Answer on Question #76806, Chemistry / Physical Chemistry

a) For a reaction of the type:
   A Products

   t/ s 0 20 40 60 80
   [A] / mol dm-3 0.964 0.689 0.492 0.352 0.251

   By drawing an appropriate graph, deduce the order of the reaction and determine the value of the rate constant for the reaction at = 298 K.

   b) i) At T=350 K, the root-mean-squared speed of the molecules in a gas is crms = 558 m-1Calculate the molar mass of the gas (in units of g mol—1).

   ii) At what temperature is the root-mean-squared speed of the molecules in the gas equal to twice the value at = 350 K ?

   C) i) A vessel of volume 16.8 dms contains 0.164 mol of oxygen gas at a temperature of 500 °C. Assuming ideal gas behaviour, calculate the pressure inside the vessel.

   ii) An amount (0.088 mol) of krypton gas is then inserted into the vessel, with the original oxygen gas still present, and the temperature is raised to 700 °C. Assuming ideal gas behaviour, calculate the total pressure inside the vessel.

Question 1

For a reaction of the type:
A Products

t/ s 0 20 40 60 80
[A] / mol dm-3 0.964 0.689 0.492 0.352 0.251

By drawing an appropriate graph, deduce the order of the reaction and determine the value of the rate constant for the reaction at = 298 K.

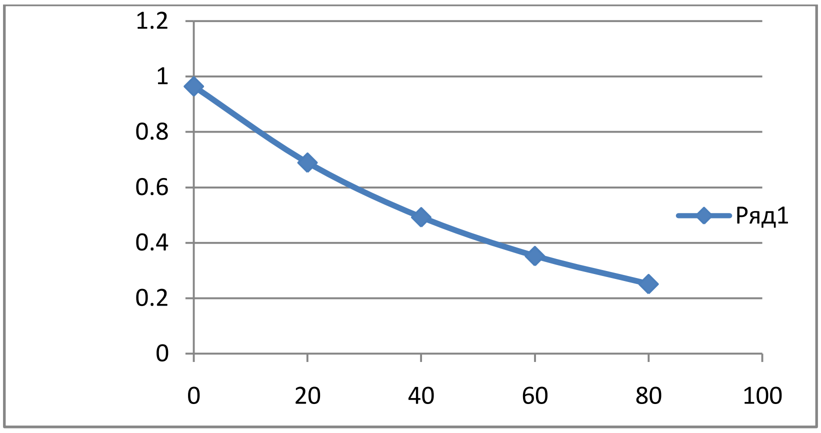
Solution

a) To determine the order of reaction we should draw different graphs.

The first graph is a graph of the concentration as a function of time.

t, s	[A], mol/dm3
0	0,964
20	0,689

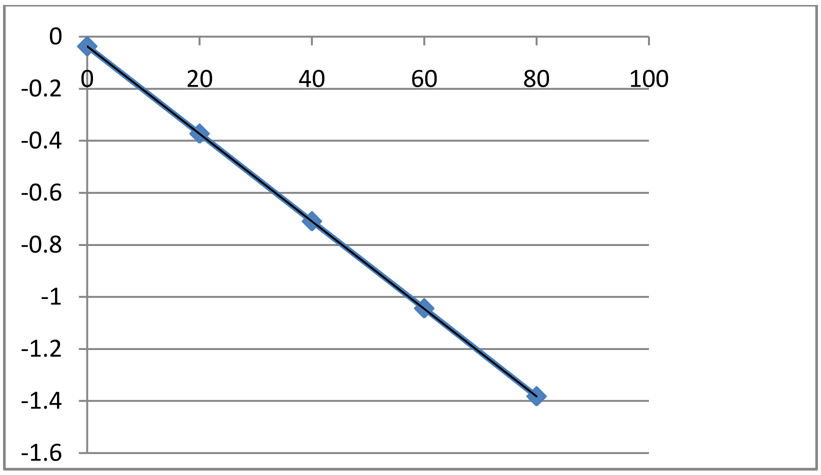
40	0,492
60	0,352
80	0,251



We can see that this graph is not a straight line, consequently this is not a zeroth-order reaction.

To check up if this reaction is first order we should draw a graph of the ln[A] as a function of time

t, s	ln[A]
0	-0,03666398
20	-0,37251400
40	-0,70927656
60	-1,04412410
80	-1,38230234



For the the first order reaction we have an logarithmic expression of the relationship between the concentration of A and *t*:

$$\ln[A]=\ln[A]_0-kt.$$

This equation has the form of the algebraic equation for a straight line, $y = mx + b$, with y = ln[A] and b = ln$[A]_0$, a plot of ln[A] versus t for a first-order reaction should give a straight line with a slope of $-k$ and an intercept of ln$[A]_0$. We can see that the graph drawn is a straight line, consequently, we have a first order reaction.

To calculate the slope we should take any two points on the graph:

t, s	ln[A]
20	-0,3725140
40	-0,7092765

$$slope = \frac{-0.7092765 - (-0.3725140)}{40 - 20} = -0.0168$$

So -k= -0.0168

k= 0.0168

So the rate constant for the reaction at = 298 K is k=0.0168 s^{-1}

Answer : first order reaction, rate constant k=0.0168 s^{-1}

Question 2

b) i) At T=350 K, the root-mean-squared speed of the molecules in a gas is crms = 558 m-1Calculate the molar mass of the gas (in units of g mol—1).
ii) At what temperature is the root-mean-squared speed of the molecules in the gas equal to twice the value at = 350 K ?
Solution

i) T= 350 K

rms =558 m^{-1}

M-?

Average molecular speed of a gas is directly proportional to it's absolute temperature and inversely proportional to it's molar mass:

υ_{rms} = √3RT/M

$$558 = \sqrt{\frac{3 \times 8.314 \times 350}{M}}$$

M= 0.028 kg/mol = 28 g/mol

ii) υ_{rms}= 558·2= 1116 m^{-1}

M= 0.028 kg/mol

T-?

Average molecular speed of a gas is directly proportional to it’s absolute temperature and inversely proportional to it’s molar mass:

$\upsilon_{rms} = \sqrt{3RT/M}$

$$1116 = \sqrt{\frac{3 \times 8.314 \times T}{0.028}}$$

T=1398 K

Answer: i) M= 28 g/mol

ii) 1398 K

Question 3

C) i) A vessel of volume 16.8 dms contains 0.164 mol of oxygen gas at a temperature of 500 °C. Assuming ideal gas behaviour, calculate the pressure inside the vessel.

ii) An amount (0.088 mol) of krypton gas is then inserted into the vessel, with the original oxygen gas still present, and the temperature is raised to 700 °C. Assuming ideal gas behaviour, calculate the total pressure inside the vessel.

Solution

i) V= 16.8 dm^3=16.8·10^{-3} m^3

$n(O_2)$=0.164 mol

T= 500^0C = 500+273.15=773.15 K

R = 8.314 m^3·Pa/K·mol

P-?

We should use Ideal Gas Law to find pressure:

PV =nRT ⇒ P=nRT/V

$$P = \frac{0.164 \times 8.314 \times 773.15}{16.8 \times 10^{-3}} = 62749\ Pa$$

ii) V= 16.8 dm^3=16.8·10^{-3} m^3

$n(O_2)$=0.164 mol

n(Kr)=0.088 mol

$T = 700^0C = 700+273.15=973.15\ K$

$R = 8.314\ m^3 \cdot Pa/K \cdot mol$

P-?

We should use Ideal Gas Law to find pressure:

$PV = nRT \Rightarrow P = nRT/V$

$n = n(O_2)+n(Kr)=0.164+0.088= 0.252\ mol$

$$P = \frac{0.252 \times 8.314 \times 973.15}{16.8 \times 10^{-3}} = 121362\ Pa$$

Answer: i) $62749\ Pa$

ii) $121362\ Pa$