Section C

Question 16

(*a*) Given the time-independent stoichiometry,

$$J = -\frac{1}{2}\frac{\mathrm{d}[\mathrm{H_2O_2}]}{\mathrm{d}t} \tag{8}$$

and

$$J = \frac{\mathrm{d}[\mathrm{O_2}]}{\mathrm{d}t} \tag{9}$$

(*b*) From the information provided, the experimental rate equation will be of the form

$$J = k_{\mathrm{R}}[\mathrm{H_2O_2}] \tag{10}$$

where k_{R} is the experimental rate constant.

The most appropriate means of determining a value for the experimental rate constant at 300 K would be to use the integrated rate equation for a first-order reaction (a rearranged form of that given on the *Data Sheet* that accompanied the examination paper):

$$\ln[\mathrm{A}]_0 - \ln[\mathrm{A}] = ak_{\mathrm{R}}t \tag{11}$$

In the present case, A represents H_2O_2, and $a = 2$, so that

$$\ln[\mathrm{H_2O_2}]_0 - \ln[\mathrm{H_2O_2}] = 2k_{\mathrm{R}}t \tag{12}$$

To use this equation, values of $[H_2O_2]$ as a function of time at 300 K are required (a kinetic reaction profile).

A plot of $\ln[H_2O_2]$ versus time at 300 K will be a straight line.

If the slope of this plot is determined, a value of the experimental rate constant, k_{R}, can be calculated, because

$$\text{slope} = -2k_{\mathrm{R}} \tag{13}$$

(c) The experimental rate constant will more than likely have an Arrhenius-type dependence on temperature, where

$$k_{\mathrm{R}} = A\exp\left(\frac{-E_{\mathrm{a}}}{RT}\right) \tag{14}$$

With the reaction conditions kept the same, the magnitude of the activation energy will be the key factor in determining the degree of change in k_{R} and, hence, the degree of change in the rate of reaction.

The rate of reaction will increase. Since there is a 10 K rise in temperature, the general 'rule of thumb' may hold; in other words, the rate of reaction will increase by a factor of 2–3.

Question 17

(*a*) H—C, C=O and ∠H—C=O.

(*b*) The carbon atom is sp^2 hybridized. Two sp^2 orbitals on carbon form σ bonds to the two hydrogen atoms, and one carbon sp^2 orbital forms a σ bond with O. The remaining 2p orbital on carbon forms a π orbital with a 2p orbital on O.

(*c*) H_2CO is neither octahedral nor tetrahedral. It has a C_2 axis, and this is the only axis of symmetry, so $n = 2$. There are no $2C_2$ axes perpendicular to this axis. There are $2\sigma_v$ planes.

H_2CO belongs to the symmetry point group $\mathbf{C_{2v}}$.