Self-test Questions

Topic 6 (HL)

1. The rate of the reaction $2A \rightarrow B$ was investigated in a series of experiments. Data from the experiments are shown in the table. What is the order of reaction with respect to $A$?

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[A] / mol dm$^{-3}$</th>
<th>Rate / mol dm$^{-3}$ s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>0.40</td>
<td>8.0</td>
</tr>
</tbody>
</table>

A 1  
B 2  
C 3  
D 4

2. The rate of the reaction $2A + 2B \rightarrow C + D$ was investigated in a series of experiments. Data from the experiments are shown in the table. What are the orders of reaction with respect to $A$ and $B$?

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[A] / mol dm$^{-3}$</th>
<th>[B] / mol dm$^{-3}$</th>
<th>Rate / mol dm$^{-3}$ s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20</td>
<td>0.20</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>0.60</td>
<td>0.20</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>0.60</td>
<td>0.80</td>
<td>24</td>
</tr>
</tbody>
</table>

A A: 1; B: 1  
B A: 1; B: 2  
C A: 2; B: 1  
D A: 2; B: 2

3. The rate of the reaction $3A + 2B \rightarrow 2C + D$ was investigated in a series of experiments. Data from the experiments are shown in the table. What are the orders of reaction with respect to $A$ and $B$?

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[A] / mol dm$^{-3}$</th>
<th>[B] / mol dm$^{-3}$</th>
<th>Rate / mol dm$^{-3}$ s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.400</td>
<td>0.400</td>
<td>1.400</td>
</tr>
<tr>
<td>2</td>
<td>0.800</td>
<td>0.400</td>
<td>2.800</td>
</tr>
<tr>
<td>3</td>
<td>1.200</td>
<td>0.800</td>
<td>8.400</td>
</tr>
</tbody>
</table>

A A: 1; B: 1  
B A: 1; B: 2  
C A: 2; B: 2  
D A: 3; B: 2
4 The rate of the reaction $3A + 2B \rightarrow 2C + D$ was investigated in a series of experiments. Data from the experiments are shown in the table. The rate expression is

\[
\text{rate} = k[A]
\]

What is the rate constant for this reaction at this temperature?

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[A] / mol dm$^{-3}$</th>
<th>[B] / mol dm$^{-3}$</th>
<th>Rate / mol dm$^{-3}$ s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.400</td>
<td>0.400</td>
<td>1.400</td>
</tr>
<tr>
<td>2</td>
<td>1.200</td>
<td>0.400</td>
<td>4.200</td>
</tr>
<tr>
<td>3</td>
<td>1.200</td>
<td>0.800</td>
<td>4.200</td>
</tr>
</tbody>
</table>

A 3.50 mol dm$^{-3}$ h$^{-1}$  
B 3.50 h$^{-1}$  
C 0.286 mol dm$^{-3}$ h$^{-1}$  
D 0.286 h$^{-1}$

5 The rate expression for a particular reaction is

\[
\text{rate} = k[A][B]^2
\]

If the concentration of A is doubled and the concentration of B is increased by a factor of 3, by what factor does the rate of reaction increase?

A 5  
B 6  
C 18  
D 36

6 If the rate expression is

\[
\text{rate} = k[Y]^2[Z]
\]

What value is missing from the table?

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[Z] / mol dm$^{-3}$</th>
<th>[Y] / mol dm$^{-3}$</th>
<th>Rate / mol dm$^{-3}$ s$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$2.0 \times 10^{-3}$</td>
<td>$2.0 \times 10^{-3}$</td>
<td>0.0500</td>
</tr>
<tr>
<td>2</td>
<td>$1.0 \times 10^{-2}$</td>
<td>?</td>
<td>2.25</td>
</tr>
</tbody>
</table>

A $3.6 \times 10^{-3}$  
B $6.0 \times 10^{-3}$  
C 0.0190  
D $1.8 \times 10^{-2}$

7 Three possible mechanisms for the reaction $2NO + Br_2 \rightarrow 2NOBr$ are shown below.

The rate expression is

\[
\text{rate} = k[NO]^2[Br_2].
\]

Which mechanism(s) is/are consistent with this rate expression?

Mechanism 1  
NO + Br$_2$ $\rightarrow$ NOBr$_2$ rate-determining step  
NOBr$_2$ + NO $\rightarrow$ 2NOBr fast

Mechanism 2  
2NO $\rightarrow$ N$_2$O$_2$ rate-determining step  
N$_2$O$_2$ + Br$_2$ $\rightarrow$ 2NOBr fast

Mechanism 3  
NO + Br$_2$ $\Rightarrow$ NOBr$_2$ fast  
NOBr$_2$ + NO $\rightarrow$ 2NOBr rate-determining step

A mechanism 1 only  
B mechanism 2 only  
C mechanism 3 only  
D mechanisms 2 and 3 only
8 Given the data in the table for the reaction \(2A + B \rightarrow C + D\), which of the following is \textbf{unlikely} to be a rate-determining step? (X is an intermediate.)

<table>
<thead>
<tr>
<th>Expt.</th>
<th>[A] / mol dm(^{-3})</th>
<th>[B] / mol dm(^{-3})</th>
<th>Rate / mol dm(^{-3}) s(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10</td>
<td>0.10</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td>0.10</td>
<td>4.0</td>
</tr>
<tr>
<td>3</td>
<td>0.20</td>
<td>0.30</td>
<td>12.0</td>
</tr>
</tbody>
</table>

A \(A + B \rightarrow C\)  
B \(A + A \rightarrow D\)  
C \(B + X \rightarrow C\)  
D \(2A + B \rightarrow C + D\)

9 Which of the following would \textbf{not} be a straight-line graph?  
A Concentration against time for a zero-order reaction.  
B \(\ln k\) against \(1/T\) for a first-order reaction, where \(T\) is the temperature in °C.  
C Rate against concentration\(^2\) for a second-order reaction.  
D Rate against concentration for a zero-order reaction.

10 Using the graph below, what is the activation energy of the reaction?  
\[ R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \]

\[ \begin{align*} \text{ln } k & \quad 1/T/\text{K}^{-1} \\ \text{0} & \quad 0.0005 \quad 0.001 \quad 0.0015 \quad 0.002 \quad 0.0025 \quad 0.003 \quad 0.0035 \rangle \\ \end{align*} \]

A 25 kJ mol\(^{-1}\)  
B 50 kJ mol\(^{-1}\)  
C 75 kJ mol\(^{-1}\)  
D 100 kJ mol\(^{-1}\)