16.1 Rate Expression & Reaction Mechanism

Question Paper

Course	DP IB Chemistry
Section	16. Chemical Kinetics (HL only)
Topic	16.1 Rate Expression & Reaction Mechanism
Difficulty	Easy

Time allowed: 50

Score: /37

Percentage: /100

Question 1a

a)
Outline two ways a rate of a reaction can be expressed and state the units for rate of reaction.

[2]

[2 marks]

Question 1b

b)
Explain what is meant by the *order* of a reaction and how it may be determined.

[2]

[2 marks]

Question 1c

c)
Carbon monoxide and chlorine react together to make phosgene, $COCl_2$. The equation for the reaction is given below:

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

A possible rate equation for the reaction is:

$$\text{rate} = k[CO(g)]^2[Cl_2(g)]^{½}$$

What is the overall reaction order?

[1]

[1 mark]

Question 1d

d)
Determine the units of the rate constant, *k*, for the following rate equation:

$$\text{rate} = k[NO]^2[O_2]$$

[1]

[1 mark]

Question 2a

a)
The rate of hydrolysis of sucrose under acidic conditions can be determined experimentally. The following data was obtained:

Experiment	Initial [HCl] / mol dm^{-3}	Initial [sucrose] / mol dm^{-3}	Rate of reaction / mol dm^{-3} s^{-1}
1	0.10	0.10	0.024
2	0.10	0.15	0.036
3	0.20	0.10	0.048

Determine the order of reaction with respect to HCl.

[1]

[1 mark]

Question 2b

b)
Determine the order of reaction with respect to sucrose.

[1]

[1 mark]

Question 2c

c)
Determine the overall order of reaction, write the rate expression and state the units of the rate constant, *k*.

[3]

[3 marks]

Question 2d

d)
Determine the following:

i)
The value of k, using Experiment 1

[1]

ii)
The rate of reaction if the concentration of HCl and sucrose are both 0.20 mol dm^{-3}

[1]

[2 marks]

Question 3a

a)
Sketch graphs of a first order and second order reaction of concentration against time.

[2]

[2 marks]

Question 3b

b)
Draw sketch graphs for a first and second order reaction of rate against concentration.

[2]

[2 marks]

Question 3c

c)
Deduce the units of the rate constant, k, for a first order reaction.

[1]

[1 mark]

Question 3d

d)
State, with a reason, how the value of the rate constant, *k*, varies with increased temperature for a reaction.

[4]

[4 marks]

Question 4a

a)
State what is meant by the terms *rate determining step* and *molecularity* in a chemical reaction.

[2]

[2 marks]

Question 4b

b)
The following reaction mechanism has been proposed for the formation of nitrosyl bromide, NOBr, from nitrogen monoxide and bromine:

Step 1: $NO + NO \rightarrow N_2O_2$
Step 2: $N_2O_2 + Br_2 \rightarrow 2NOBr$

Deduce the overall reaction equation and comment on the molecularity of Step 1 and 2.

[2]

[2 marks]

Question 4c

c)
A student proposes an alternative one step mechanism for the formation of nitrosyl bromide.

$$NO + NO + Br_2 \rightarrow NOBr_2$$

Explain why this mechanism is not likely to take place.

[2]

[2 marks]

Question 4d

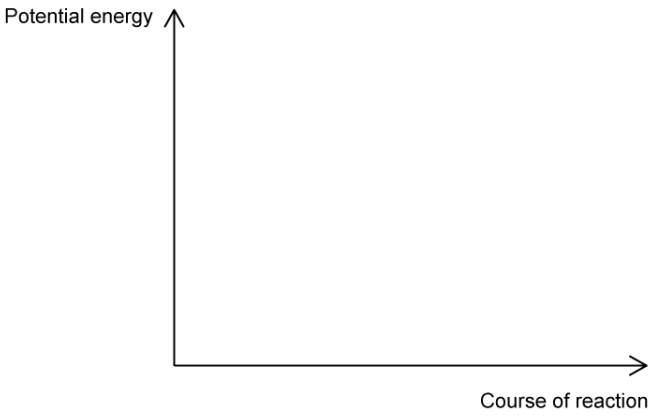
d)
State the role of N_2O_2 in the mechanism in part b).

[1]

[1 mark]

Question 5a

a)
Draw a labelled diagram, on the follow grid, showing a potential energy profile in a two step reaction. The second step is the slow step of the reaction.



[3]

[3 marks]

Question 5b

b)
State which step of the mechanism in a) is affected by the addition of a catalyst.

[1]

[1 mark]

Question 5c

c)
A reaction mechanism is shown below.

Step 1: $NO_2 + NO_2 \rightarrow NO + NO_3$ (slow)
Step 2: $NO_3 + CO \rightarrow NO_2 + CO_2$ (fast)

Deduce the overall reaction equation and the rate equation for the reaction.

[2]

[2 marks]

Question 5d

d)
State the overall reaction order in part c) and state the units of the rate constant.

[2]

[2 marks]