**Quiz (Rate Law 2)**

1. Nitrogen monoxide reacts with hydrogen at 1150℃. The equation of the reaction is as follows: $2NO(g) + 2H_2(g) \longrightarrow N_2(g) + 2H_2O(g)$

   The results of the series of experiments are shown below:

| Experiment | Initial [NO(g)] (mol dm$^{-3}$) | Initial [$H_2$(g)] (mol dm$^{-3}$) | Initial rate (mol dm$^{-3}$ s$^{-1}$) |
|---|---|---|---|
| 1 | 0.010 | 0.010 | 0.006 |
| 2 | 0.020 | 0.030 | 0.144 |
| 3 | 0.010 | 0.020 | 0.012 |

   Write the rate equation for the reaction.

2. Consider the following reaction: $CO(g) + NO_2(g) \longrightarrow CO_2(g) + NO(g)$

   A series of experiments was carried out to study the relationship between the initial concentration and the initial rate at 298 K. The results are shown below:

| Experiment | Initial concentration of CO(g) (mol dm$^{-3}$) | Initial concentration of $NO_2$(g) (mol dm$^{-3}$) | Initial rate (mol dm$^{-3}$ s$^{-1}$) |
|---|---|---|---|
| 1 | 0.1 | 0.2 | 0.025 |
| 2 | 0.2 | 0.2 | 0.050 |
| 3 | 0.1 | 0.4 | 0.050 |
| 4 | 0.4 | 0.2 | 0.100 |

   Write the rate equation for the reaction.

3. The decomposition of nitrogen dioxide is a second order reaction. The equation of the reaction is as follows: $2NO_2(g) \longrightarrow 2NO(g) + O_2(g)$

   The initial rate of decomposition is $4.3 \times 10^{-4}$ mol dm$^{-3}$ s$^{-1}$ when the initial concentration of $NO_2$ is 0.57 mol dm$^{-3}$. What is the initial rate of decomposition when the initial concentration of $NO_2$ is 1.14 mol dm$^{-3}$?

4. The following are some information about a reaction at 298 K:
   $A + B + C \longrightarrow$ products

| Experiment | Initial [$A$] (mol dm$^{-3}$) | Initial [$B$] (mol dm$^{-3}$) | Initial [C] (mol dm$^{-3}$) | Initial rate (mol dm$^{-3}$ s$^{-1}$) |
|---|---|---|---|---|
| 1 | 0.05 | 0.02 | 0.03 | 0.3 |
| 2 | 0.10 | 0.02 | 0.03 | 0.6 |
| 3 | 0.05 | 0.06 | 0.03 | 0.9 |
| 4 | 0.05 | 0.06 | 0.06 | 3.6 |

   Write the rate equation for the reaction.

**Suggested Answer**

1. Let the rate equation: Rate = $k$ [NO(g)]$^x$ [$H_2$(g)]$^y$
   For Expt 1: $0.006 = k\,(0.01)^x\,(0.01)^y$ --- (1)
   For Expt 2: $0.144 = k\,(0.02)^x\,(0.03)^y$ --- (2)
   For Expt 3: $0.012 = k\,(0.01)^x\,(0.02)^y$ --- (3)

   (3)/(1): $0.012 / 0.006 = (0.02 / 0.01)^y$
   $\Rightarrow$ $y = 1$

   (2)/(1): $0.144 / 0.006 = (0.02 / 0.01)^x\,(0.03 / 0.01)$
   $\Rightarrow$ $x = 3$

   Sub x = 3 and y = 1 into (1) $\Rightarrow$ k = 600000

   Rate equation: Rate = 600000 [NO(g)]$^3$ [$H_2$(g)]

2. Let the rate equation: Rate = $k$ [CO(g)]$^x$ [$NO_2$(g)]$^y$

   For Expt 1 and 2: [$NO_2$(g)] was kept constant,
   If [CO(g)] was doubled, initial rate was also doubled.
   $\Rightarrow$ 1$^{st}$ order w.r.t. CO(g)
   $\Rightarrow$ i.e. x = 1

   For Expt 1 and 3 [CO(g)] was kept constant,
   If [$NO_2$(g)] was doubled, initial rate was also doubled.
   $\Rightarrow$ 1$^{st}$ order w.r.t. $NO_2$(g)
   $\Rightarrow$ i.e. y = 1

   Sub x = 1 and y = 1 into (1) $\Rightarrow$ k = 1.25

   Rate equation: Rate = 1.25 [CO(g)] [$NO_2$(g)]

3. Rate = k [$NO_2$(g)]$^2$
   $4.3 \times 10^{-4} = k\,(0.57)^2$
   $k = 1.323 \times 10^{-3}$

   Rate = $1.323 \times 10^{-3}$ [$NO_2$(g)]$^2$
   $= 1.323 \times 10^{-3}\,(1.14)^2$
   $= 1.72 \times 10^{-3}$ mol dm$^{-3}$ s$^{-1}$

4. Let the rate equation: Rate = $k$ $[A]^x [B]^y [C]^z$

For Expt 1 and 2: [B] and [C] was kept constant,
If [A] was doubled, initial rate was also doubled.
$\Rightarrow$ 1st order w.r.t. A
$\Rightarrow$ i.e. $x = 1$

For Expt 1 and 3 [A] and [C] was kept constant,
If [B] was tripled, initial rate was also tripled.
$\Rightarrow$ 1st order w.r.t. B
$\Rightarrow$ i.e. $y = 1$

For Expt 3 and 4 [A] and [B] was kept constant,
If [C] was doubled, initial rate was quadrupled.
$\Rightarrow$ 2nd order w.r.t. C
$\Rightarrow$ i.e. $z = 1$

Sub $x = 1$; $y = 1$ and $z = 2$ into (1) $\Rightarrow$ $k = 10^6/3$

Rate equation: Rate = $10^6/3$ [A] [B] $[C]^2$

**The End**