Oxford Cambridge and RSA

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Question Set 14

1 Dinitrogen pentoxide, N_2O_5 is an oxide of nitrogen that is formed in the stratosphere by reactions such as those shown below.

$NO_2 + O_3 \rightarrow NO_3 + O_2$

$NO_3 + NO_2 \rightleftharpoons N_2O_5$

The dinitrogen pentoxide acts as a ‘sink’ for NO_2, stopping it breaking down ozone.

(a) A student says that oxides of nitrogen catalyse the breakdown of ozone in the stratosphereby the reactions shown below.

$NO_2 + O_3 \rightarrow NO_3 + O_2$

$O_3 + NO_3 \rightarrow NO_2 + 2O_2$

Discuss the student’s choice of reactions, giving the correct chemistry if necessary. **[2]**

(b) **(i)** In the troposphere, dinitrogen pentoxide decomposes as shown below.

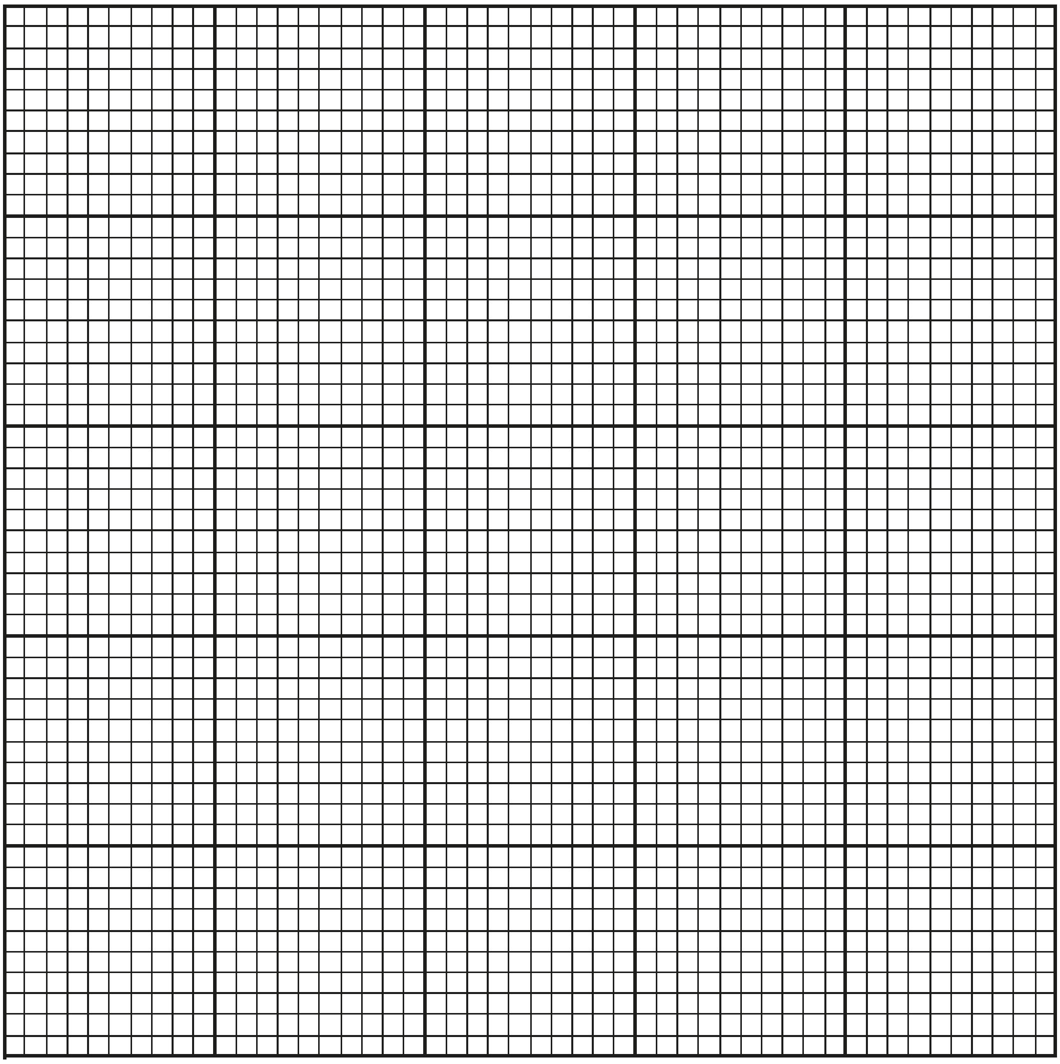
$2N_2O_5 \rightarrow 4NO_2 + O_2$ **Equation 4.1**

The table shows how the concentration of $2N_2O_5$ varies with time at 315 K.

Time / s	**$[N_2O_5]$ / mol dm^{-3}**
0	0.330
1000	0.210
2000	0.124
3000	0.078
4000	0.048

Use the data in the table to plot a graph to determine the half-life for the reaction.

Label the axes.



half-life = ... s **[4]**

(ii) How does the graph show that the reaction in **equation 4.1** is first order with respect to N_2O_5?

Draw construction lines on the graph to explain your answer. **[1]**

(c) The gradient of the graph at 1000 s is 9.8×10^{-5} mol dm^{-3} s^{-1}.

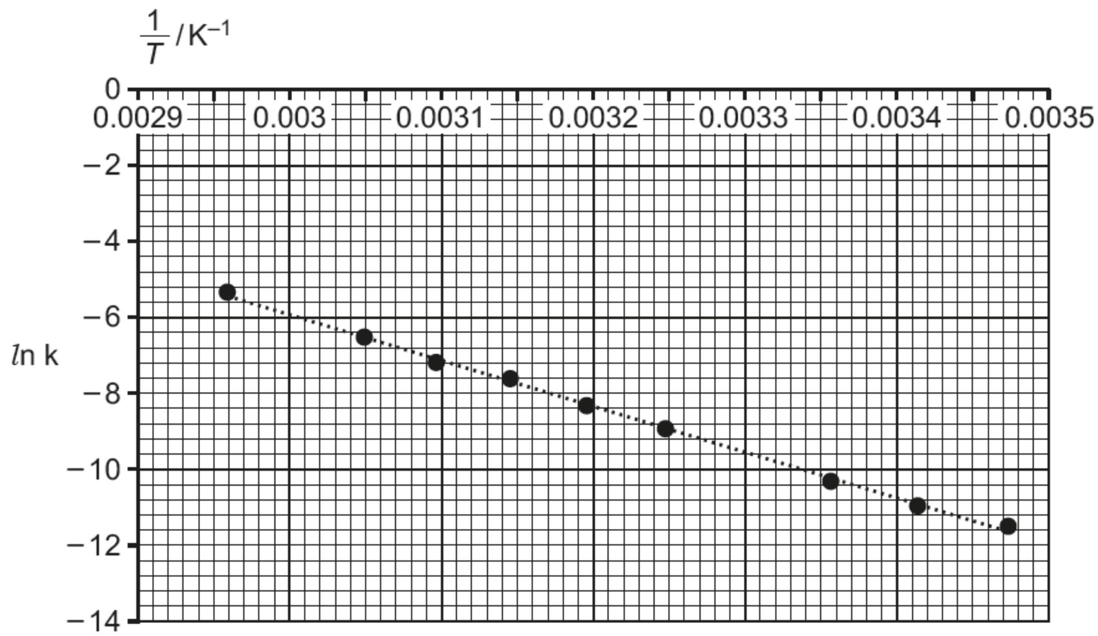
Work out the rate constant for the reaction in **equation 4.1** at 315 K.

Give the units in your answer.

rate constant = ... units .... **[2]**

(d) The reaction in equation 4.1 was repeated with a fixed concentration of N_2O_5 at different temperatures.

A graph of *l*n k against 1/T for the reaction in **equation 4.1** is given below.



Use the graph to work out a value for the activation enthalpy (in kJ mol^{-1}) for the reaction.

E_a = ...kJ mol^{-1} **[3]**

(e)

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$ **Equation 4.1**

A student suggests the following mechanism for the reaction in **equation 4.1**.

The reaction is first order with respect to N_2O_5.

$N_2O_5 \rightarrow NO_2 + NO_3$ **step 1**

$NO_3 \rightarrow O_2 + NO$ **step 2**

$NO + N_2O_5 \rightarrow 3NO_2$ **step 3**

Show that this is a possible mechanism.

Consider which step(s) could be rate-determining. **[3]**

Total Marks for Question Set 14: 15

Resource Materials

Question Set No: 14

General Information

Molar gas volume = 24.0 $dm^3 mol^{-1}$ at RTP

Avogadro constant, $N_A = 6.02 \times 10^{23} mol^{-1}$

Specific heat capacity of water, $c = 4.18 J g^{-1} K^{-1}$

Planck constant, $h = 6.63 \times 10^{-34} J Hz^{-1}$

Speed of light in a vacuum, $c = 3.00 \times 10^8 m s^{-1}$

Ionic product of water, $K_w = 1.00 \times 10^{-14} mol^2 dm^{-6}$ at 298 K

1 tonne = 10^6 g

Arrhenius equation: $k = Ae^{-E_a/RT}$ or $\ln k = -E_a/RT + \ln A$

Gas constant, $R = 8.314 J mol^{-1} K^{-1}$