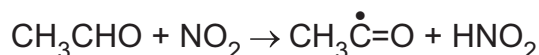


- 2 Ethanal, CH_3CHO , reacts with nitrogen dioxide, NO_2 . The products of the first step of this reaction are a $\text{CH}_3\dot{\text{C}}=\text{O}$ radical and a molecule of nitrous acid, HNO_2 .



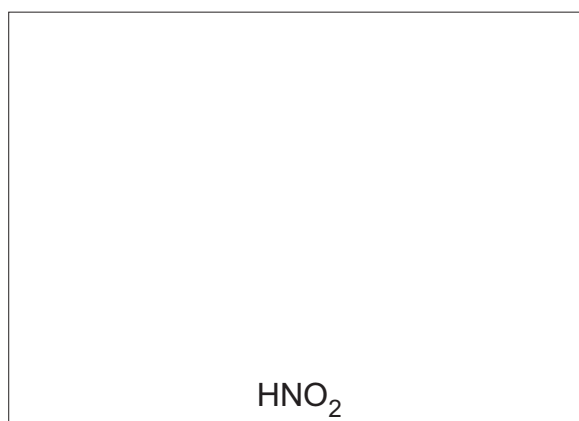
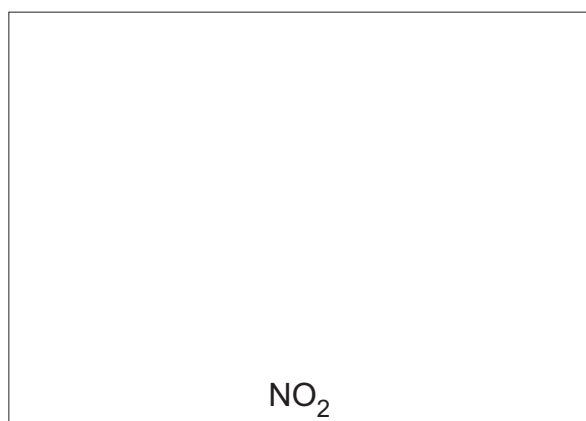
- (a) (i) Use **two** words to complete the sentence.

This reaction involves of the single covalent bond between a hydrogen atom and a carbon atom in CH_3CHO .

[1]

- (ii) The hydrogen atom mentioned in (a)(i) forms a covalent bond with one of the oxygen atoms of an NO_2 molecule. An NO_2 molecule has a single, unpaired electron on the nitrogen atom. All electrons are paired in an HNO_2 molecule.

Draw dot-and-cross diagrams of NO_2 and HNO_2 in the boxes. Show outer shell electrons only.



[1]

- (iii) Use VSEPR theory to predict the bond angle at the nitrogen atom in an HNO_2 molecule.

bond angle = [1]

- (b) The rate equation for the reaction between CH_3CHO and NO_2 is shown.

$$\text{rate} = k[\text{CH}_3\text{CHO}][\text{NO}_2]$$

Under certain conditions, when the concentrations of both CH_3CHO and NO_2 are $0.200 \text{ mol dm}^{-3}$, the rate of the reaction is $1.53 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$.

Calculate the value of the rate constant, k , under these conditions. Give the units of k .

$k = \dots\dots\dots$ units [2]

- (c) The reaction mixture described in (b) is monitored over a period of time.

Predict whether the graph of $[\text{NO}_2]$ against time shows a constant half-life.

Explain your answer.

prediction

explanation

[1]

- (d) NO_2 also reacts with ozone, O_3 .

The rate equation is shown.

$$\text{rate} = k_1[\text{NO}_2]$$

Under certain conditions, the value of k_1 is 0.0848 s^{-1} .

The reaction has a constant half-life under these conditions.

Calculate the half-life in seconds.

half-life = s [1]

- (e) NO_2 is present in the exhaust gases of cars. It can react with carbon monoxide, CO , on the surface of a heterogeneous catalyst in the car's catalytic converter.

Describe the mode of action of this heterogeneous catalyst.

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..... [2]

[Total: 9]