Solutions

Solution 1:

a) $d\xi/dt = 0.001$ mol/ 0.01 s = 0.1 mol s^{-1}

b) $v = (1/V)\, d\xi/dt = 0.1$ mol s^{-1}/ 0.25 L = 0.4 mol L^{-1} s^{-1}

c) $d[H_2]$ / dt = - 0.4 mol L^{-1} s^{-1}

$d[Br_2]$ / dt = -0.4 mol L^{-1} s^{-1}

d[HBr] / dt = 0.8 mol L^{-1} s^{-1}

Solution 2:

The rate law is

$$v = k[\mathrm{A}]^a \propto p^a = \{p_0(1-f)\}^a$$

where a is the reaction order, and f the fraction reacted (so that $1-f$ is the fraction remaining). Thus

$$\frac{v_1}{v_2} = \frac{\{p_0(1-f_1)\}^a}{\{p_0(1-f_2)\}^a} = \left(\frac{1-f_1}{1-f_2}\right)^a \quad \text{and} \quad a = \frac{\ln(v_1/v_2)}{\ln\left(\frac{1-f_1}{1-f_2}\right)} = \frac{\ln(9.71/7.67)}{\ln\left(\frac{1-0.100}{1-0.200}\right)} = \boxed{2.00}$$

Solution 3:

The half life in seconds will be

$$1600x325.25x24x60x60 = 5.049x10^{10}\, s$$

$$k = \frac{0.693}{t_{1/2}} = 1.37x10^{-11}\, s^{-1}$$

the number of nuclei present in 1 g of radium is

$$\frac{6.023x10^{23}\, mol^{-1}}{226\ g/mol} = 2.666x10^{21}\, g^{-1}$$

the number of disintegration, is therefore;

$1.37x10^{-11}$ s^{-1} x $2.67x10^{21}$ g^{-1}=$3.66x10^{10}g^{-1}s^{-1}$

Solution 4:

The rate constant is given by

$$k = A \exp\left(\frac{-E_a}{RT}\right) \ [22.31]$$

so at 24 °C it is

$$1.70 \times 10^{-2}\,\mathrm{dm^3\,mol^{-1}\,s^{-1}} = A \exp\left(\frac{-E_a}{(8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}) \times [(24+273)\,\mathrm{K}]}\right)$$

and at 37 °C it is

$$2.01 \times 10^{-2}\,\mathrm{dm^3\,mol^{-1}\,s^{-1}} = A \exp\left(\frac{-E_a}{(8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}) \times [(37+273)\,\mathrm{K}]}\right)$$

Dividing the two rate constants yields

$$\frac{1.70 \times 10^{-2}}{2.01 \times 10^{-2}} = \exp\left[\left(\frac{-E_a}{8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}}\right) \times \left(\frac{1}{297\,\mathrm{K}} - \frac{1}{310\,\mathrm{K}}\right)\right]$$

$$\text{so} \ \ln\left(\frac{1.70 \times 10^{-2}}{2.01 \times 10^{-2}}\right) = \left(\frac{-E_a}{8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}}\right) \times \left(\frac{1}{297\,\mathrm{K}} - \frac{1}{310\,\mathrm{K}}\right)$$

$$\text{and} \ E_a = -\left(\frac{1}{297\,\mathrm{K}} - \frac{1}{310\,\mathrm{K}}\right)^{-1} \ln\left(\frac{1.70 \times 10^{-2}}{2.01 \times 10^{-2}}\right) \times (8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}})$$

$$= 9.9 \times 10^3\,\mathrm{J\,mol^{-1}} = \boxed{9.9\,\mathrm{kJ\,mol^{-1}}}$$

With the activation energy in hand, the prefactor can be computed from either rate constant value

$$A = k \exp\left(\frac{E_a}{RT}\right) = (1.70 \times 10^{-2}\,\mathrm{dm^3\,mol^{-1}\,s^{-1}}) \times \exp\left(\frac{9.9 \times 10^3\,\mathrm{J\,mol^{-1}}}{(8.3145\,\mathrm{J\,K^{-1}\,mol^{-1}}) \times (297\,\mathrm{K})}\right)$$

$$= \boxed{0.94\,\mathrm{dm^3\,mol^{-1}\,s^{-1}}}$$

Here solution method is same, but the values given in question paper are different. Please substitute those values and get answer.

Solution 5:

$$\frac{\ln 2}{t\,{}^{1}\!/_{2}} = A\exp^{-E_a/RT}$$

T = 269.5 K

Substitute half – life in sec and all other values and solve for T.

Solution 6:

Number of configurations of combined system $W = W_1W_2$
W = 2∗1040

$S = k\ \ln W$; $S_1 = k\ \ln W_1$; $S_2 = k\ \ln W_2$
S = k ln(2 ˣ 1040) = 92.8k = **1.282*10^{-21} J K^{-1}**

S_1 = k ln(1020) = **0.637*10^{-21} J K^{-1}**

S_2 = k ln(2*1020) = **0.645*10^{-21} J K^{-1}**

Solution 7:

$\frac{n_1}{n_0} = \frac{g_1 e^{-\varepsilon_1/kT}}{g_0 e^{-\varepsilon_0/kT}} = 3\ e^{-hcB/kT}$

$\frac{n_1}{n_0}$ = 1/e and solve for T

T = **7.26 K**

Solution 8:

a) The ratio of populations is given by the Boltzmann factor

$\frac{n_2}{n_1} = \exp(\frac{-\Delta E}{kT}) = e^{-25K/T}$ and $\frac{n_3}{n_1} = e^{-50K/T}$

At 25 K $\frac{n_2}{n_1}$ = 0.368 and $\frac{n_3}{n_1}$ = **0.135**

b) The molecular partition function is

$$q = \sum e^{-E_{state}/kT} = 1 + e^{-25K/T} + e^{-50K/T}$$

At 25 K q = **1.503**

c) The molar internal energy is

$$U_m = U_m(0) - \frac{N_A}{q}\left(\frac{\partial q}{\partial \beta}\right) \text{ where } \beta = (kT)^{-1}$$

At 25 K $U_m = U_m(0) =$ **88.3 J mol^{-1}**

Solution 9:

The relative population of states is given by Boltzmann distribution

$\frac{n_2}{n_1} = \exp(\frac{-\Delta E}{kT}) = \exp(\frac{-hc\dot{\nu}}{kT})$ and solve for T

Having 15 % of the molecules in the upper level means

$$\frac{2n_2}{n_1} = \frac{0.15}{1 - 0.15}$$

Hence T = **213 K**