Blue Print (As per PU Board)

Topic	1 mark questions	2 marks questions	3 marks questions	5 marks questions	Total Marks
Chemical Kinetics	1	1	–	1	8

One mark questions

1. **The unit of rate constant of a reaction is $mol^{-1}Ls^{-1}$. What is the order of the reaction?**
   Answer: Second order or 2
2. **What happens to the half-life period for a first order reaction, if the initial concentration of the reactants is increased?**
   Answer: No change or remains constant
   Answer: A
3. **Give an example of a zero-order reaction**
   Answer: Decomposition of hydrogen iodide on the surface of gold

Two marks questions

4. **A reaction is first order with respect to the reactant and A and second order w.r.t the reactant B in a reaction, $A+B\rightarrow$product.**
   (i) Write the differential rate equation
   (ii) How is the rate of the reaction affected on increasing the concentration of B by 2 times?
   Answer: (i) $\frac{dx}{dt}=k[A][B]^2$ (1 mark)
   (ii) $\frac{dx}{dt}=k[A][2B]^2=4\,\text{times}$ (1 mark)
5. **Define collision frequency. Give an example for pseudo-first order reaction**
   Answer: It is the number of collisions per second per unit volume of the reaction mixture. (1 mark)
   Acid hydrolysis of ester or
   $CH_3COOC_2H_5+H_2O\xrightarrow{H^+}CH_3COOH+C_2H_5OH$ (1 mark)
   or Inversion of cane sugar or
   $C_{12}H_{22}O_{11}+H_2O\xrightarrow{H^+}C_6H_{12}O_6+C_6H_{12}O_6$
6. **Given $2NO_{(g)}+O_{2(g)}\rightarrow 2NO_{2(g)}$; rate $=k[NO]^2[O_2]^1$**
   By how many times does not rate of the reaction change when the volume of the reaction vessel is reduced to $\frac{1}{3}^{\text{rd}}$ of its original volume? Will there be any change in the order of the reaction?
   Answer: Rate $=k[NO]^2[O_2]^1$
   $=k[3]^2[3]^1=27$ times (1 mark)
   There will be no change in the order. (1 mark)

Three marks questions

7. **A certain first order reaction is half completed in 46 mins. Calculate the rate constant and also time taken for 75% completion of the reaction.** (3 marks)
   Answer: $k=\frac{0.693}{t_{1/2}}$
   $=\frac{0.693}{46}=0.015\,\text{min}^{-1}$ (1 mark)
   To find $t_{75\%}$, $[R]_0=100$

$[R] = 25$

$\therefore t_{75\%} = \frac{2.303}{k}.\log\frac{[R_0]}{[R]}$ (1 mark)

$= \frac{2.303}{0.015}.\log\frac{100}{25} \quad = 92.02\,\text{mins}$ (1 mark)

8. **Show that in case of a first order reaction, the time taken for completion of 99.9% reaction is ten times the time required for half change of the reaction.** (3 marks)

Answer: To show that $t_{99.9\%} = 10t_{50\%}$ (1 mark)

For $\frac{t_{99.9\%}}{t_{50\%}} = \frac{\frac{2.303}{k}\log\frac{[R_0]}{[R]}}{\frac{0.693}{k}}$ (1 mark)

$= \frac{2.303.\log\frac{100}{0.1}}{0.693}$

$= \frac{2.303\times 3}{0.693} = 9.96 \simeq 10$ (1 mark)

$\therefore \quad t_{99.9\%} = 10t_{50\%}$

9. **The half-life for radioactive decay of ^{14}C is 5730 years. An archaeological artifact containing wood had only 80% of the ^{14}C found in a living tree. Estimate the age of the sample.** (3 marks)

Answer: Radioactive decay follows first order kinetics

$\therefore$ Decay constant $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{5730}\,\text{yr}^{-1}$ (1 mark)

$t = \frac{2.303}{k}.\log\frac{[R_0]}{[R]}$

$= \frac{2.303}{\frac{0.693}{5730}}\log\left(\frac{100}{80}\right)$ (1 mark)

$= \frac{2.303\times 5730}{0.693}\times 0.0969 \; = 1845\,\text{years}$ (1 mark)

Five marks questions

10. **(a) Derive integrated rate equation for the first order reaction.** (3 marks)
(b) According to collision theory, what are the two factors that lead to effective collision? (2 marks)

Answer: (a) The rate of reaction is directly proportional to the I power of the concentration of reactant $R \;\; R - P$

Rate $= \frac{-d[R]}{dt} = k[R]$ (1 mark)

$\frac{d[R]}{dt} = -k[R]$ or $\frac{d[R]}{[R]} = -k.dt$

Integrating both sides, $\int\frac{d[R]}{[R]} = -\int k.dt$

$\ell n[R] = -k\cdot t + I$ (1) where I = integration constant (1 mark)

when $t = 0$, $[R] = [R]_0 \qquad \therefore I = \ell n[R]$

substituting in (1) we get

$\ell n[R_0] - \ell n[R] = kt$

$\ell n\frac{[R]_0}{[R]} = kt$ or $k = \frac{1}{t}\ell n\frac{[R]_0}{[R]}$ or $k = \frac{2.303}{t}.\log\frac{[R]_0}{[R]}$ (1 mark)

(b) (1) Activation energy (1 mark)

(2) Proper orientation of the colloiding molecules (1 mark)

11. **(a) The rate of a particular reaction doubles when the temperature changes from 300 K to 310 K. calculate the energy of activation of the reaction [given $R = 8.314\, JK^{-1}mol^{-1}$]** (3 marks)

(b) Show that the half-life period of a first order reaction is independent of initial concentration of reacting species. (2 marks)

Answer: (a) $\log\frac{k_2}{k_1} = \frac{Ea}{2.303R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$ (1 mark)

$Ea = \frac{2.303 \times 8.314 \times 310 \times 300}{10}.\log\frac{2}{1}$ (1 mark)

$Ea = 53598.59\, J$ or $53.598\, kJ$ (1 mark)

(b) $k = \frac{2.303}{t}\log t\frac{[R_0]}{[R]}$ …(1) (1 mark)

When $t = t_{1/2}, [R] = \frac{[R_0]}{2}$

Substituting in (1), $t_{1/2} = \frac{0.693}{k}$ (1 mark)

12. **Rate constant of a first order reaction $0.0693 \min^{-1}$. Calculate the percentage of the reactant remaining at the end of 60 minutes** (3 marks)

Answer: $k = \frac{2.303}{t}.\log\frac{[R_0]}{[R]}$ (1 mark)

$0.0693 = \frac{2.303}{60}\log\frac{100}{[R]}$ (1 mark)

$[R] = 1.56\%$ (1 mark)

OR

Alternate method:

Half-life $= \frac{0.693}{0.0693} = 10$ (1 mark)

60 mins means 6 half-lives (1 mark)

$\therefore$ Reactant remaining at the end of 60 mins

$= 100 \times \frac{1}{2^6} = 1.56\%$ (1 mark)

(b) Show that half-life period for a zero order reaction is directly proportional to initial concentration. (2 marks)

Answer: $k = \frac{[R_0] - [R]}{t}$ for a zero order reaction

At $t = t_{1/2}; [R] = \frac{1}{2}[R_0]$ (1 mark)

$\therefore\ k = \frac{[R_0] - \frac{1}{2}[R_0]}{t_{1/2}} \Rightarrow t_{1/2} = \frac{[R_0]}{2k}$ or $t_{1/2} \propto [R_0]$ (1 mark)