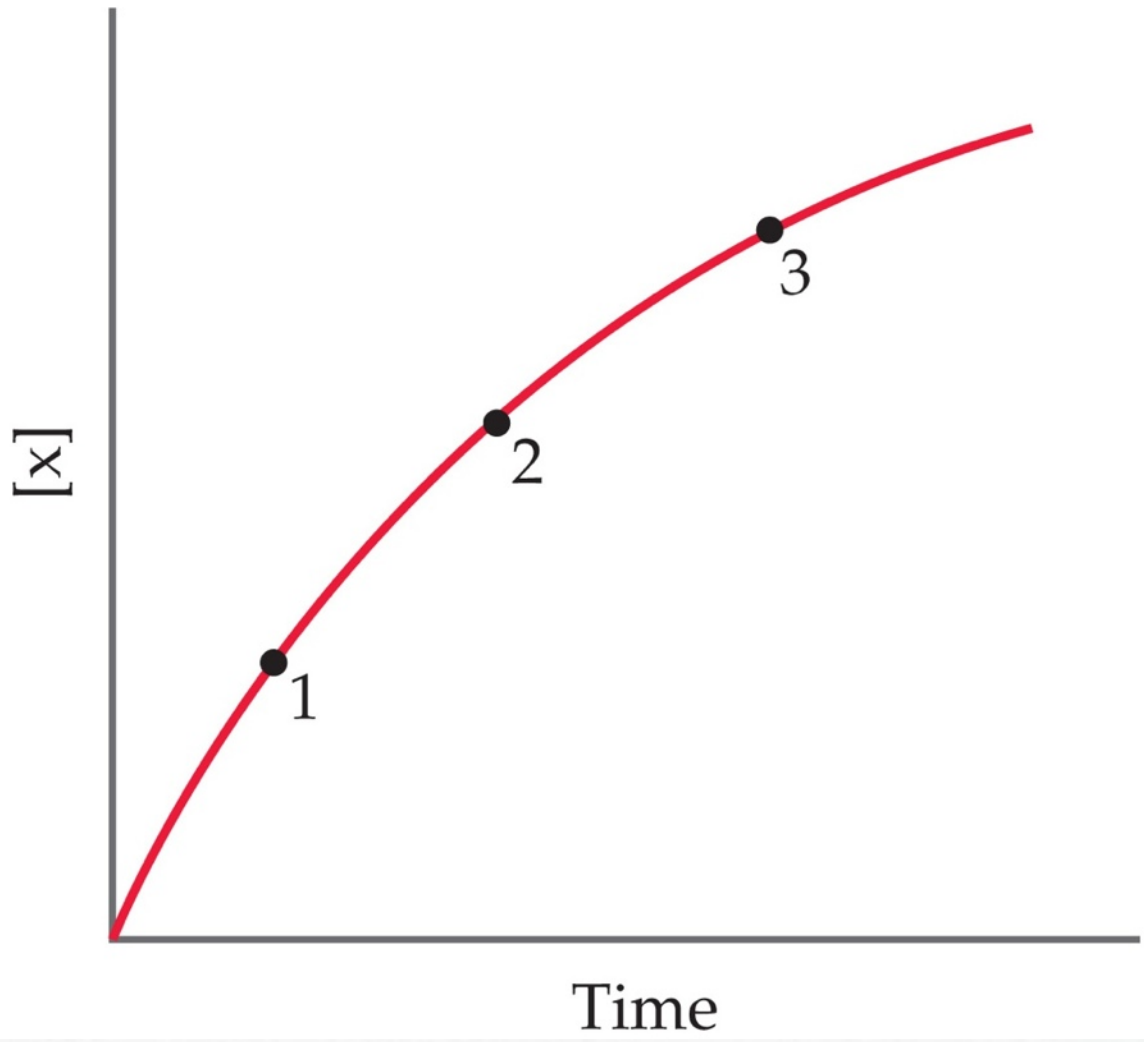
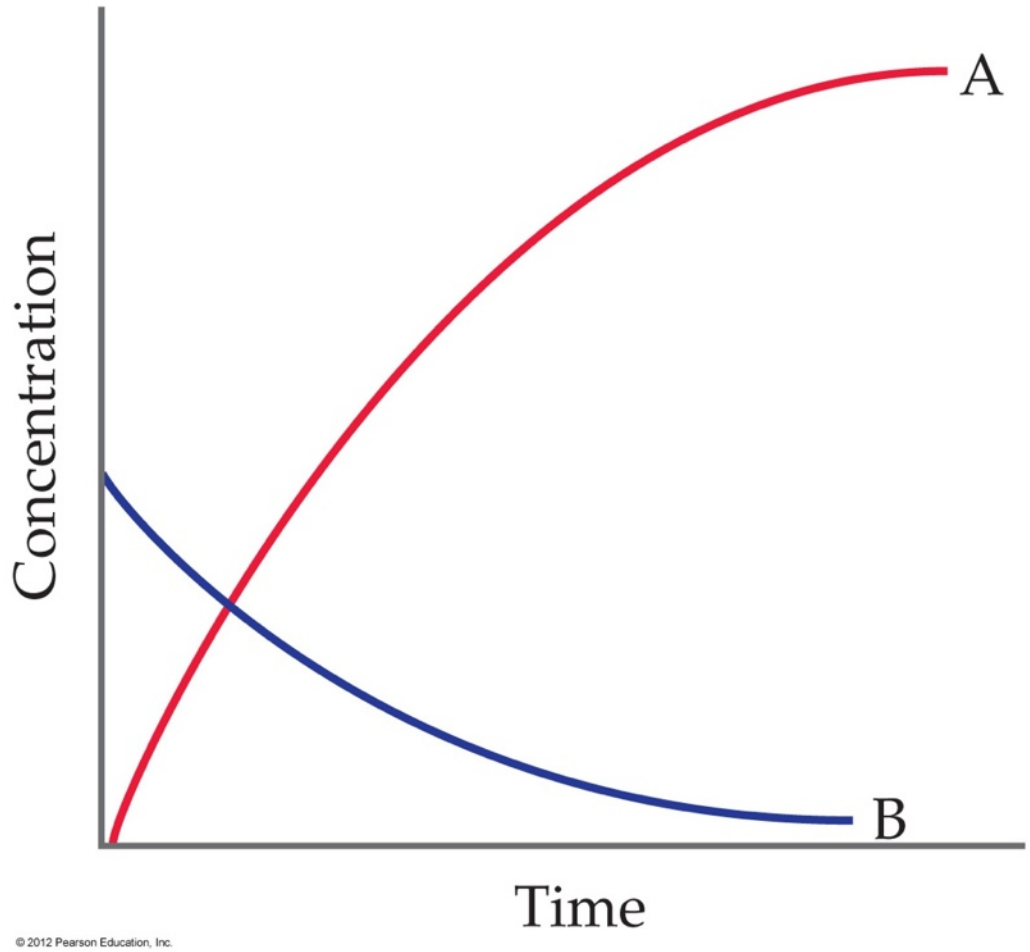


2] a. X is a product in the reaction.

b. The reaction is slowing down.

c. Average rate represents the change between 2 points

$$\frac{\Delta [\,]}{\Delta t} = \text{Rate}$$



3] answer D

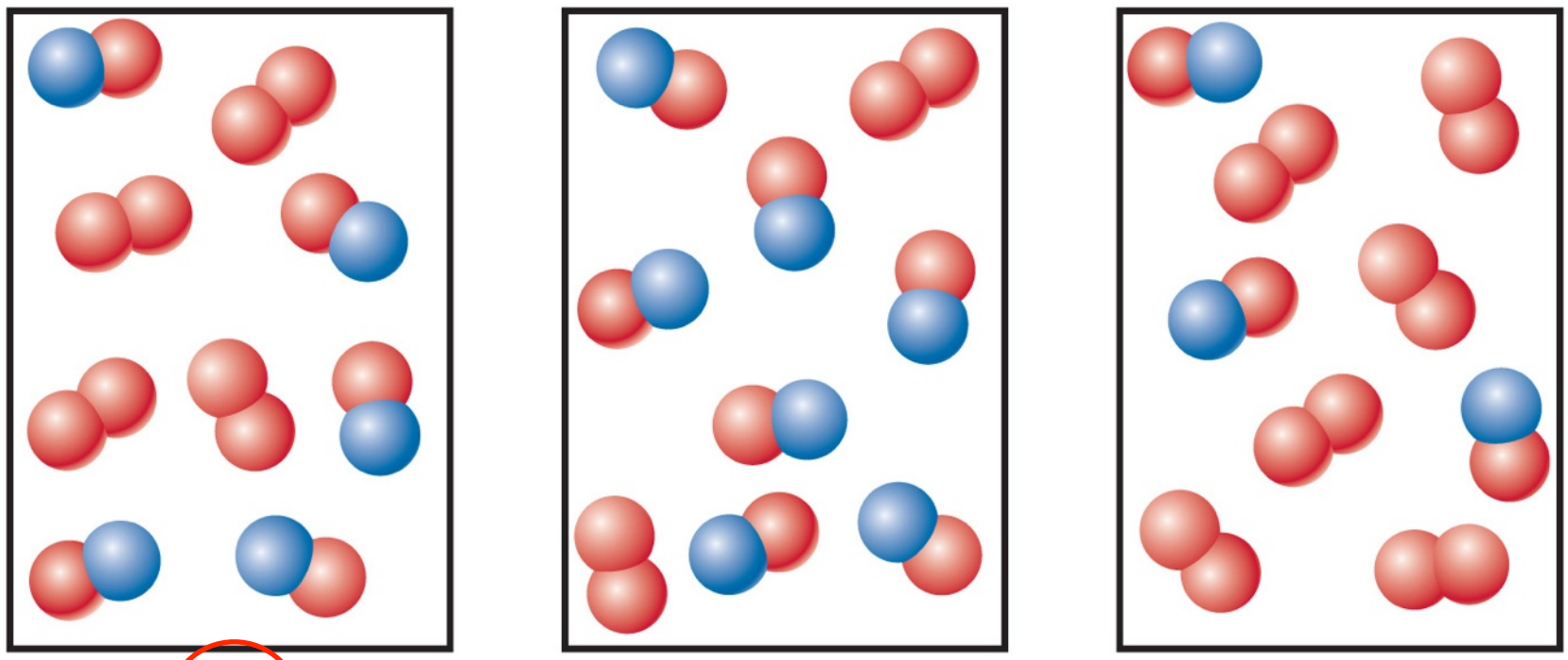
$B \rightarrow 2A$

5] $A \rightarrow B + C$

a. $Rate = k[A]^0$

b. $Rate = k[A]^2$

c. $Rate = k[A]^3$



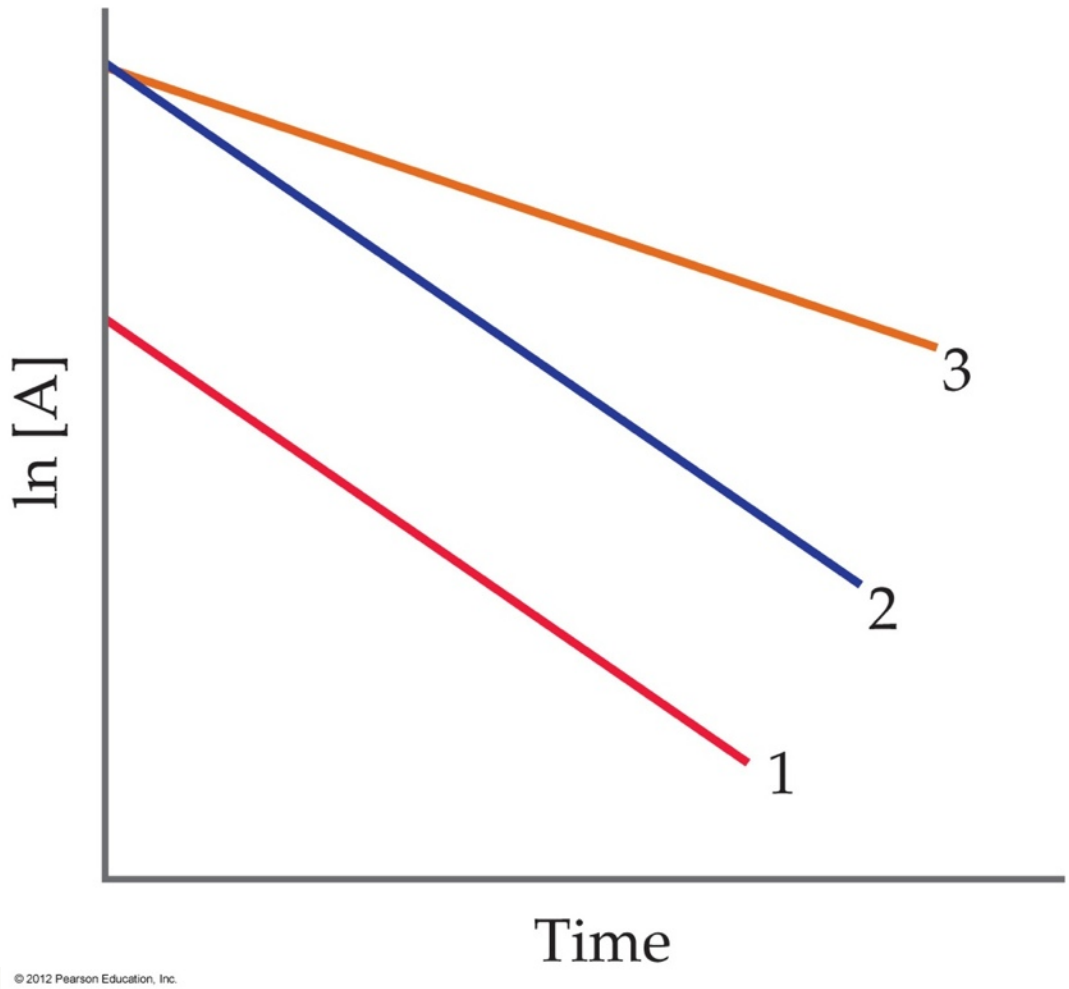
(1)

(2)

(3)

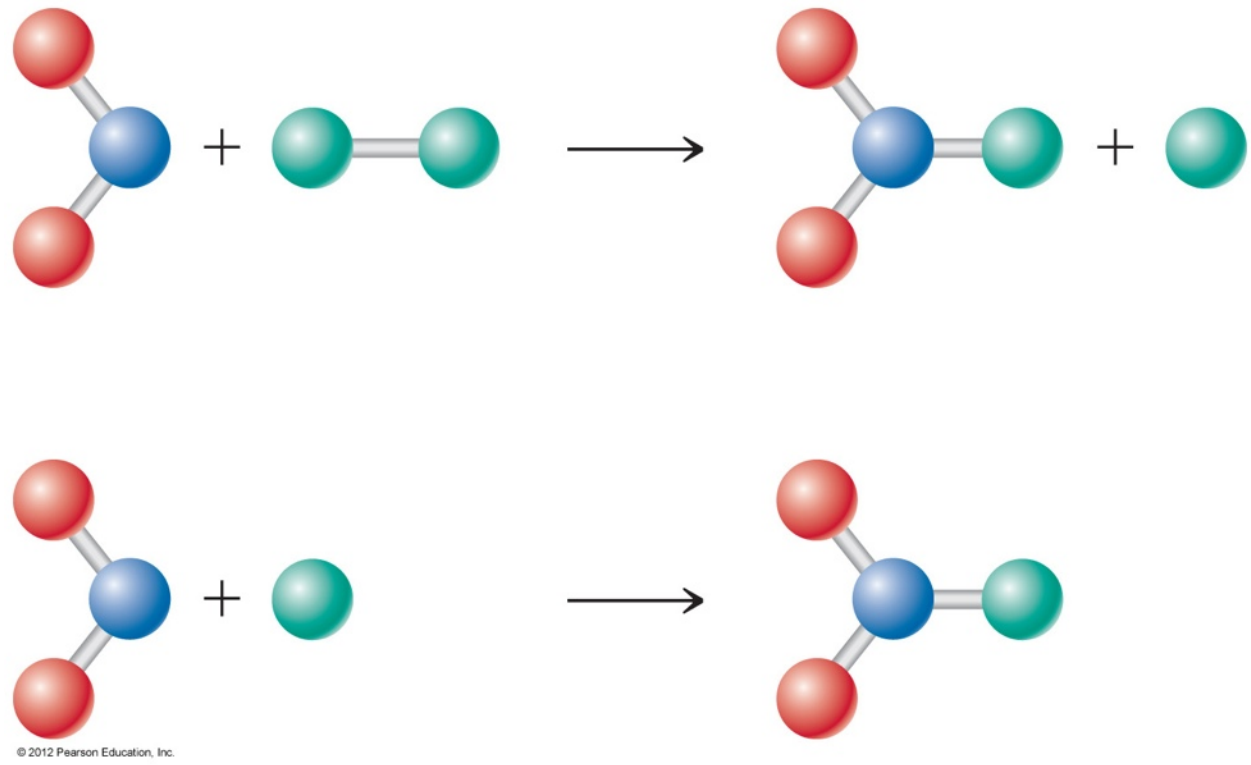
6] $[NO]^2[O_2]k = Rate$

$(5)^2(4) \propto 100$



7] a. Experiments 1 and 2 are occuring at the same temp. 1 and 2 have the same magnitude of slope.

b. 2 and 3 are starting at the same concentration. 3 is occuring at a lower temp.



12 a. $BR_2 + G_2 \rightarrow BR_2G + G$

$BR_2 + G \rightarrow BR_2G$

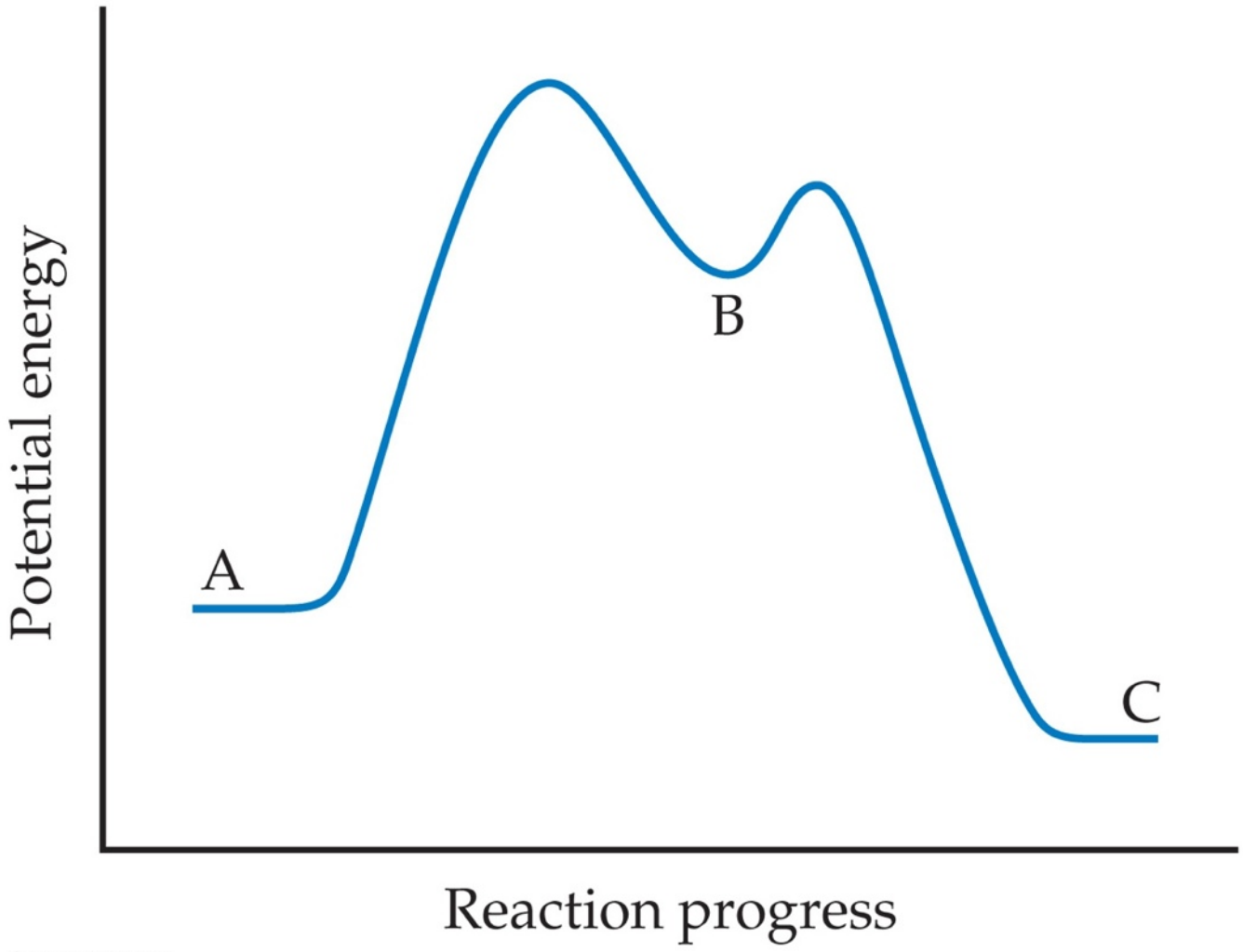
---

b. $2BR_2 + G_2 \rightarrow 2BR_2G$

c. G is an intermediate

d. $[BR_2][G_2]k = \text{Rate}$

Rate law for the slow step.



13

- There is one intermediate
- Two transition states
- The 2nd step is the fast step.
- $A \longrightarrow C$ is an exothermic reaction

17 a. $\frac{\Delta[A]}{\Delta t}$ = Rate

b. Temperature
concentration
surface area
catalyst

c. No - Relative rate depends on the coefficients in the balanced equation

19 $A \rightarrow B$

0 – 10 min .065 – .051 = 0.014 mol/L min

10 min – 20 min .051 – .042 = 0.009 mol/L min

20 min – 30 min .042 – .036 = 0.006 mol/L min

30 min – 40 min .036 – .031 = 0.005 mol/L min

Time (s)	[CH_3NC] (*M*)
0	0.0165
2,000	0.0110
5,000	0.00591
8,000	0.00314
12,000	0.00137
15,000	0.00074

21

$0 - 2000_s$ $\quad \frac{0.0165 - 0.0110}{2000_s} = 2.75 \times 10^{-6} M/s$

$2000 - 5000_s$ $\quad \frac{0.0110 - 0.00591}{3000_s} = 1.70 \times 10^{-6} M/s$

$5000 - 8000_s$ $\quad \frac{0.0051 - 0.00314}{3000_s} = 6.53 \times 10^{-7} M/s$

$8000 - 12000_s$ $\quad \frac{0.00314 - 0.00317}{4000_s} = 7.5 \times 10^{-9} M/s$

26 $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

$$0.036 \frac{\text{mol } C_2H_4}{\text{L s}} \times \frac{2 \text{ mol } CO_2}{1 \text{ mol } C_2H_4} = 0.072 \frac{M}{s} \; CO_2$$

$$0.036 \frac{\text{mol } C_2H_4}{\text{L s}} \times \frac{2 \text{ mol } H_2O}{1 \text{ mol } C_2H_4} = 0.072 \frac{M}{s} \; H_2O$$

b. $N_2H_4 + H_2 \rightarrow 2NH_3$

$$\frac{74 \text{ torr } N_2H_4}{\text{hr}} \times \frac{2 \text{ torr } NH_3}{1 \text{ torr } N_2H_4} =$$

$$\frac{148 \text{ torr } NH_3}{\text{hr}}$$

There is no overall change in pressure per hour.

$[OCl^-]$ (M)	$[I^-]$ (M)	Initial Rate (M/s)
1.5×10^{-3}	1.5×10^{-3}	1.36×10^{-4}
3.0×10^{-3}	1.5×10^{-3}	2.72×10^{-4}
1.5×10^{-3}	3.0×10^{-3}	2.72×10^{-4}

33

$$\frac{3.0\times10^{-3}}{1.5\times10^{-3}} = 2 \qquad \frac{2.72\times10^{-4}}{1.36\times10^{-4}} = 2$$

a. $[OCl^-][I^-]k = \text{Rate}$

b. $\left(1.5\times10^{-3}\ \frac{mol}{L}\right)\left(1.5\times10^{-3}\ \frac{mol}{L}\right)k = 1.36\times10^{-4}\ \frac{mol}{L\ s}$

k = 60.4 L /mol s

c. $\left(2\times10^{-3}\ \frac{mol}{L}\right)\left(5.0\times10^{-4}\ \frac{mol}{L}\right)\left(1.36\times10^{-4}\ \frac{mol}{L\ s}\right)$

$= 1.65\times10^{-8}\ \frac{mol}{L\ s}$

Experiment	$[ClO_2]$ (*M*)	$[OH^-]$ (*M*)	Initial Rate (*M*/s)
1	0.060	0.030	0.0248
2	0.020	0.030	0.00276
3	0.020	0.090	0.00828

34] $2ClO_2 + 2OH^- \rightarrow ClO_3^- + ClO_2^- + H_2O$

$[ClO_2]^2$ $\frac{0.06}{0.02} = 3$ $\frac{0.0248}{0.00276} = 9$

$[OH^-]$ $\frac{0.09}{0.03} = 3$ $\frac{0.00828}{0.00276} = 3$

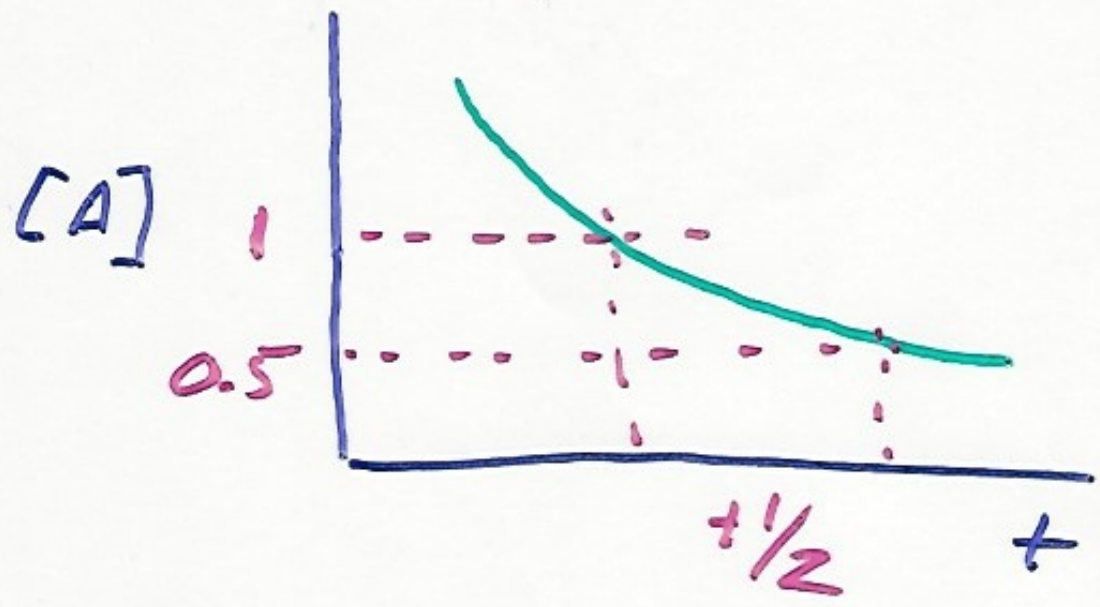
a. $Rate = k[ClO_2]^2[OH^-]$

b. $\dfrac{0.0248 \frac{mol}{L s}}{(0.06 \frac{mol}{L})^2 (0.03 \frac{mol}{L})} = 230 \frac{L^2}{mol^2 s}$

c. $(0.100 \frac{mol}{L})^2 (0.050 \frac{mol}{L}) \left(230 \frac{L^2}{mol^2 s}\right)$

$= 0.12 \frac{mol}{L s}$

42 $A \rightarrow B$



a. No - as the [A] changes so does the slope of the line

b.

46 $2N_2O_5 \longrightarrow 4NO_2 + O_2$

$$Rate = k[N_2O_5]$$

a. $k = 6.82 \times 10^{-3}\ 1/s$

$$[N_2O_5]_0 = \frac{0.0250 mol}{2.0 L} = 0.013 M$$

$$\boxed{\ln[\ ] = -kt + \ln[\ ]_0}$$

$$= -(6.82 \times 10^{-3}\ 1/s)(300 s) + \ln(0.013)$$

$$[N_2O_5] = 1.68 \times 10^{-3} \frac{mol}{L} \times 2L =$$

3.3×10^{-3} mol N_2O_5

46 b.

$$\ln\left(\frac{0.010\,mol}{2L}\right) = -6.82\times10^{-3}\,1/s\,(t) + \ln(0.0125)$$

$$t = 134\,s \times \frac{1\,min}{60\,s} = 2.2\,min$$

c. $$t_{1/2} = \frac{\ln 2}{6.82\times10^{-3}\,1/s}$$

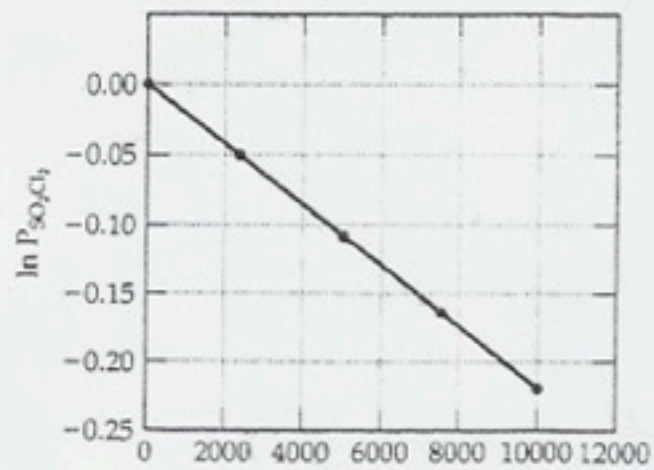
$$= 101.6\,s \times \frac{1\,min}{60\,s} = 1.69\,min$$

47

Time (s)	Pressure SO_2Cl_2 (atm)
0	1.000
2,500	0.947
5,000	0.895
7,500	0.848
10,000	0.803

14.47

t(s)	$P_{SO_2Cl_2}$	$\ln P_{SO_2Cl_2}$
0	1.000	0
2500	0.947	−0.0545
5000	0.895	−0.111
7500	0.848	−0.165
10000	0.803	−0.219



$$\frac{\Delta \ln P}{\Delta t} = k = \frac{0.219 - 0}{10000 - 0}$$

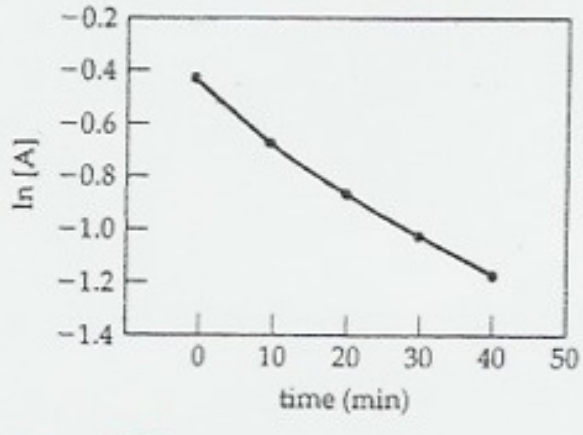
$$k = 2.19 \times 10^{-5}\ 1/s$$

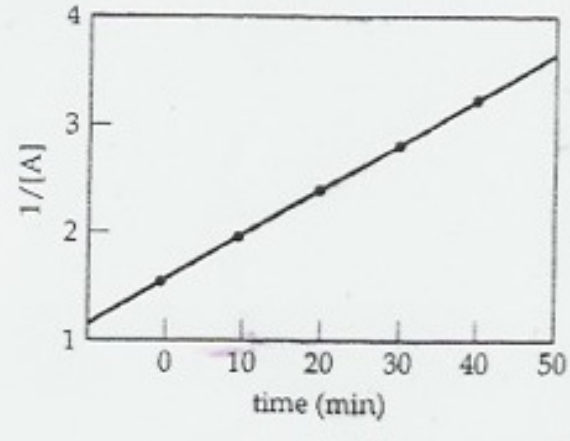
49

Time (min)	0	10	20	30	40
Moles of A	0.065	0.051	0.042	0.036	0.031

(a)	time(min)	mol A	[A] (*M*)	ln[A]	1/mol A
	0	0.065	0.65	−0.43	1.5
	10	0.051	0.51	−0.67	2.0
	20	0.042	0.42	−0.87	2.4
	30	0.036	0.36	−1.02	2.8
	40	0.031	0.31	−1.17	3.2

49 a.





A → B

Rate = k [A]^2

49 b. $$k = \frac{\Delta\, 1/[A]}{\Delta t}$$

$$= \frac{0.65 - 0.31}{40\,min - 0}$$

$$k = \frac{0.04\ L}{mol\ min}$$

c. $$t_{1/2} = \frac{1}{k[A]_0}$$

$$= \frac{1}{\left(\frac{0.04\ L}{mol\ min}\right)\left(0.65\ \frac{mol}{L}\right)}$$

$$t_{1/2} = 38\ min$$

63 a. $\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$

$= \frac{75.5\times10^3\,J}{8.314\,J/mol\,k}\left(\frac{1}{333k} - \frac{1}{293k}\right)$

$\ln\left(\frac{k_1}{k_2}\right) = -3.723$

$\frac{k_1}{k_2} = 0.0242$

$k_2 = \frac{2.75\times10^{-2}\,1/s}{0.0242} = 1.14\,1/s$

63 b. $\ln\left(\frac{k_1}{k_2}\right) =$

$$\frac{125 \times 10^3 \text{ J/mol}}{8.314 \text{ J/mol K}}\left(\frac{1}{353} - \frac{1}{295}\right)$$

$$\ln\left(\frac{k_1}{k_2}\right) = -6.16$$

$$\frac{k_1}{k_2} = 2.104 \times 10^{-3}$$

$$k_2 = \frac{0.0275 \text{ 1/s}}{2.104 \times 10^{-3}}$$

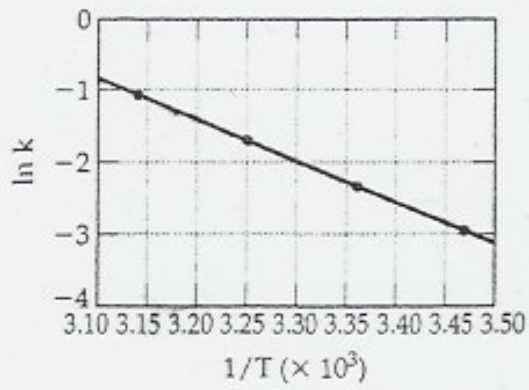
$$= 13.07$$

$$\text{slope} = -E_a/R$$

$$= \frac{\Delta \ln k}{\Delta\, 1/T}$$

14.65

k	ln k	T(K)	1/T(× 10^3)
0.0521	−2.955	288	3.47
0.101	−2.293	298	3.36
0.184	−1.693	308	3.25
0.332	−1.103	318	3.14



$$\frac{-2.955 - (-1.103)}{3.47 - 3.14} = -5.71 \times 10^3$$

$$(-1)(-5.71 \times 10^3)(8.314) = 47.5\ \text{kJ/mol}$$

73 a. $Cl_2 \rightarrow 2Cl$

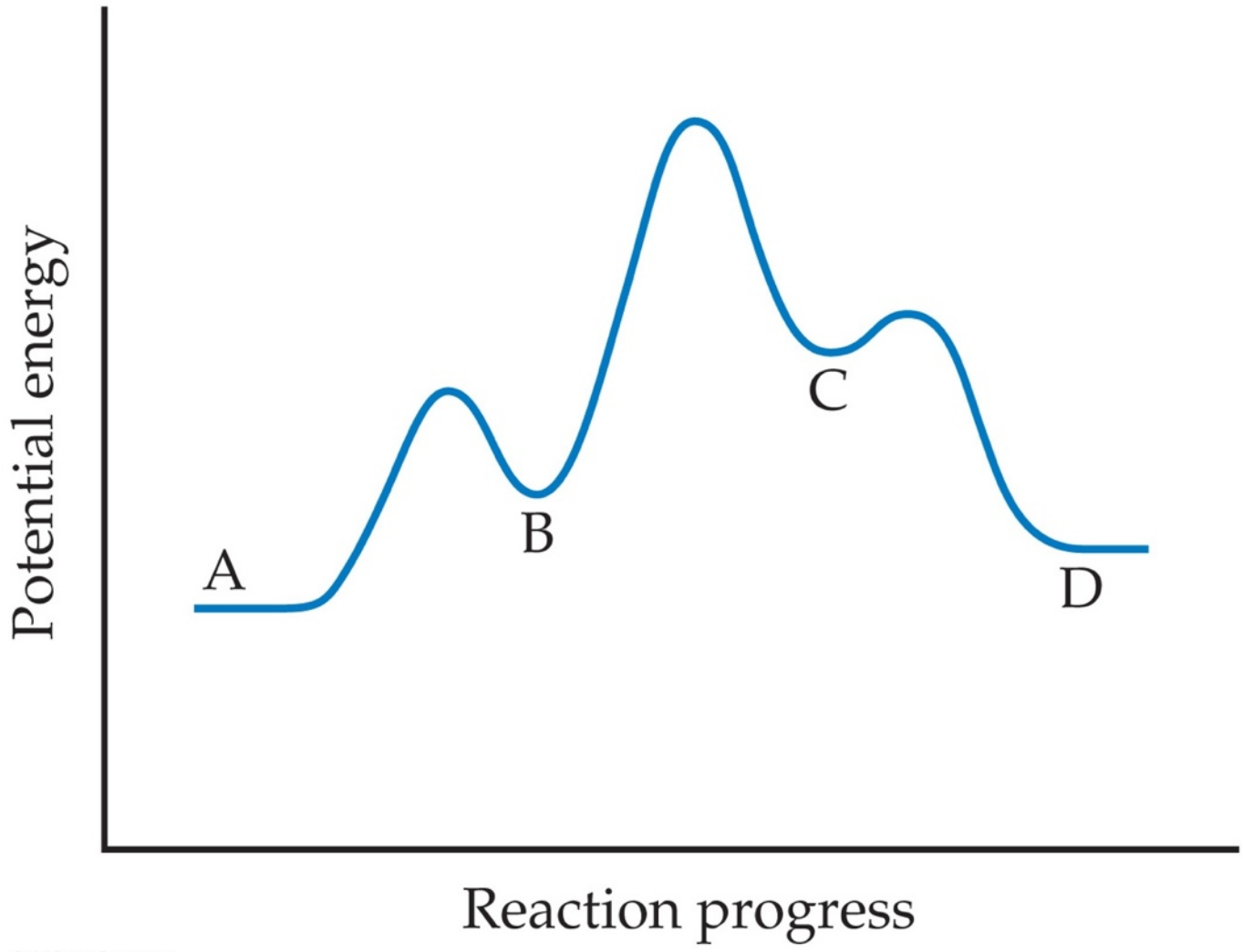
$Rate = k[Cl_2]$

b. $OCl^- + H_2O \rightarrow HOCl + OH^-$

$Rate = k[OCl^-][H_2O]$

c. $NO + Cl_2 \rightarrow NOCl_2$

$Rate = k[NO][Cl_2]$



75 a. 2 intermediates

b. 3 transition states

c. C → D fastest step
lowest activation energy

d. This is an endothermic reaction.

77 a. $H_2 + ICl \rightarrow \cancel{HI} + HCl$

$\cancel{HI} + ICl \rightarrow I_2 + HCl$

$H_2 + 2ICl \rightarrow I_2 + 2HCl$

b. HI is an intermediate (made in one step used in another step)

c. Rate = $k[H_2][ICl]$

the slow step determines matches the overall rate law.

85

a. $2NO_2 + 2SO_2 \rightarrow 2NO + 2SO_3$

$2NO + O_2 \rightarrow 2NO_2$

$2SO_2 + O_2 \rightarrow 2SO_3$

b. NO_2 is the catalyst

comes into the reaction the same way it goes out.

c. NO_2 is a homogenous catalyst

in the same state as the reactants