

# SOLUTIONS

## Module - 4 / JEE-2021

IN-CHAPTER EXERCISES	Chemistry	Chemical Kinetics
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### EXERCISE-A

1.  $\text{Rate} = k [\text{P}] [\text{Q}] \Rightarrow \text{Overall order} = 1 + 1 = 2$

Exp. (i) and (ii), [P] is kept constant and [Q] is doubled, rate is also doubled.

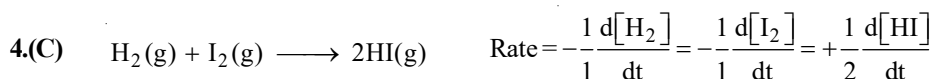
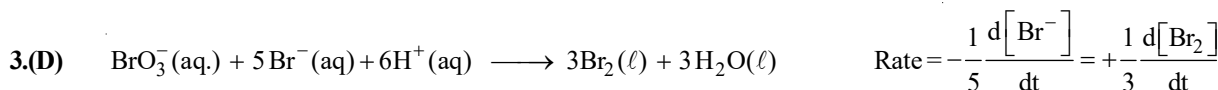
Exp. (i) and (iii), [Q] is kept constant and [P] is doubled, rate is also doubled.

From (i),  $0.0012 = k \times 6 \times 10^{-2} \times 10^{-2} \Rightarrow k = 2 \text{ L mol}^{-1} \text{ min}^{-1}$

2.  $\text{Rate} = k [\text{A}] [\text{B}]^0$

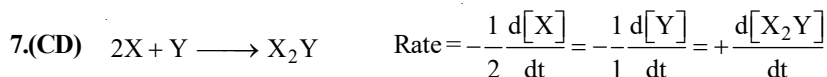
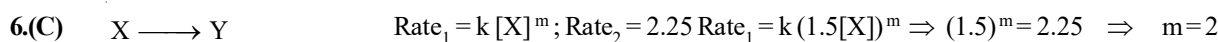
Exp. (i) and (ii), [B] is kept constant and [A] is doubled, rate is also doubled.

Exp. (i) and (iii), [A] is kept constant and [B] is doubled, rate remains unchanged.



Now,  $\frac{d[\text{H}_2]}{dt} = -10^{-4} \text{ Ms}^{-1} \Rightarrow \frac{d[\text{I}_2]}{dt} = 2 \times 10^{-4} \text{ Ms}^{-1}$

5.(D)  $\text{Rate}_{\text{old}} = k [\text{A}]^n [\text{B}]^m$  ;  $\text{Rate}_{\text{New}} = k (2[\text{A}])^n \left(\frac{[\text{B}]}{2}\right)^m = k \cdot 2^{n-m} [\text{A}]^n [\text{B}]^m \Rightarrow \frac{\text{Rate}_{\text{new}}}{\text{Rate}_{\text{old}}} = 2^{n-m}$



8.(A)  $\text{Rate} = k [\text{A}]^m \left( \text{A} \xrightarrow{k} \text{B} \right) \Rightarrow \text{Units of Rate and } k \text{ are same if } m = 0.$

### EXERCISE-B

1. No. of half lives =  $\frac{11540}{5770} = 2 \Rightarrow \frac{N_t}{N_0} = \left(\frac{1}{2}\right)^2 = \frac{1}{4} = \text{fraction left}$

2.  $t_{1/2} = 3 \text{ hrs} ; t = 15 \text{ hrs} \Rightarrow \text{No. of half lives} = \frac{15}{3} = 5$

$\Rightarrow \frac{n_t}{n_0} = \left(\frac{1}{2}\right)^5 = \frac{1}{32} \Rightarrow g_{\text{left}} = \frac{1}{32} \times 100 \text{ gm} = 3.125 \text{ gm}$

3.  $k_{27^\circ\text{C}} = \frac{0.693}{5 \times 10^3} \text{ s}^{-1} ; k_{37^\circ\text{C}} = \frac{0.693}{10^3} \text{ s}^{-1}$

$\Rightarrow \frac{k_{37^\circ\text{C}}}{k_{27^\circ\text{C}}} = 5 \Rightarrow \log_{10} \frac{k_2}{k_1} = \log_{10} 5 = \frac{E_a}{2.303 \times 2} \times \frac{(310 - 300)}{300 \times 310} \Rightarrow E_a = 299.85 \text{ kcal mol}^{-1}$

$$4. \quad t_{99.9\%} = \frac{2.303}{k} \log_{10} \frac{C_0}{C_0 - 0.999C_0} = \frac{2.303}{k} \log_{10} 1000 = \frac{3 \times 2.303}{k}$$

$$t_{1/2} = \frac{2.303 \log_{10} 2}{k} \Rightarrow \frac{t_{99.9\%}}{t_{1/2}} = \frac{3}{\log_{10} 2} \approx 10$$

$$5. \quad k \times 8 = \log_e \frac{C_0}{C_0 - 0.4C_0} = \ln \frac{5}{3} \quad \text{and} \quad k \times t = \log_e \frac{C_0}{C_0 - 0.9C_0} = \ln 10 \quad \left. \vphantom{\frac{C_0}{C_0 - 0.9C_0}} \right\} t = 36.06 \text{ min}$$

$$6. \quad k = Ae^{-E_a/RT} \quad \text{Here: } \frac{E_a}{RT} = \frac{187.06 \times 10^3}{8.314 \times 750} \approx 30 \Rightarrow k = 1.97 \times 10^{12} \times e^{-30} = 0.184 \text{ s}^{-1} \quad \text{and} \quad t_{1/2} = \frac{0.693}{k} = 3.76 \text{ s}$$

$$7. \quad \text{Use: } \log_{10} \frac{k_2}{k_1} = \frac{E_a}{2.303R} \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \quad \text{and} \quad \log_{10} 2.5 = 0.4 \quad \text{and} \quad \log_{10} 2 = 0.3$$

$$8. \quad k \times 10 = \ln \frac{C_0}{C_0 - 0.2C_0} = \ln \frac{5}{4} \Rightarrow k = 0.022 \text{ min}^{-1} ; \quad k \times t = \ln \frac{C_0}{C_0 - 0.75C_0} = \ln 4 \Rightarrow t = 62.16 \text{ min}$$

$$9.(D) \quad \log_{10} k = \log_{10} A - \frac{E_a}{2.303RT} \Rightarrow \text{Slope of } \log_{10} k \text{ vs. } \frac{1}{T} \text{ is: } S = \frac{E_a}{2.303R} \Rightarrow E_a = 2.303 \text{ RS}$$

$$10.(A) \quad (E_a)_b < (E_a)_f \text{ in case of endothermic reaction.} \quad (E_a)_b > (E_a)_f \text{ in case of exothermic reaction.}$$

$$11.(A) \quad \log_{10} \frac{k_2}{k_1} = \log_{10} 2 = \frac{E_a}{2.303 \times R} \times \frac{(310 - 300)}{310 \times 300} \Rightarrow E_a = 12.89 \text{ kcal mol}^{-1}$$

$$12.(A) \quad \left. \begin{array}{l} 0.06 \text{ M} \xrightarrow{10\text{hr}} 0.03 \text{ M} \\ 0.12 \text{ M} \xrightarrow{10\text{hr}} 0.06 \text{ M} \end{array} \right\} \text{Half life is same} \Rightarrow \text{First order reaction.}$$

$$13.(D) \quad \text{Spontaneity doesn't relate to the rate of a chemical reaction.}$$

$$14.(B) \quad \log_e \frac{C_0}{C_0 - x} \text{ vs. } t \text{ is linear for a first order reaction.}$$

$$15.(B) \quad k = Ae^{-E_a/RT} \Rightarrow 'A' \text{ has same units as 'k'}$$

$$16.(C) \quad \left. \begin{array}{l} C_0 = 0.1 \text{ M} \longrightarrow t_{1/2} = 200 \text{ s} \\ C_0 = 0.5 \text{ M} \longrightarrow t_{1/2} = 40 \text{ s} \end{array} \right\} \Rightarrow t_{1/2} \propto C_0^{-1} \Rightarrow 2^{\text{nd}} \text{ order reaction.}$$

$$17.(D) \quad k = Ae^{-E_a/RT} \Rightarrow k \text{ will be least when } E_a \text{ is high and } T \text{ is low.}$$

$$18.(C) \quad A \longrightarrow B \quad \Rightarrow k \times 1 = \ln \frac{0.8}{0.2} = \ln 4$$

$$\begin{array}{lll} t = 0 \text{ (moles)} & 0.8 & - \\ t = 1 \text{ hr} & 0.2 & 0.6 \end{array}$$

$$A \longrightarrow B \quad \Rightarrow k \times 1 = \ln \frac{0.9}{0.225} = \ln 4$$

$$\begin{array}{lll} t = 0 \text{ (moles)} & 0.9 & - \\ t = t \text{ hr} & 0.225 & 0.675 \end{array} \quad \Rightarrow t = 1 \text{ hr}$$

## EXERCISE-C

1. Radioactive decay follows first order kinetics.

$$\therefore t_{1/2} = \frac{\ln 2}{\lambda}, \text{ where } \lambda = \text{disintegration constant or rate constant.}$$

$$\Rightarrow \lambda = \frac{\ln 2}{3.8} = 0.18 \text{ day}^{-1}$$

Let No. be the initial nuclei at time  $t = 0$

$$N_t = \frac{1}{20} N_0 \text{ at time } t$$

$$\therefore \ln \frac{N_0}{N_t} = \lambda t$$

$$\Rightarrow \ln 20 = 0.18 t \quad \Rightarrow \quad t = 16.63 \text{ days}$$

2.  $\ln \frac{N_0}{N_t} = \lambda t$

$$\Rightarrow \ln \frac{N_0}{N_0/64} = \lambda \times 2 \quad \Rightarrow \quad \lambda = 2.08 \text{ hr}^{-1}$$

$$t_{1/2} = \frac{\ln 2}{2.08} = 0.33 \text{ hr.}$$

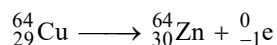
3.(C) Mean life =  $\frac{1}{\lambda}$

$$\therefore \frac{\ln 2}{\lambda_X} = \frac{1}{\lambda_Y} \quad \Rightarrow \quad \lambda_X = \ln 2 \times \lambda_Y$$

$$\Rightarrow \lambda_X < \lambda_Y \Rightarrow \text{Rate of decay of } X = \lambda_X N_0 < \text{Rate of decay of } Y = \lambda_Y N_0$$

- 4.(A) All these particles have same energy –  $1/2 mv^2$ .  $\therefore$  Lower the mass, greater will be the velocity for the same energy  $\Rightarrow$  More will be the penetrating power. Here,  $\alpha$  has the highest mass whereas  $\gamma$  has the least mass.

- 5.(D) Nucleus containing even no. of neutrons and protons is stable.  ${}^{64}_{29}\text{Cu}$  has odd no. of neutrons and protons and  $\therefore$  decays to  ${}^{64}_{30}\text{Zn}$  which has even no. of neutrons and protons.



6.(D) For  $X_1 \Rightarrow N_t^1 = N_0 e^{-10\lambda t}$

$$X_2 \Rightarrow N_t^2 = N_0 e^{-\lambda t}$$

At time  $t$ ,  $\frac{N_t^1}{N_t^2} = \frac{1}{e}$

$$\Rightarrow e^{-9\lambda t} = e^{-1} \quad \Rightarrow \quad t = \frac{1}{9\lambda}$$

7.(C) Neutrons transform into a proton within the nucleus emitting an  $e^-$ .

8.(B) Half life  $t_{1/2} = 140$  days

After 280 days, i. e. two half - lives

$$A_t = 6000 \text{ dps}$$

$$\text{As } \frac{A_0}{A_t} = 2^n$$

$$n = 2$$

$$\therefore \frac{A_0}{6000} = 2^2 = 4$$

$$\Rightarrow A_0 = 24000 \text{ dps}$$

9.(CD) For  ${}^1_1\text{H}$ , mass number = atomic number and usually, mass number > atomic number

10.(D) Nuclear fusion process involves combining of two or more light nuclei into heavier nucleus.

11.(B) For a first order kinetics.

$$t_{1/2} = \frac{\ln 2}{\lambda} \text{ and mean - life } \tau = \frac{1}{\lambda} \left[ \frac{\int_0^{\infty} \lambda t N_0 e^{-\lambda t} dt}{N_0} \right]$$

12.(C) Let 1 gm of Rn is allowed to decay.

After five minutes, (i.e.  $5 \times 60$  seconds)

$$\text{mass of Rn left} = 1 \times e^{-\frac{\ln 2}{55} \times 5 \times 60}$$

$$= 0.023 \text{ gms.}$$

Since, decay constant of  $\text{Po}$  is  $43.32\text{s}^{-1}$ ,  $\therefore$  as soon as  $\text{Po}$  is formed, it decays into  $\text{Pb}$ .  $\therefore$  All of  $\text{Po}$  is converted to  $\text{Pb}$  which then decays to  $\text{Bi}$ .

Also, since  $t_{1/2}$  for decay of  $\text{Pb}$  is 10.6 hrs.,

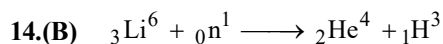
$\therefore$  in five minutes, negligible amount of  $\text{Pb}$  is decayed

$\therefore$  After five minutes,

$$\text{mass of Po left} \approx 0 \text{ gm}$$

$$\text{mass of Pb left} \approx 1 - 0.023 \text{ gms} \approx 0.977 \text{ gms.}$$

13.(B) Because of higher n/p ratio  ${}^{29}_{13}\text{Al}$  disintegrate by  $\beta$ -emission.



$$N_0 \equiv x \quad 0$$

$$N_t \equiv x - y \quad y$$

$$\Rightarrow \frac{N_0}{N_t} = \frac{x}{x-y} \quad \text{Also, given : } \frac{x-y}{y} = 3$$

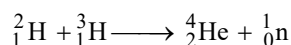
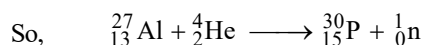
$$\therefore \frac{x}{x-y} = \frac{4}{3}$$

$$\Rightarrow \log \frac{N_0}{N_t} = \frac{\ln 2}{k} \times \frac{1}{2.303} \times t$$

$$\Rightarrow \log \frac{4}{3} = \frac{\ln 2}{4.5 \times 10^9} \times \frac{1}{2.303} \times t$$

$$\Rightarrow t = 1.85 \times 10^9 \text{ years}$$

**16.(AC)** When neutron ( ${}_0^1\text{n}$ ) is emitted, then atomic no. remains same but mass no. decreases by 1.



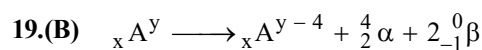
**17.(B)** For stable nucleus, we have

$$1 \leq \frac{n}{p} \leq 1.5$$

$$\Rightarrow \frac{p}{n} \leq 1$$

$\therefore$  For instability,  $\frac{p}{n} \geq 1$  i.e. high proton to neutron ratio.

**18.(D)** Nucleus decays into proton and emits an electron.



$\therefore$  Atomic number remains same but mass number Change.

**20.(D)** According to group displacement law.