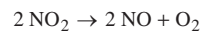
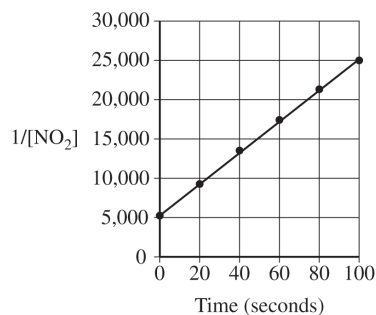
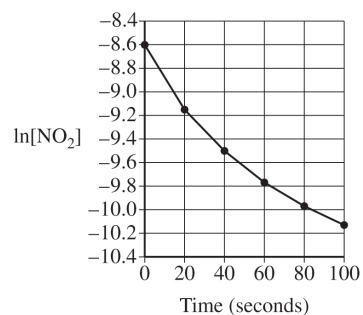


6. At elevated temperatures, NO_2 undergoes decomposition in the gas phase, forming NO and O_2 as represented by the following equation.



A scientist measures the change in $[\text{NO}_2]$ over the first 100. s of the reaction at 546°C . The scientist uses the data collected from the experiment to generate the following two graphs.



Based on these data, the scientist makes the claim that the rate law for the reaction is $\text{rate} = k[\text{NO}_2]^2$.

- (a) Explain how the graphs indicate that the reaction is second order with respect to NO_2 .

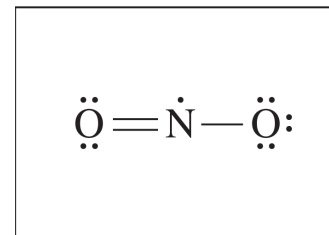
- (b) At a certain point in the reaction, the rate of disappearance of NO_2 is determined to be $6.52 \times 10^{-7} \text{ M/s}$.

Determine the rate of appearance, in M/s , of O_2 at this same point in the reaction.

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Continue your response to **QUESTION 6** on this page.

- (c) NO_2 is a molecule that contains an odd number of electrons and can be oxidized to form the NO_2^+ ion. In NO_2 , the unpaired electron is presumed to be localized on the nitrogen atom, as shown in the Lewis diagram in the box on the left.



- (i) In the box on the right, complete the Lewis diagram for NO_2^+ . Be sure to show all bonding and nonbonding electrons.
- (ii) A student makes the claim that the bond angles in NO_2 and NO_2^+ are different from each other. Do you agree or disagree with the student's claim? Justify your answer.

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Answer the following questions about an experiment in which $\text{CaCO}_3(s)$ is combined with $\text{HCl}(aq)$, represented by the following balanced equation.



(a) Write the balanced net ionic equation for the reaction.

A student performs an investigation to study factors that affect the rate of the reaction. In each trial the student combines 50.0 mL of $\text{HCl}(aq)$ at 21.2°C with 1.00 g of $\text{CaCO}_3(s)$ and measures the time required for the reaction to go to completion. The data are given in the following table.

Trial	Concentration of $\text{HCl}(aq)$ (M)	Particle Size of $\text{CaCO}_3(s)$	Time of Reaction (s)
1	1.00	Fine powder	67
2	1.00	Small chunks	112
3	1.00	Large chunk	342
4	3.00	Fine powder	22
5	3.00	Small chunks	227
6	3.00	Large chunk	114

(b) The student correctly identifies that trial 5 is inconsistent with the other trials. Explain why the student's claim is correct using the data in the table.

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Continue your response to **QUESTION 3** on this page.

(c) Based on the reaction conditions and the collisions that occur between particles, explain the reason for the difference in the reaction times for trial 2 and trial 3.

(d) The student claims that the reaction is zero order with respect to $\text{HCl}(aq)$. Do you agree or disagree with the student's claim? Justify your answer using the student's data.

(e) The $\text{HCl}(aq)$ was present in excess in all trials of the experiment. Determine the molarity of the $\text{HCl}(aq)$ in the beaker after the reaction is complete in trial 2. Assume that the volume of the mixture remains constant at 50.0 mL throughout the trial. (The molar mass of CaCO_3 is 100.09 g/mol.)

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Continue your response to **QUESTION 2** on this page.

In order to measure the enthalpy of the reaction shown, the student repeats trial 1 by mixing 50.0 mL of $\text{HCl}(aq)$ with 1.00 g of $\text{CaCO}_3(s)$ using a coffee cup calorimeter. The student records the temperature of the system every 20 seconds. The data are given in the following table.

Time (s)	Measured Temperature of Solution ($^{\circ}\text{C}$)
0	21.20
20	21.51
40	21.70
60	21.85
80	21.90
100	21.90

(f) Is the reaction endothermic or exothermic? Justify your answer using the information in the table.

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Continue your response to **QUESTION 3** on this page.

(g) Based on the experimental data, the mass of the system is 51.0 g, and the specific heat of the reaction mixture is $4.0 \text{ J} / (\text{g} \cdot ^{\circ}\text{C})$.

(i) Calculate the magnitude of heat transfer, q , in joules.

(ii) Calculate the enthalpy of reaction in units of $\text{kJ/mol}_{\text{rxn}}$. Include the algebraic sign on your answer.

GO ON TO THE NEXT PAGE.