrow$ CO + Cl_2	(4) $1\frac{1}{2}$
40) Zero order reactions	(5) $t_{100\%} = [A]_{0/k}$
41) First order reactions	(6) $[A] = [A]_0 e^{-kt}$
42) Second order reactions	(7) $t_{1/2} \propto \frac{1}{[A]_0}$

Assertion and reason

6 × 1 = 6

43) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion $(\mathrm{A})\ \Delta[R]$ is multiplied with -1 to make the rate of the reaction a positive quantity.

Reason (R) $\Delta[R]$ is a negative quantity in the expression, rate of disappearance of $R = \frac{-\Delta[R]}{\Delta t}$

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

44) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion (A) Some zero order reactions may have order in fractions.

Reason (R) Order cannot be determined from balanced chemical equation.

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

45) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion (A) Decomposition of gaseous ammonia on a hot platinum surface is a zero order reaction at high pressure.

Reason (R) At high pressure, the metal surface gets saturated with gas molecules.

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

46) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion (A) A catalyst increases the rate of reaction.

Reason (R) Catalyst also changes the equilibrium constant.

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

47) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion (A) A positive catalyst increases the rate of reaction.

Reason (R) A catalyst increases the rate of reaction by making available a new and more efficient mechanism.

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

48) In the following questions. an Assertion (A) is followed by a corresponding Reason (R) Use the following keys to choose the appropriate answer.

Assertion (A) Order of reaction can be zero or fractional.

Reason (R) We cannot determine order from balanced chemical equation.

Codes:

(a) Both (A) and (R) are correct, (R) is the correct explanation of (A).
(b) Both (A) and (R) are correct, (R) is not the correct explanation of (A).
(c) (A) is correct; (R) is incorrect.
(d) (A) is incorrect; (R) is correct.

4 Mark Questions

3 × 4 = 12

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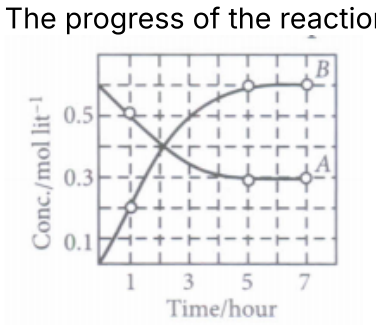
49) **Read the passage given below and answer the following questions :**

The progress of the reaction, $A \rightleftharpoons nB$ with time is represented in the following figure.



The following questions are multiple choice questions. Choose the most appropriate answer:

(i) What is the value of n?

(a) 1 **(b) 2** **(c) 3** **(d) 4**

(ii) Find the-value of the equilibrium constant

(a) 0.6 M **(b) 1.2M** **(c) 0.3M** **(d) 2.4M**

(iii) The initial rate of conversion of A will be

(a) 0.1 mol L^{-1} hr^{-1} **(b) 0.2 mol L^{-1} hr^{-1}** **(c) 0.4 mol L^{-1} hr^{-1}** **(d) 0.8 mol L^{-1} hr^{-1}**

(iv) For the reaction, if $\frac{d[B]}{dt} = 2 \times 10^{-4}$, value of $-\frac{d[A]}{dt}$ will be

(a) 2 × 10^{-4} **(b) 10^{-4}** **(c) 4 × 10^{-4}** **(d) 0.5 × 10^{-4}**

50) **Read the passage given below and answer the following questions:**

For the reaction: $2NO_{(g)} + Cl_{2(g)} \rightarrow 2NOCl_{(g)}$, the following data were collected. All the measurements were taken at 263 K.

Experiment No.	Initial [NO] (M)	Initial [Cl_2] (M)	Initial rate of disapp. of Cl_2 (M/min)
1.	0.15	0.15	0.60
2.`	0.15	0.30	1.20
3.	0.30`	0.15	2.40
4	0.25	0.25	?

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) The molecularity of the reaction is

(a) 1 **(b) 2** **(c) 3** **(d) 4**

(ii) The expression for rate law is

(a) r = k[NO] [Cl_2] **(b) r = k$[NO]^2[Cl_2]$** **(c)) r = k$[NO] [Cl_2]^2$** **(d) r = k$[NO]^2[Cl_2]^2$**

(iii) The overall order of the reaction is

(a) 2 **(b) 0** **(c) 1** **(d) 3**

(a) 150.32 M^{-2} min^{-1} (b) 200.08 M^{-1} min^{-1} (c) 177.77 M^{-2} min^{-1} (d) 155.75 M^{-1} min^{-1}

51) **Read the passage given below and answer the following questions:**

A reaction is said to be of the first order if the rate of the reaction depends upon one concentration term only. For a first order reaction of the type A $\rightarrow$ Products, the rate of the reaction is given as : rate = k[A]. The differential rate law is given as $\frac{dA}{dt} = -k[A]$ .The integrated rate law : ln $\frac{[A]}{[A]_0} = -kt$ where [A] is the concentration of reactant left at time t and $[A]_o$ is the initial concentration of the reactant, k is the rate constant.

The following questions are multiple choice questions. Choose the most appropriate answer :

(i) The unit of rate constant for a first order reaction is

(a) s^{-1} (b) mol L^{-1} s^{-1} (c) L mol^{-1} s^{-1} (d) L^2 mol^{-2} s^{-1}

(ii) Half-life period of a first order reaction is 10 min. Starting with initial concentration 12 M, the rate after 20 min is

(a) 0.693 × 3 M min^{-1} (b) 0.0693 × 4 M min^{-1} (c) 0.0693 M min^{-1} (d) 0.0693 × 3 M min^{-1}

(iii) For a first order reaction, (A) $\rightarrow$ products, the concentration of A changes from 0.1 M to 0.025 M in 40 minutes. The rate of reaction when the concentration of A is 0.01 M, is

(a) 3.47×10^{-4} M/min (b) 3.47×10^{-5} M/min (c) 1.73×10^{-4} M/min (d) 1.73×10^{-5} M/min

(iv) The half-life period of a 1^{st} order reaction is 60 minutes. What percentage will be left over after 240 minutes?

(a) 6.25% (b) 4.25% (c) 5% (d) 6%

Multiple Choice Question

30 × 1 = 30

1)
(b) A only

2)
(d) Zero order

3)
(a) 1 hour

4)
(b) 32 times

5)
(c) 16 min

6)
(c) 3

7)
(b) $6.0 \times 10^{14} s^{-1}$

8)
(b) - $-\frac{E_a}{2.303R}$

9)
(c) K_2 = 0.25 K

10)
(c) Bimolecular reactions

11)
(b) 4 years

12)
(c) 12.5 g

13)
(a) slow

14)
(b) -110 kJ mol^{-1}

15)
(a) H_2SO_4 is stronger than HCl

16)
(c) activation energy of reaction

17)
(c) remains unchanged

18)
(b) determining the rate constants at two temperatures

19)
(b) k = $\frac{2.303}{t} log \frac{p_i}{2p_i - p_i}$

20)
(d) Rate constant increases exponentially with decreasing activation energy and increasing temperature

21)
(d) $\frac{d[Br_2]}{dt} = -\frac{3}{5}\frac{d[Br^-]}{dt}$

22)

k

23)

(c) 1, 3, 2

24)

(d) 16

25)

(c) 1/2

26)

(a) increasing the temperature

27)

(a) mol L^{-1} s^{-1}

28)

(a) 2×10^{-2} sec^{-1}

29)

(c) third

30)

(c) three and three

Fill up / 1 Marks

5 × 1 = 5

31)

atm time $^{-1}$ or bar time $^{-1}$, e.g., atm s^{-1} or bar min^{-1} etc.

32)

negative

33)

3.6×10^{-3} mol L^{-1} s^{-1}

34)

rate constant or specific reaction rate

35)

1 , 1

Match the following

7 × 1 = 7

36)

2

37)

0

38)

1

39)

$1\frac{1}{2}$

40)

$t_{100\%} = [A]_{0/k}$

41)

$[A] = [A]_0 e^{-kt}$

42)

$t_{1/2} \propto \frac{1}{[A]_0}$

Assertion and reason

6 × 1 = 6

43)

(a) Rate of disappearance of $R = \frac{-\Delta[R]}{\Delta t}$

Since,$\Delta[R]$ is a negative quantity, it is multiplied with -1 to make the reaction rate a positive quantity. Hence, both (A) and (R) are correct and (R) is the correct explanation of (A).

44)

(d) Only reactions with zero order do not have the order in fractions. Thus, (A) is incorrect but (R) is correct.

45)

(a) It is a zero order reaction at high pressure.

$2\mathrm{NH_3}(g) \frac{1130\ \mathrm{K}}{\text{Pt catalyst}} \mathrm{N_2}(g) + 3\mathrm{H_2}(\ \mathrm{g})$

$\text{Rate } = k[\mathrm{NH_3}]^0 = k$

In this reaction, Pt acts as a catalyst the metal surface gets saturated with gas molecules at high pressure. Thus, a further change in reaction conditions does not alter the amount of ammonia on the surface of the catalyst making rate of the reaction independent of its concentration. Thus, both (A) and (R) are correct and (R) is the correct explanation of (A).

46)

not change the equilibrium constant rather, it helps in attaining the equilibrium faster, i.e. it catalyses the forward and backward directions both to the same extent so that the equilibrium state remains same and is achieved earlier. Thus, (A) is correct but (R) is incorrect.

47)

(a) A positive catalyst increases rate of reaction by making a new and more efficient mechanism. Thus, both (A) and (R) are correct and (R) is the correct explanation of (A).

48)

(b) Order of reaction can be zero or fractional as order of reaction is directly related to sum of power of reactants. Hence, both (A) and (R) are correct and (R) is the correct explanation of (A).

4 Mark Questions

3 × 4 = 12

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49)

(i) (b) : According to the figure, in the given time of 4 hours (1 to 5) concentration of A falls from 0.5 to 0.3 M, while in the same time concentration of B increases from 0.2 to 0.6 M.
Decrease in concentration of A in 4 hours
= 0.5 - 0.3 = 0.2 M
Increase in concentration of B in 4 hours
= 0.6 - 0.2 = 0.4 M
Thus, increase in concentration of B in a given time is twice the decrease in concentration of A. Thus, n = 2

(ii) (b) : $K = \frac{[B]^2}{[A]} = \frac{(0.6)^2}{0.3} = 1.2\text{M}$

(iii) (a) : From t = 0 to t = 1 hr,
For A, dx = 0.6 - 0.5 = 0.1 mol L^{-1}
$\therefore$ Initial rate of conversion of $A = \frac{dx}{dt}$
$= \frac{0.1 \text{ mol L}^{-1}}{1\text{hr}} = 0.1 \text{ mol L}^{-1}\text{hr}^{-1}$

(iv) (b) : $A \rightleftharpoons 2B$
$-\frac{d[A]}{dt} = +\frac{1}{2}\frac{d[B]}{dt} = \frac{1}{2} \times 2 \times 10^{-4} = 10^{-4}$

50)

(i) (c) : $2\text{NO}_{(g)} + \text{Cl}_{2(g)} \rightarrow 2\text{NOCl}_{(g)}$
Molecularity = 3

(ii) (b) : Let rate of this reaction, r = $k[NO]^m[Cl_2]^n$ then $\frac{r_1}{r_2} = \frac{0.60}{1.20} = \frac{k(0.15)^m(0.15)^n}{k(0.15)^m(0.30)^n}$
or $\frac{1}{2} = \left(\frac{1}{2}\right)^n \Rightarrow n = 1$
Again from $\frac{r_2}{r_3} = \frac{1.20}{2.40} = \frac{k(0.15)^m(0.30)^n}{k(0.30)^m(0.15)^n}$
or $\frac{1}{2} = \left(\frac{1}{2}\right)^m \cdot \frac{2}{1}$ or $\frac{1}{4} = \left(\frac{1}{2}\right)^m \Rightarrow m = 2$
Hence, expression for rate law is
r = $k[NO]^2[Cl_2]^1$

(iii) (d) : As the order W.r.t. NO is 2 and order W.r.t. Cl_2 is 1, hence the overall order is 3.

(iv) (c) : Substituting the values of experiment 1 in rate law expression
0.60 M min^{-1} = k(0.15 M)^2 (0.15 M)^1
or $k = \frac{0.60\text{Mmin}^{-1}}{0.0225 \times 0.15\text{M}^3} = 177.77\text{M}^{-2}\text{ min}^{-1}$

51)

(i) (a) : Unit of rate constant for a reaction of n^{th} order = (conc.)$^{1-n}$ time^{-1}
For a first order reaction, n = 1
Unit of rate constant = (mol L^{-1})$^{1-1}$ s^{-1}= s^{-1}

(ii) (d) : $\underset{\text{Initial conc.}}{12\text{M}} \xrightarrow{t_{1/2}} 6\text{M} \xrightarrow{t_{1/2}} 3\text{M}$
$t_{1/2}$ = 10 min
$k = \frac{0.693}{10} = 0.0693 \text{ min}^{-1}$
As $t_{1/2}$ is 10 min, after 20 minutes the concentration will be 3 M.
Hence, Rate = 0.0693 × 3 M min^{-1}

(iii) (a) : For the first order reaction,
$k = \frac{2.303}{t}\log\frac{a}{a-x}$
a = 0.1 M, a - x = 0.025 M, t = 40 min
$k = \frac{2.303}{40}\log\frac{0.1}{0.025} = \frac{2.303}{40}\log 4 = 0.0347 \text{ min}^{-1}$
$[A] \rightarrow \text{ product}$
Thus, rate = k[A]
rate = 0.0347 × 0.01 M min^{-1}= 3.47 × 10^{-4} M min^{-1}

(iv) (a) : $t_{1/2} = \frac{0.693}{k} \Rightarrow \frac{0.693}{t_{1/2}} = k \Rightarrow \frac{0.693}{60} = k$
k = 0.01155 min^{-1}
$k = \frac{2.303}{t}\log\left(\frac{a}{a-x}\right)$
Let the initial amount (a) be 100
$0.01155 \text{ min}^{-1} = \frac{2.303}{240 \text{ min}}\log\left(\frac{100}{a-x}\right)$
1.204 = log100 - log(a-x)
1.204 = 2 - log(a-x)
log (a - x) = 2 - 1.204 = 0.796
(a - x) = 6.25%