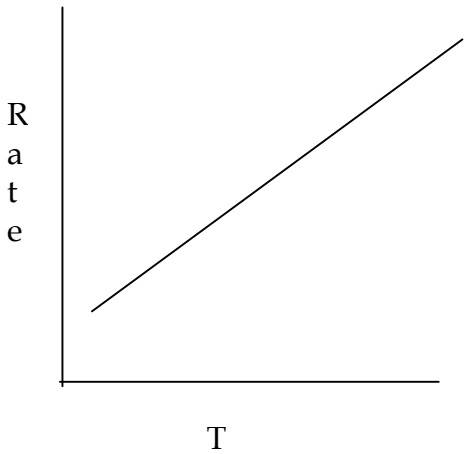
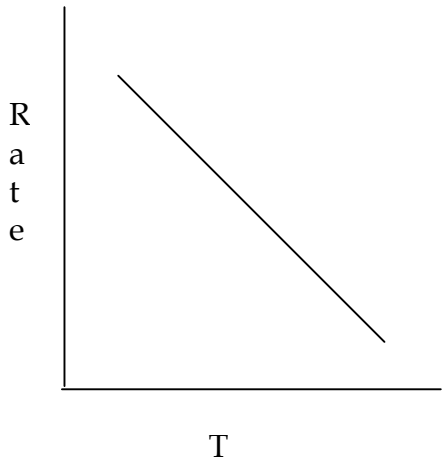
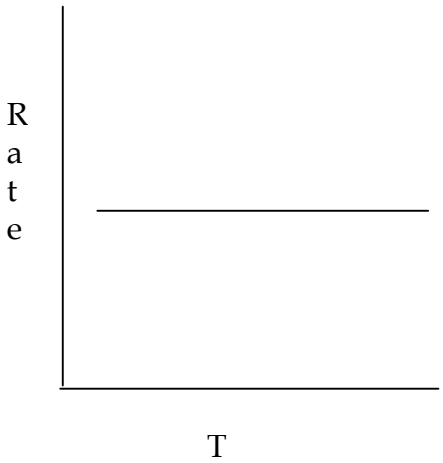
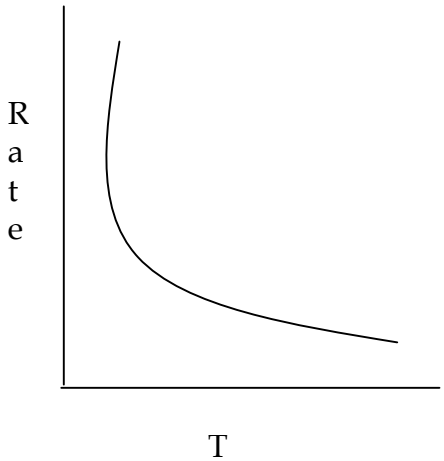
Chemical Kinetics - Practice Problems

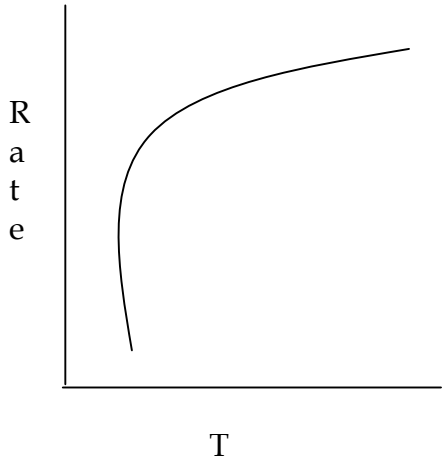
1. Which of the following graphs best describes the relationship between the *rate of a reaction* and the *temperature of the reaction*?











2. Describe the difference between the terms *rate of reaction, rate law,* and *rate constant*. Give an example of each.

3. What are the units of the rate constant for the following reaction?

$$2NO_2(g) \rightarrow N_2O_4(g) \qquad \text{Rate} = k\,[NO_2]^2$$

4. Calculate the rate at which N_2O_4 is formed in the following reaction at the moment in time when NO_2 is being consumed at a rate of 0.0592 M/s:

$$2NO_2(g) \rightarrow N_2O_4(g)$$

5. NO reacts with H_2 according to the following equation:

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

The mechanism for this reaction involves two steps:

$2NO + H_2 \rightarrow N_2 + H_2O_2$ (slow step)
$H_2O_2 + H_2 \rightarrow 2H_2O$ (fast step)

What is the experimental rate law for this reaction?

6. The disproportionation of NO to N_2O and NO_2 is third order in NO:

$3NO(g) \rightarrow N_2O(g) + NO_2(g) \qquad \text{Rate} = k\,[NO]^3$

This rate law is consistent with which of the following mechanisms?

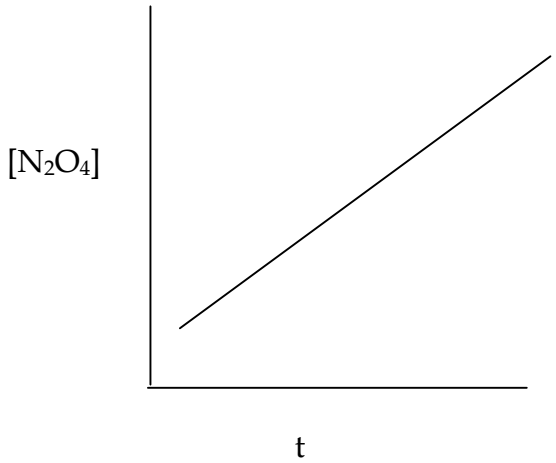
a) $3NO \rightarrow N_2O + NO_2$ (one-step)

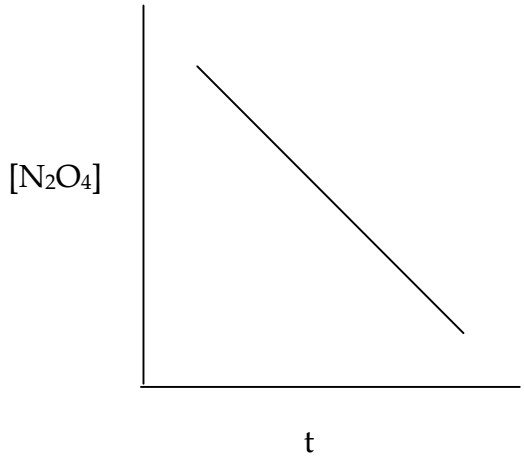
b) $2NO \rightarrow N_2O_2$ (slow step)
$N_2O_2 + NO \rightarrow N_2O + NO_2$ (fast step)

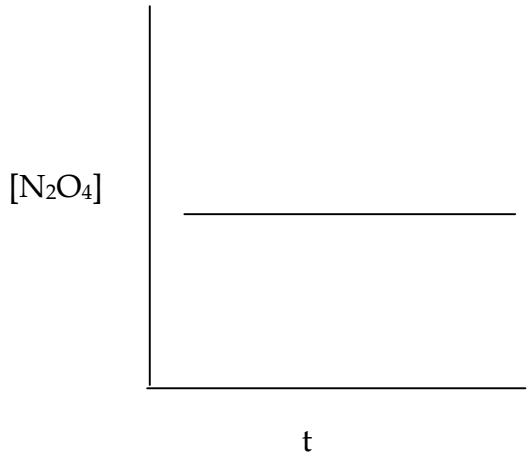
c) $2NO$ □ N_2O_2 (fast step)
$N_2O_2 + NO \rightarrow N_2O + NO_2$ (slow step)

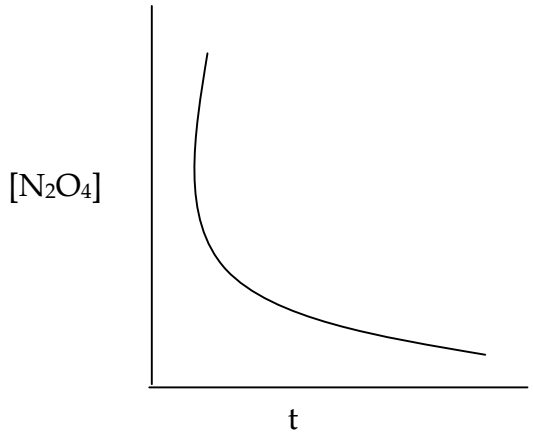
7. Which graph best describes the rate of the following reaction if this reaction is first order in N_2O_4?

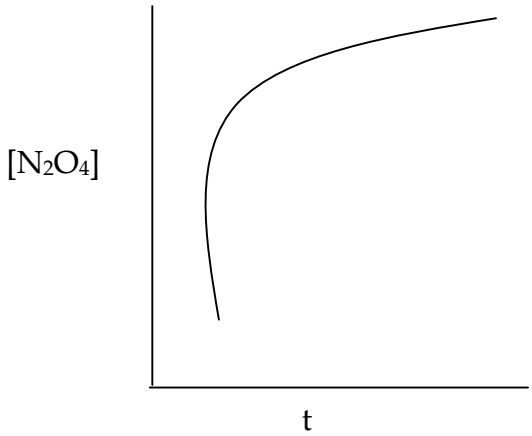
$$N_2O_4(g) \rightarrow 2NO_2(g)$$











8. The reaction in which NO_2 forms a dimer is second order in NO_2:

   $2NO_2(g) \rightarrow N_2O_4(g)$ Rate = k $[NO_2]^2$

   Calculate the rate constant for this reaction if it takes 0.005 s for the initial concentration of NO_2 to decrease from 0.50M to 0.25M.

9. The decomposition of hydrogen peroxide is first order in H_2O_2:

   $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ Rate = k $[H_2O_2]$

   How long will it take for half of the H_2O_2 in a 10-gal sample to be consumed if the rate constant for this reaction is $5.6 \times 10^{-2}\ s^{-1}$?

10. Calculate the rate constant for the following acid-base reaction if the half-life for this reaction is 0.0282 s at 25^0C and the reaction is first order in the NH_4^+ ion:

$$NH_4^+(aq) + H_2O(l) \rightarrow NH_3(aq) + H_3O^+(aq)$$

11. Use the following data to determine the rate law for the decomposition of N_2O.

$$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$$

[N_2O](M):	0.100	0.086	0.079	0.075	0.066	0.059	0.049
Time (s):	0	80	120	160	240	320	480

12. Use the results of the preceding problem to calculate the rate constant for this reaction. Predict the concentration of N_2O after 900 s.

13. Dimethyl ether, CH_3OCH_3,, decomposes at high temperatures as shown in the following equation:

$$CH_3OCH_3(g) \rightarrow CH_4(g) + H_2(g) + CO(g)$$

   The following data were obtained when the partial pressure of CH_3OCH_3 was studied as this compound decomposed at 500^oC. Use these data to determine the order of this reaction.

$P_{CH3OCH3}$ (mmHg):	312	278	251	227	157
Time (s):	0	390	777	1195	3155

14. The rate constant for the decomposition of N_2O_5 increases from $1.52 \times 10^{-5}\ s^{-1}$ at 25^0C to $3.83 \times 10^{-3}\ s^{-1}$ at 45^0C. Calculate the activation energy for this reaction.

15. Calculate the activation energy for the following reaction if the rate constant for this reaction increases from $87.1\ M^{-1}s^{-1}$ at 500K to $1.53 \times 10^3\ M^{-1}s^{-1}$ at 650K:

$$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$$

16. Calculate the activation energy for the decomposition of NO_2 from the temperature dependence of the rate constant for this reaction:

$$2NO_2(g) \rightarrow N_2(g) + 2O_2(g)$$

Temperature (K):	319	329	352	381	389
k ($M^{-1}s^{-1}$):	0.522	0.755	1.70	4.02	5.03

17. Calculate the rate constant at 780 K for the following reaction if the rate constant for the reaction is $3.5 \times 10^{-7}\ M^{-1}s^{-1}$ at 550 K and the activation energy is 188 kJ/mol:

$$2HI(g) \rightarrow H_2(g) + I_2(g)$$

18. Calculate the rate constant at 75^0C for the following reaction if the rate constant for this reaction is $6.5 \times 10^{-5}\ M^{-1}s^{-1}$ at 25^0C and the activation energy is 92.9 kJ/mol:

$$CH_3I(aq) + OH^-(aq) \rightarrow CH_3OH(aq) + I^-(aq)$$