



AP[®] Chemistry
2004 Sample Student Responses
Form B

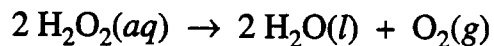
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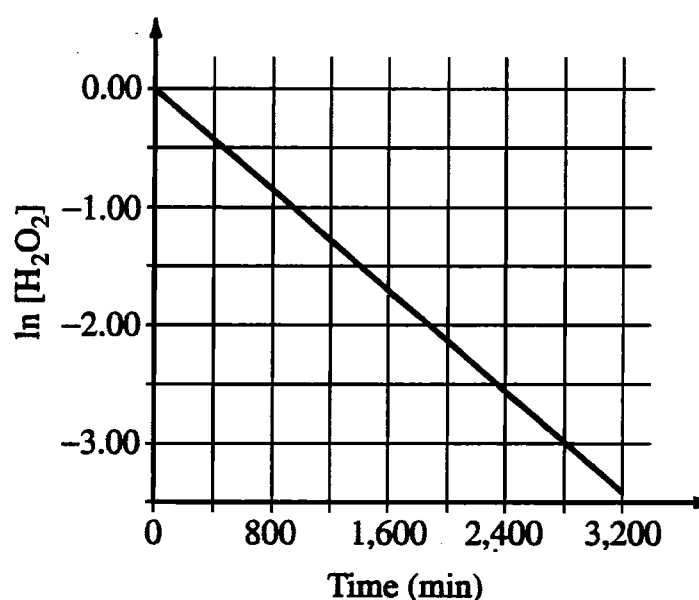
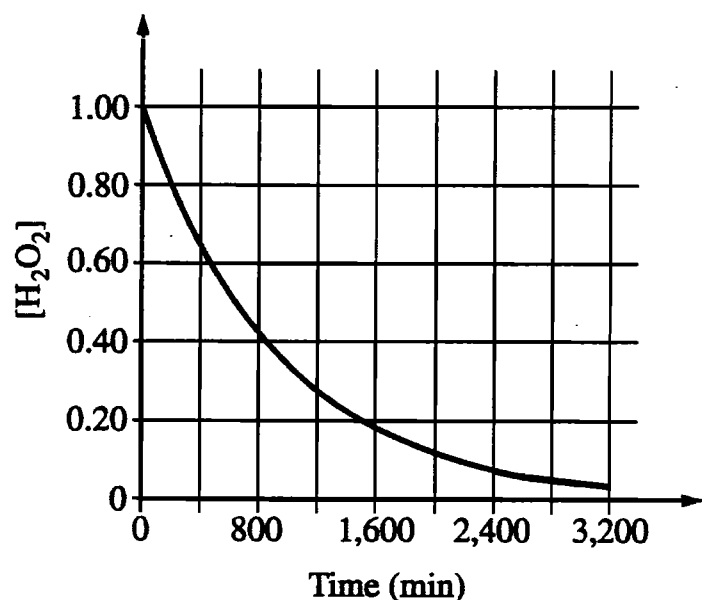


3. Hydrogen peroxide decomposes according to the equation above.

(a) An aqueous solution of H_2O_2 that is 6.00 percent H_2O_2 by mass has a density of 1.03 g mL^{-1} . Calculate each of the following.

- The original number of moles of H_2O_2 in a 125 mL sample of the 6.00 percent H_2O_2 solution
- The number of moles of $\text{O}_2(\text{g})$ that are produced when all of the H_2O_2 in the 125 mL sample decomposes

(b) The graphs below show results from a study of the decomposition of H_2O_2 .



- Write the rate law for the reaction. Justify your answer.
- Determine the half-life of the reaction.
- Calculate the value of the rate constant, k . Include appropriate units in your answer.
- Determine $[\text{H}_2\text{O}_2]$ after 2,000 minutes elapse from the time the reaction began.

$$a) \text{ i) } (125 \text{ mL}) \left(\frac{1.03 \text{ g}}{1 \text{ mL}} \right) \left(\frac{6.00}{100} \right) \left(\frac{1 \text{ mol H}_2\text{O}_2}{34.0158 \text{ g}} \right) = \boxed{0.227 \text{ mol H}_2\text{O}_2}$$

$$\text{ii) } \left(\frac{0.227 \text{ mol H}_2\text{O}_2}{2 \text{ mol H}_2\text{O}_2} \right) \left(\frac{1 \text{ mol O}_2}{1 \text{ mol O}_2} \right) = \boxed{0.114 \text{ mol O}_2}$$

$$b) \text{ i) } \text{rate} = k[\text{H}_2\text{O}_2]$$

Since the plot of the graph of $\ln[\text{H}_2\text{O}_2]$ vs. time produces a straight line, the reaction is a first-rate reaction

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3.

$$\text{ii) } t_{1/2} = 600 \text{ min}$$

$$\text{iii) } t_{1/2} = \frac{0.693}{k}$$

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{600} = \boxed{0.00116 \text{ min}^{-1}}$$

$$\text{iv) } \ln[\text{H}_2\text{O}_2] = -kt + \ln[\text{H}_2\text{O}_2]_0$$

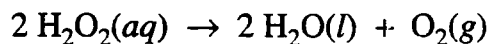
$$\ln[\text{H}_2\text{O}_2] = (-0.00116 \text{ min}^{-1})(2000 \text{ min}) + \ln(1.00 \text{ M})$$

$$\ln[\text{H}_2\text{O}_2] = -2.31$$

$$[\text{H}_2\text{O}_2] = \boxed{0.0993 \text{ M}}$$

STOP

If you finish before time is called, you may check your work on this part only.
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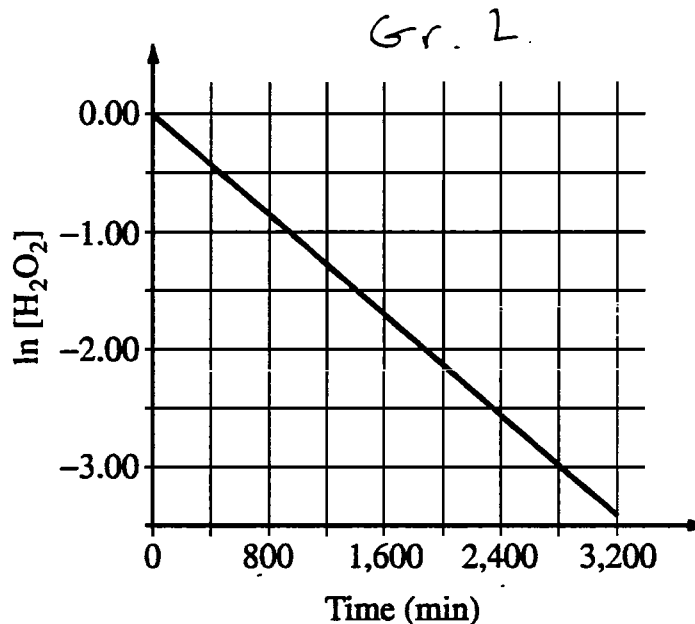
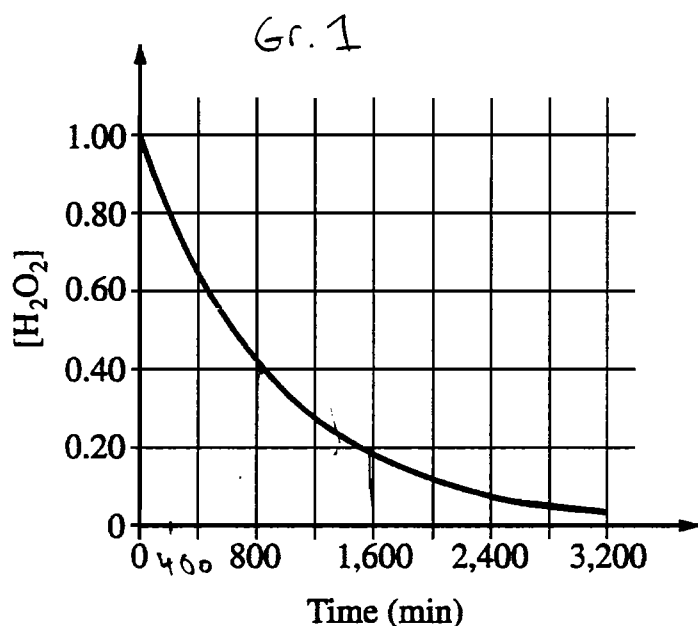


3. Hydrogen peroxide decomposes according to the equation above.

(a) An aqueous solution of H_2O_2 that is 6.00 percent H_2O_2 by mass has a density of 1.03 g mL^{-1} . Calculate each of the following.

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(b) The graphs below show results from a study of the decomposition of H_2O_2 .



- Write the rate law for the reaction. Justify your answer.
- Determine the half-life of the reaction.
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- Determine $[\text{H}_2\text{O}_2]$ after 2,000 minutes elapse from the time the reaction began.

$$\rho = \frac{m}{V}$$

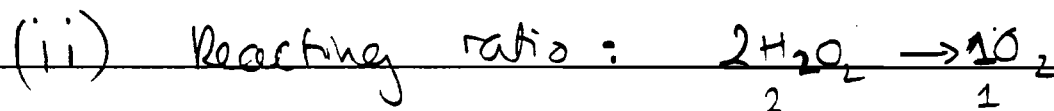
a) % by mass $\text{H}_2\text{O}_2 = \frac{m_{\text{H}_2\text{O}_2} \times 100}{m_{\text{soln}}} = 6\%$ $\rho_{\text{H}_2\text{O}_2} = 1.03 \text{ g/mL}$

(i) $n = ?$ $V = 125 \text{ mL} \Rightarrow m_{\text{soln}} = \rho \cdot V = 1.03 \text{ g} \times 125 \text{ mL} = 128.75 \text{ g}$

$M = \frac{m}{n}$ $M_{\text{H}_2\text{O}_2} = 2(1.0079) + 2(16) = 34.0158 \text{ g/mol}$

$m_{\text{H}_2\text{O}_2} = \frac{\% \text{ mass of H}_2\text{O}_2 \times \text{mass of soln}}{100} = \frac{6 \times 128.75}{100} = 7.725 \text{ g}$

$n_{\text{H}_2\text{O}_2} = \frac{m}{M} = \frac{7.725}{34.0158} = 0.22710 = 0.227 \text{ moles}$



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3B₂

$$\begin{array}{cc} 2 & 1 \\ 0.227 & x \end{array} \Rightarrow x = \frac{0.22710 - 0.11355}{2} = \boxed{0.114} \text{ moles}$$

b)(i) It is of the 1st order.

$$\ln[H_2O_2] = \ln[H_2O_2]_{\text{initial}} - kt$$

In Gr 1 \Rightarrow exponential graph with $t_{1/2} =$

In Gr 2 \Rightarrow a straight line with -ve slope.

for the plot of $\ln[H_2O_2]$ vs time

ii) $t_{1/2} = \frac{\ln 2}{k}$ $k = \text{slope of Gr 2} = \frac{\text{rise}}{\text{run}} = \frac{0 - (-3)}{2800}$

$$= \frac{\ln 2}{3/2800} = \frac{3}{2800} = 1.07 \times 10^{-3}$$

$$= 646.937 = \boxed{647 \text{ minutes}}$$

(iii) $k = \text{slope of graph 2} = \frac{0 - (-3)}{2800} = 1.07 \times 10^{-3} \text{ M/min.}$

(iv) $t = 2000$

$$\ln[H_2O_2] = \ln[H_2O_2]_{\text{initial}} - kt$$

$$\ln[H_2O_2] = 0 - \frac{3(2000)}{2800}$$

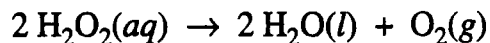
$$\ln[H_2O_2] = 2.1428$$

$$e^{\ln H_2O_2} = e^{2.1428}$$

$$H_2O_2 = 8.5237 = \boxed{8.524 \text{ M}}$$

STOP

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$$d = \frac{m}{V}$$

3C,

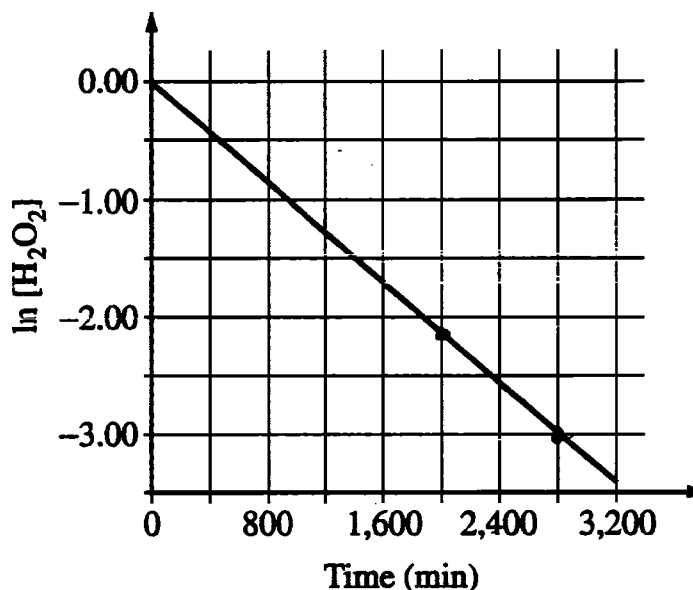
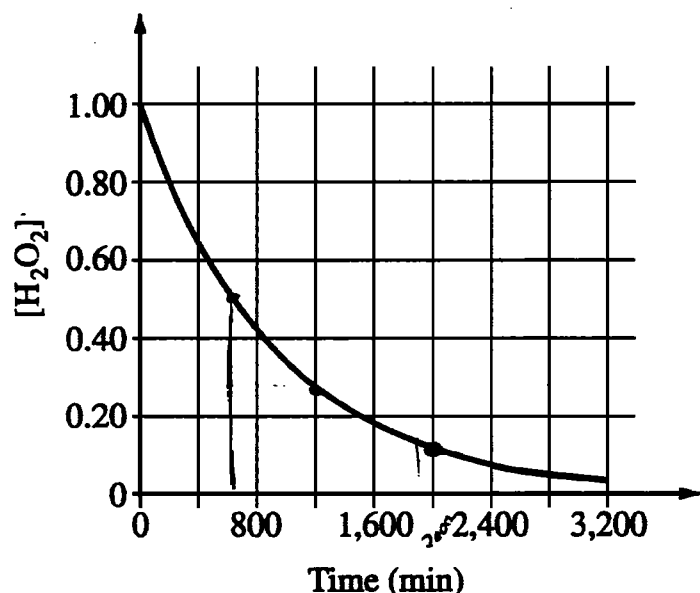
$$\frac{1.03 \text{ g}}{\text{ml}} \times 125.06$$

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a). density = $\frac{\text{mass}}{\text{volume}}$ $d = 1.03 \frac{\text{g}}{\text{ml}}$ $m = x$ $V = x$

~~$\frac{1}{1.03} = 125.0$~~ $1.03 \frac{\text{g}}{\text{ml}} = \frac{x \text{ grams } \text{H}_2\text{O}_2}{125.06}$

$7.725 \text{ g } \text{H}_2\text{O}_2$

$\frac{7.725 \text{ g}}{34 \frac{\text{mol}}{\text{g}}} = \boxed{.227 \text{ mol } \text{H}_2\text{O}_2}$

GO ON TO THE NEXT PAGE.

3C₂

ii

Since .227 mol H₂O₂ decomposes and ratio to O₂ is 2:1, $\frac{1}{2}$ of moles of H₂O₂ = mol O₂

$$\frac{.227 \text{ mol}}{2} = \boxed{.114 \text{ mol O}_2 \text{ produced}}$$

b. i For every 600 minutes the H₂O₂ loses half its previous mols.

ii Based on the graphs given the half life appears to be in the vicinity of 600 minutes as it takes that long for $\frac{1}{2}$ of the reactant to disappear/decompose.

$$\text{iii } \ln[A]_t - \ln[A]_0 = -kt$$

~~$$\ln \frac{1}{2} = \ln 1 = -k \cdot 2800$$~~

$$\ln .05 - \ln 1 = -k \cdot 2800$$

iv Based on the graph, the H₂O₂ will be 10.42 at t = 2000.

$$t = 1800 \rightarrow \text{H}_2\text{O}_2 = 12.65 \quad \frac{2000}{2400} = .83$$

$$.83 \cdot 12.5 = 10.416$$

STOP

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