Fill Ups of Chemical Kinetics & Nuclear Chemistry

Fill in the Blanks

1. An element $^{A}_{Z}M$ undergoes an α-emission followed by two successive β-emissions. The element formed is ..... . (1982 - 1 Mark)

Ans: $^{A-4}_{Z}M$

Solutions :

TIPS/Formulae :
When an element emits **α** -particle atomic mass decreases by four and atomic number decreases by two. Loss of β - particle results in increase in atomic number by 1 and no change in atomic mass.

$$^{A}_{Z}M \xrightarrow{-\alpha} {}^{A-4}_{Z-2}X \xrightarrow{-\beta} {}^{A-4}_{Z-1}Y \xrightarrow{-\beta} {}^{A-4}_{Z}M$$

2. The rate of chemical change is directly proportional to ..... . (1985 - 1 Mark)

Ans: Product of active masses of reactants at that temperature

Solutions : Product of active masses of reactants at that time

3. The number of neutrons in the parent nucleus which gives $^{14}_{7}N$ on beta emission is ..... . (1985 - 1 Mark)

Ans: 8

Solutions : $8;\ ^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$. 2 particles.

4. The hydrolysis of ethyl acetate in ..... medium is a ..... order reaction. (1986 - 1 Mark)

Ans: acidic, first (or basic, second)

5. A radioactive nucleus decays emitting one alpha and two beta particles; the daughter nucleus is ..... of the parent. (1989 - 1 Mark)

Ans: Isotope

Solutions: Isotope; (because new atom has same atomic number but different atomic mass).

6. For the reaction N2 (g) + 3H_2 (g) → 2NH_3 (g), under certain conditions of temperature and partial pressure of the reactants, the rate of formation of NH^3 is 0.001 kg h^{-1}. The rate of conversion of H_2 under the same condition is.....kg h^{-1}.

Ans: 1.765×10^{-4} kg/hr

Solutions: N_2 (g) + 3H_2 (g) ⟶ 2NH_3 (g)

Here Rate of reaction = 1/3 [Rate of disappearance of H_2] = 1/2 [Rate of appearance of NH_3]

$$\text{or} \quad \frac{1}{3}\frac{d[H_2]}{dt} = \frac{1}{2}\frac{d[NH_3]}{dt} \quad \Rightarrow \quad \frac{d[H_2]}{dt} = \frac{3}{2}\frac{d[NH_3]}{dt}$$

$$\frac{d[NH_3]}{dt} = 0.01 \text{ kg/hr} = \frac{0.001}{17} \times 1000 = \frac{1}{17} \text{ mole/hr}$$

$$\therefore \frac{d[H_2]}{dt} = \frac{1}{17} \times \frac{3}{2} = \frac{3}{34} \text{ mole/hr} = \frac{3}{34} \times \frac{2}{1000} \text{ kg/hr}$$

$= 1.765 \times 10^{-4}$ kg/hr.

7. In the Arrhenius equation, $k = A \exp(-E_a/RT)$, A may be termed as the rate constant at ..... . (1997 - 1 Mark)

Ans: very high temperature or zero activation energy

Solutions: very high temperature (T=∞) or zero activation energy

True False of Chemical Kinetics & Nuclear Chemistry

True / False

1. For a first order reaction, the rate of the reaction doubles as the concentration of the reactant (s) doubles. (1986 - 1 Mark)

Ans: True

Solution: True: The rate of reaction of first order is directly proportional to the concentration of reacting substance

2. Catalyst makes a reaction more exothermic. (1987 - 1 Mark)

Ans: False

Solution: False : Catalyst does not make a reaction more exothermic, but decreases the activation energy and hence increase the rate of reaction.

3. Catalyst does not affect the energy of activation in a chemical reaction. (1989 - 1 Mark)

Ans: False

Solution: False: Catalyst lowers the energy of activation and therefore influences the rate as well as rate constant of the reaction.

4. In β-emission from a nucleus the atomic number of the daughter element decreases by one. (1990 - 1 Mark)

Ans: False

Solution: False: In β-emission $(_{-1}e^{0})$ the atomic number of the daughter nuclei increases by 1.

5. The rate of an exothermic reaction increases with increasing temperature. (1990 - 1 Mark)

Ans: True

Solution: True: The rate of a reaction increases with increase in temperature because at higher temperature more number of molecules attain the activation energy.

Integer Type ques of Chemical Kinetics & Nuclear Chemistry

Integer Value Correct Type

1. The total number of a and b particles emitted in the nuclear reaction $^{238}_{92}U \rightarrow {}^{214}_{82}Pb$

Ans: 8

Solution : $_{92}U^{238} \xrightarrow{-6\alpha} {}_{80}X^{214} \xrightarrow{-2\beta} {}_{82}Pb^{214}$

Hence total number of particles emitted are 2 +6 = 8

2. The concentration of R in the reaction R → P was measured as a function of time and the following data is obtained:

[R] (molar)	1.0	0.75	0.40	0.10
t(min.)	0.0	0.05	0.12	0.18

The order of reaction is (2010)

Ans: 5

Solution: The integrated form of a zero-order reaction is

$[A_0] - [A_t] = k_0 t$; $1.0 - 0.75 = k_0 \times 0.05$, $k_0 = 5$

Again, $1.0 - 0.4 = k_0 \times 0.12$, $k_0 = 5$

3. The number of neutrons emitted when $^{235}_{92}U$ **undergoes controlled nuclear fission to** $^{142}_{54}Xe$ **and** $^{90}_{38}Sr$ **is (2010)**

Ans: 3

Solution: $_{92}U^{235} \rightarrow {}_{54}Xe^{142} + {}_{38}Sr^{90} + y_0n^1$

235 = 142 + 90 + y Þ y = 3.

The number of neutrons emitted are 3.

4. An organic compound undergoes first-order decomposition. The time taken for its decomposition to 1/8 and 1/10 of its initial concentration are $t_{1/8}$ and $t_{1/10}$ respectively. What is the value of $\left[\frac{t_{1/8}}{t_{1/10}}\right] \times 10 \, ? \, (\log_{10} 2 = 0.3)$ (2012)

Ans: 9

Solution : $t_{1/8} = \frac{2.303 \log 8}{k} = \frac{2.303 \times 3 \log 2}{k}$

$$t_{1/10} = \frac{2.303}{k} \log 10 = \frac{2.303}{k}$$

$$\left[\frac{t_{1/8}}{t_{1/10}}\right] \times 10 = \frac{\left(\frac{2.303 \times 3 \log 2}{k}\right)}{\left(\frac{2.303}{k}\right)} \times 10 = 9$$

5. The periodic table consists of 18 groups. An isotope of copper, on bombardment with protons, undergoes a nuclear reaction yielding element X as shown below. To which group, element X belongs in the periodic table? (2012)

$${}^{63}_{29}\mathrm{Cu} + {}^{1}_{1}\mathrm{H} \rightarrow 6\,{}^{1}_{0}n + {}^{4}_{2}\alpha + 2\,{}^{1}_{1}\mathrm{H} + \mathrm{X}$$

Ans: 8

Solution : ${}^{63}_{29}\mathrm{Cu} + {}^{1}_{1}\mathrm{H} \rightarrow 6\,{}^{1}_{0}n + {}^{4}_{2}\mathrm{He} + 2\,{}^{1}_{1}\mathrm{H} + {}^{A}_{Z}\mathrm{X}$

Balancing the atomic mass and atomic number

$63 + 1 = (6 \times 1) + 4 + 2 + A \Rightarrow A = 52$

$29 + 1 = (6 \times 0) + 2 + 2 + Z \Rightarrow Z = 26$

Thus, ${}^{A}_{Z}\mathrm{X} = {}^{52}_{26}\mathrm{X}$ or ${}^{52}_{26}\mathrm{Fe}$

Hence, X belongs to group 8 in the periodic table.

6. A closed vessel with rigid walls contains 1 mol of $^{238}_{92}U$ and 1 mol of air at 298 K. Considering complete decay of $^{238}_{92}U$ to $^{206}_{82}Pb$, the ratio of the final pressure to the initial pressure of the system at 298 K is (JEE Adv. 2015)

Ans: 9

Solution : Number of moles in gas phase, at start (n_i) = 1

$$^{238}_{92}U \rightarrow ^{206}_{82}Pb + 8^{4}_{2}He + 6^{0}_{-}\beta$$

Now number of moles in gas phase, after decomposition (n_F)

= 1 + 8 = 9 mole

at constant temperature and pressure

$$\frac{P_F}{P_{in}} = \frac{n_F}{n_{in}} = \frac{9}{1} = 9$$

7. In dilute aqueous H_2SO_4, the complex diaquodioxalatoferrate(II) is oxidized by MnO_4^-. For this reaction, the ratio of the rate of change of $[H^+]$ to the rate of change of

Ans: 8

Solution :

$$8H^+ + 5[Fe(H_2O)_2(OX)_2]^{2-} + MnO_4^- \rightarrow Mn^{2+} + 5[Fe(H_2O)_2(OX)_2]^- + 4H_2O$$

$$\text{Rate} = \frac{1}{8}\frac{d[H^+]}{dt} = -\frac{d[MnO_4^-]}{dt}$$

$$\text{Hence, } \frac{\text{rate of } [H^+] \text{decay}}{\text{rate of } [MnO_4^-] \text{ decay}} = 8$$

Subjective Qus. of Chemical Kinetics & Nuclear Chemistry, Past year Qus. (Part - 1)

1. Rate of a reaction A + B → products, is given below as a function of different initial concentrations of A and B : (1982 - 4 Marks)

[A] (mol/l)	[B] (mol/l)	Initial rate (mol/l/min)
0.01	0.01	0.005
0.02	0.01	0.010
0.01	0.02	0.005

Determine the order of the reaction with respect to A and with respect to B. What is the half-life of A in the reaction?

Solution:

2. Radioactive decay is a first order process. Radioactive carbon in wood sample decays with a half life of 5770 years. What is the rate constant (in years^{-1}) for the decay? What fraction would remain after 11540 years? (1984 - 3 Marks)

Solution:

3. While studying the decomposition of gaseous N_2O_5 it is observed that a plot of logarithm of its partial pressure versus time is linear. What kinetic parameters can be obtained from this observation? (1985 - 2 Marks)

Solution:

4. $^{234}_{90}Th$ **disintegrates to give** $^{206}_{82}Pb$ **as the final product. How many alpha and beta particles are emitted during this process? (1986 - 2 Marks)**

Solution:

5. A first order reaction has K = 1.5 × 10^{-6} per second at 200°C. If the reaction is allowed to run for 10 hours, what percentage of the initial concentration would

have changed in the product? What is the half life of this reaction? (1987 - 5 Marks)

Solution:

6. A first order reaction is 50% complete in 30 minutes at 27°C and in 10 minutes at 47°C. Calculate the reaction rate constant at 27°C and the energy of activation of the reaction in kJ/mole. (1988 - 3 Marks)

Solution:

7. An experiment requires minimum beta activity product at the rate of 346 beta particles per minute. The half-life period of $^{99}_{42}Mo$, which is a beta emitter is 66.6 hours. Find the minimum amount of $^{99}_{42}Mo$ required to carry out the experiment in 6.909 hours. (1989 - 5 Marks)

Solution:

8. In the Arrhenius equation for a certain reaction, the value of A and Ea (activation energy) are 4×10^{13} sec^{-1} and 98.6 kJ mol^{-1} respectively. If the reaction is of first order, at what temperature will its half-life period be ten minutes? (1990 - 3 Marks)

Solution:

9. The decomposition of N_2O_5 according to the equation: (1991 - 6 Marks)
$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$
is a first order reaction. After 30 min. from the start of the decomposition in a closed vessel, the total pressure developed is found to be 284.5 mm of Hg and on complete decomposition, the total pressure is 584.5 mm of Hg. Calculate the rate constant of the reaction.

Solution:

10. Two reactions (i) A → products, (ii) B → products, follows first order kinetics. The rate of the reaction: (i) is doubled when the temperature is raised from 300K to 310K. The half-life for this reaction at 310K is 30 minutes. At the same temperature B decomposes twice as fast as A. If the energy of activation for the reaction, (ii) is half that of reaction (i), calculate the rate constant of the reaction (ii) at 300K. (1992 - 3 Marks)
Solution:

Subjective Qus. of Chemical Kinetics & Nuclear Chemistry, Past year Qus. (Part - 2)

11. The nucleidic ratio, $^{3}_{1}H$ to $^{1}_{1}H$ in a sample of water is 8.0×10^{-18} : 1. Tritium undergoes decay with a half life period of 12.3 years. How many tritium atoms would 10.0 g of such a sample contain 40 years after the original sample is collected? (1992 - 4 Marks)

Solution:

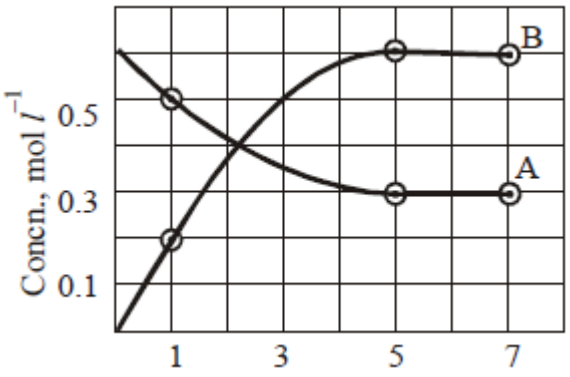
12. A first order reaction A→ B , requires activation energy of 70kJ mol^{-1}. When a 20% solution of A was kept at 25°C for 20 minutes, 25% decomposition took place. What will be the percent decomposition in the same time in a 30% solution maintained at 40°C? Assume that activation energy remains constant in this range of temperature. (1993 - 4 Marks)

Solution:

13. The gas phase decomposition of dimethyl ether follows first order kinetics.
CH_3 -O- $CH_3(g) \rightarrow CH_4(g) + H_2(g) + CO(g)$
The reaction is carried out in a constant volume container at 500°C and has a half life of 14.5 minutes. Initially, only dimethyl ether is present at a pressure of 0.40 atmosphere.
What is the total pressure of the system after 12 minutes? Assume ideal gas behavior. (1993 - 4 Marks)

Solution:

14. The progress of the reaction, A $\rightleftharpoons$ *n*B with time, is presented in figure given below. Determine



(i) the value of n
(ii) the equilibrium constant, K and
(iii) the initial rate of conversion of A. (1994 - 3 Marks)

Solution:

15. From the following data for the reaction between A and B. (1994 - 5 Marks)

	[A], mol lit^{-1}	[B], mol lit^{-1}	Initial rate mole lit^{-1} s^{-1} at	
			300 K	320 K
I	2.5×10^{-4}	3.0×10^{-5}	5.0×10^{-4}	2.0×10^{-3}
II	5.0×10^{-4}	6.0×10^{-5}	4.0×10^{-3}	–
III	1.0×10^{-3}	6.0×10^{-5}	1.6×10^{-2}	–

Calculate
(i) the order of the reaction with respect to A and with respect to B,
(ii) the rate constant at 300K
(iii) the energy of activation, and
(iv) the pre-exponential factor

Solution:

16. One of the hazards of nuclear explosion is the generation of ^{90}Sr and its subsequent incorporation in bones. This nuclide has a half-life of 28.1 years. Suppose one microgram was absorbed by a new-born child, how much ^{90}Sr will remain in his bones after 20 years? (1995 - 2 Marks)

Solution:

17. At 380°C, the half-life period for the first order decomposition of H_2O_2 is 360 min. The energy of activation of the reaction is 200 kJ mol^{-1} . Calculate the time required for 75% decomposition at 450°C. (1995 - 4 Marks)

Solution:

18. ^{227}Ac has a half-life of 21.8 years with respect to radioactive decay. The decay follows two parallel paths. one leading to ^{227}Th and the other to ^{223}Fr. The percentage yields of these two daughter nuclides are 1.2 and 98.8 respectively. What are the decay constants (l) for each of the separate paths?
(1996 - 2 Marks)

Solution:

19. The Ionisation constant of NH_4^+ in water is 5.6×10^{-10} at 25°C. The rate constant for the reaction of NH_4^+ and OH^- to form NH_3 and H_2O at 25°C is 3.4×10^{10} L $mol^{-1}s^{-1}$. Calculate the rate constant for proton transfer from water to NH_3. (1996 - 3 Marks)

Solution:

20. The rate constant for the first order decomposition of a certain reaction is described by the equation

$$\log(K) = 14.34 - \frac{1.25\times10^4 K}{T}$$

(1997 - 5 Marks)
(i) What is the energy of activation for this reaction?
(ii) At what temperature will its half-life period be 256 minutes?

Solution:

Subjective Qus. of Chemical Kinetics & Nuclear Chemistry, Past year Qus. (Part - 3)

21. Write a balanced equation for the reaction of 14N with a particle. (1997 - 1 Mark)

Solution:

22. The rate constant of a reaction is 1.5 × 107 s^{-1} at 50°C and 4.5 × 107 s–1 at 100°C. Evaluate the Arrhenius parameters A and Ea. (1998 - 5 Marks)

Solution:

23. The rate constant for an isomerization reaction, A→ B is 4.5 × 10^{-3} min^{-1}. If the initial concentration of A is 1 M, calculate the rate of the reaction after 1 h. (1999 - 4 Marks)

Solution:

24. $^{238}_{92}U$ **is radioactive and it emits α and β particles to form** $^{206}_{82}Pb$**. Calculate the number of α and β particles emitted in this conversion. An ore of** $^{238}_{92}U$ **is found to contain** $^{238}_{92}U$ **and** $^{206}_{82}Pb$ **. in the weight ratio of 1:0.1. The half-life period of** $^{238}_{92}U$ **is 4.5 × 10^{9} years. Calculate the age of the ore. (2000 - 5 Marks)**

Solution:

25. A hydrogenation reaction is carried out at 500 K. If same reaction is carried out in the presence of a catalyst at the same rate, the temperature required is 400 K. Calculate the activation energy of the reaction if the catalyst lowers the activation barrier by 20 kJ mol^{-1}. (2000 - 3 Marks)

Solution:

26. The rate of a first-order reaction is 0.04 mol litre^{-1} s^{-1} at 10 minutes and 0.03 mol litre^{-1} s^{-1} at 20 minutes after initiation. Find the half-life of the reaction. (2001 - 5 Marks)

Solution:

27. The vapour pressure of the two miscible liquids (A) and (B) are 300 and 500 mm of Hg respectively. In a flask 10 moles of (A) is mixed with 12 moles of (B). However, as soon as (B) is added, (A) starts polymerizing into a completely insoluble solid. The polymerization follows first-order kinetics. After 100 minutes, 0.525 mole of a solute is dissolved which arrests the polymerization completely. The final vapour pressure of the solution is 400 mm of Hg. Estimate the rate of constant of the polymerization reaction. Assume negligible volume change on mixing and polymerization and ideal behavior for the final solution. (2001 - 10 Marks)

Solution:

28. ^{64}Cu (half-life = 12.8 h) decays by β^- emission (38%), β^+ emission (19%) and electron capture (43%). Write the decay products and calculate partial half-lives for each of the decay processes. (2002 - 5 Marks)

Solution:

29. For the given reactions, A + B → Products, following data were obtained. (2004 - 2 Marks)

	$[A_0]$	$[B_0]$	R_0 (mol L^{-1} s^{-1})
1.	0.1	0.2	0.05
2.	0.2	0.2	0.10
3.	0.1	0.1	0.05

(a) Write the rate law expression
(b) Find the rate constant

Solution:

30. Complete and balance the following reactions

(*i*) $_{92}Th^{234} \longrightarrow \ldots\ldots\ldots + 7\ {}_2He^4 + 6\ {}_{-1}\beta^0$

(2004 - 1 Mark)

(*ii*) $_{92}U^{235} + {}_{0}n^{1} \longrightarrow \ldots\ldots\ldots + {}_{52}Te^{137} + {}_{40}Zr^{92}$

(2005 - 1 Mark)

(*iii*) $_{34}Se^{86} \longrightarrow 2\,{}_{-1}e^{0} + \ldots\ldots\ldots\ldots$ *(2005 - 1 Mark)*

Solution:

31. At constant temperature and volume, X decomposes as (2005 - 4 Marks)

$2X(g) \rightarrow 3Y(g) + 2Z(g)$; Px is the partial pressure of X.

Observation No.	Time (in minute)	P (in mm of Hg)
1	0	800
2	100	400
3	200	200

(i) What is the order of reaction with respect to X?
(ii) Find the rate constant.
(iii) Find the time for 75% completion of the reaction.
(iv) Find the total pressure when pressure of X is 700 mm of Hg.

Solution: