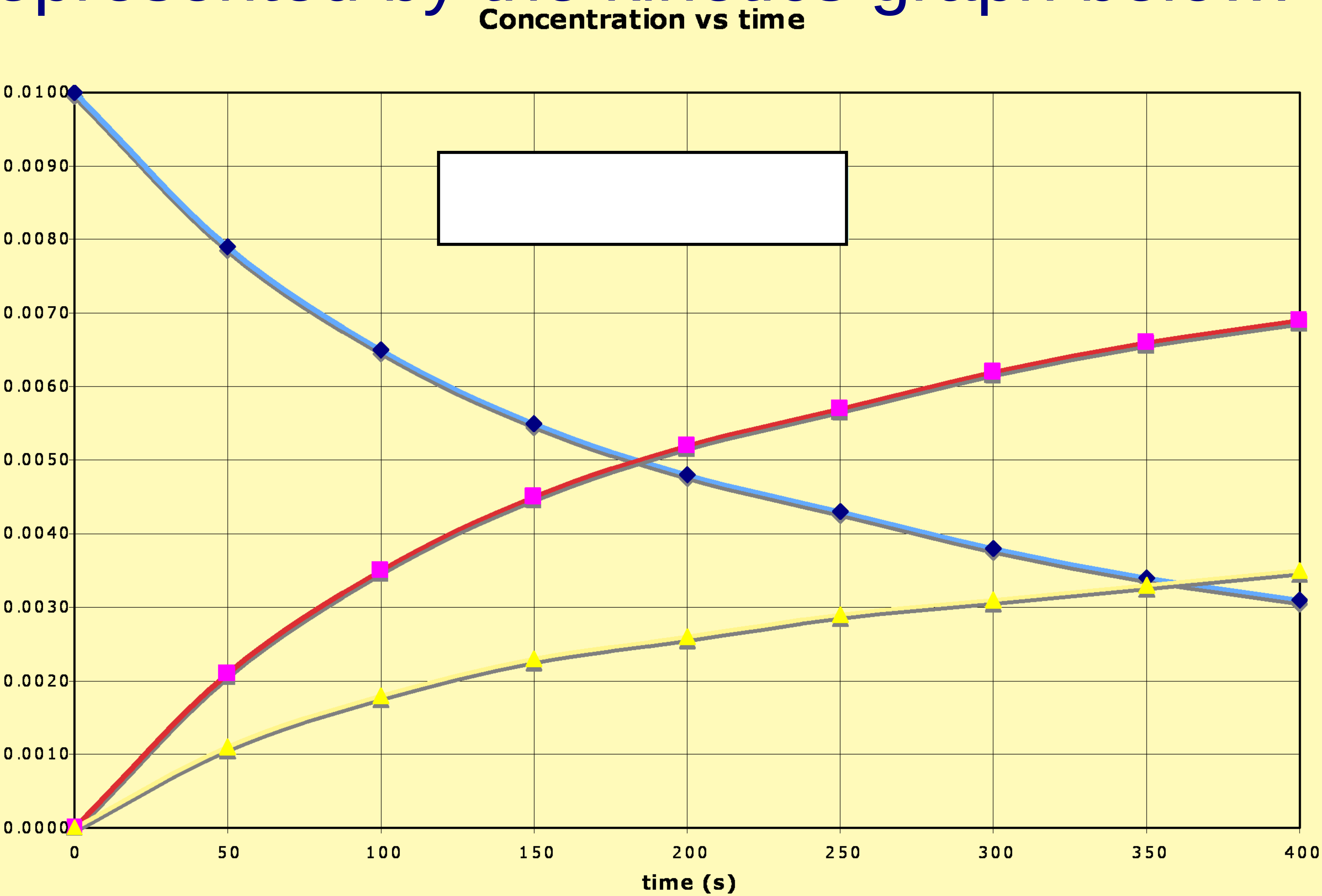
Kinetics

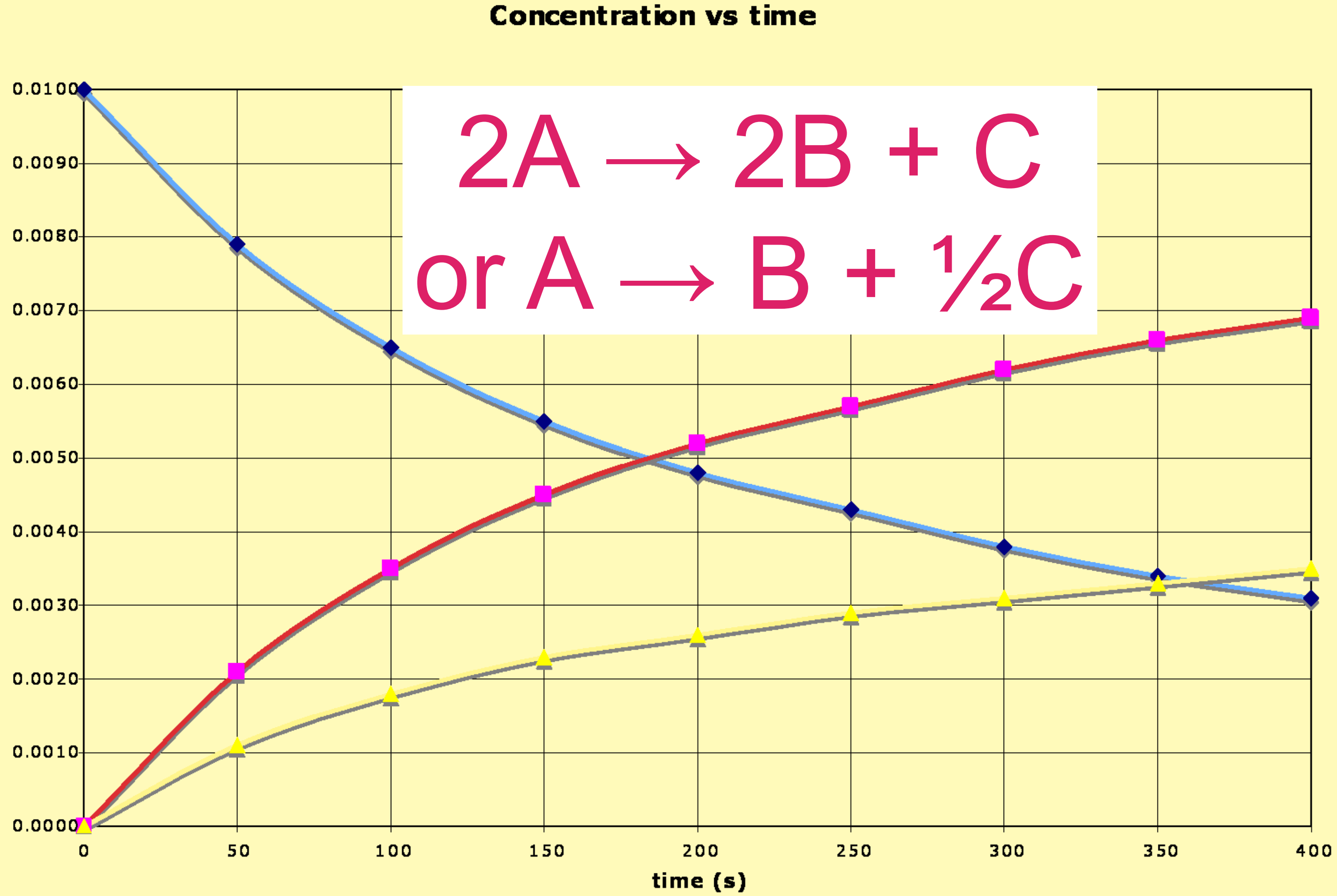
Clicker Questions

Using generic letters (A, B, C), write a balanced equation for the reaction represented by the kinetics graph below.



Using generic letters (A, B, C), write a balanced equation for the reaction represented by the kinetics graph below.

1. Since reactants decrease and products increase, and the reactant decreases at the same rate as the increase of one of the products. The other product increases at half the rate.



Which of the following affect reaction rate?
(Select all that apply.)

1. concentration of reactants
2. physical state (or phase) of reactants
3. chemical nature of reactants
4. form of the reactants: crushed vs chunky
5. temperature
6. presence of a catalyst
7. None of the above affect reaction rate

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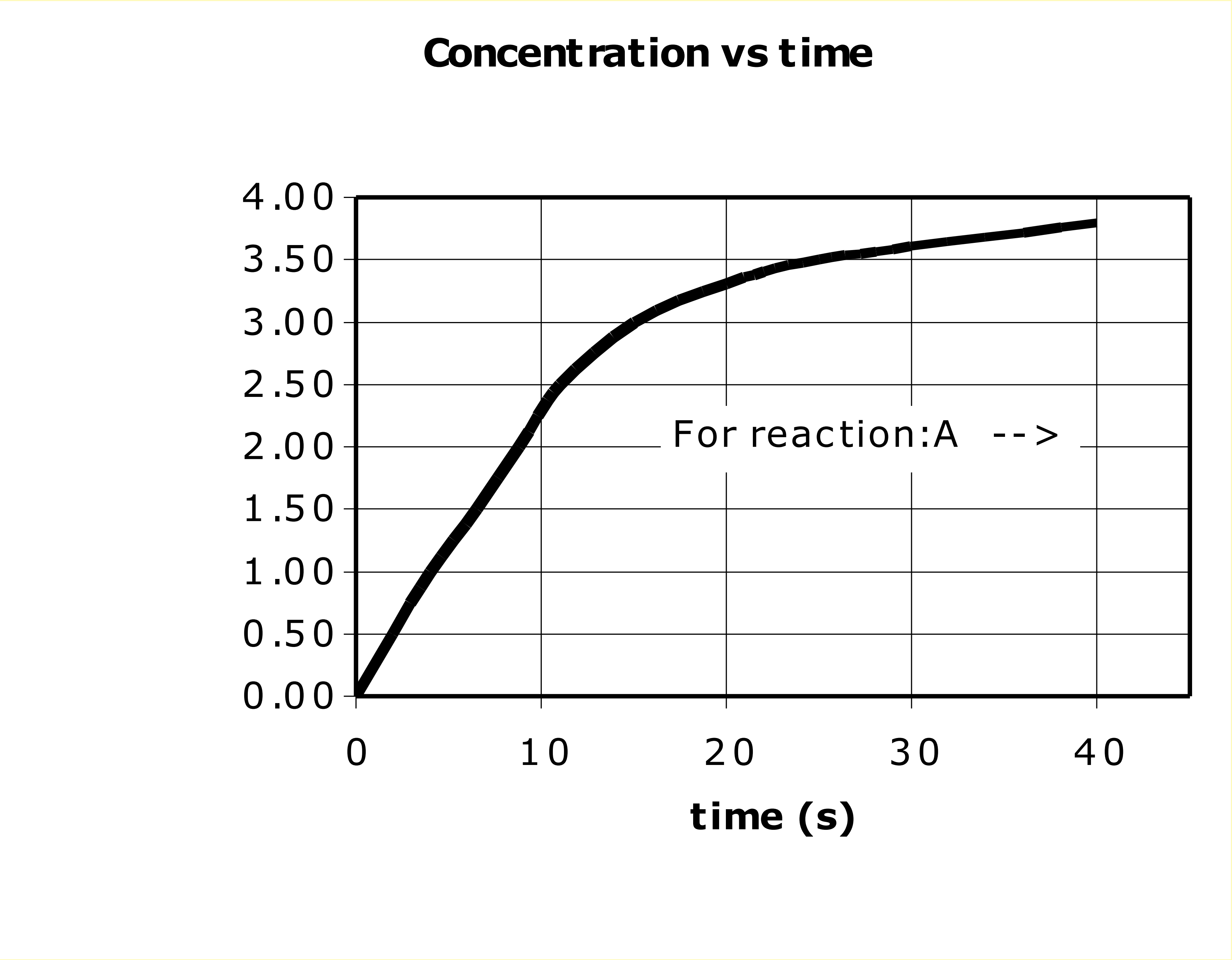
5. temperature
6. presence of a catalyst
7. None of the above affect reaction rate
8. All of the factors affect reaction rate, for many different reasons.

Use the graph below for A → B to determine the rate of appearance of B at time = 20 sec.

1. The rate would be closest to:
2. 0.05 mol $L^{-1}s^{-1}$
3. 0.01 mol $L^{-1}s^{-1}$
4. 1.0 mol $L^{-1}s^{-1}$
5. 3.4 mol $L^{-1}s^{-1}$
6. 10 mol $L^{-1}s^{-1}$
7. 20 mol $L^{-1}s^{-1}$



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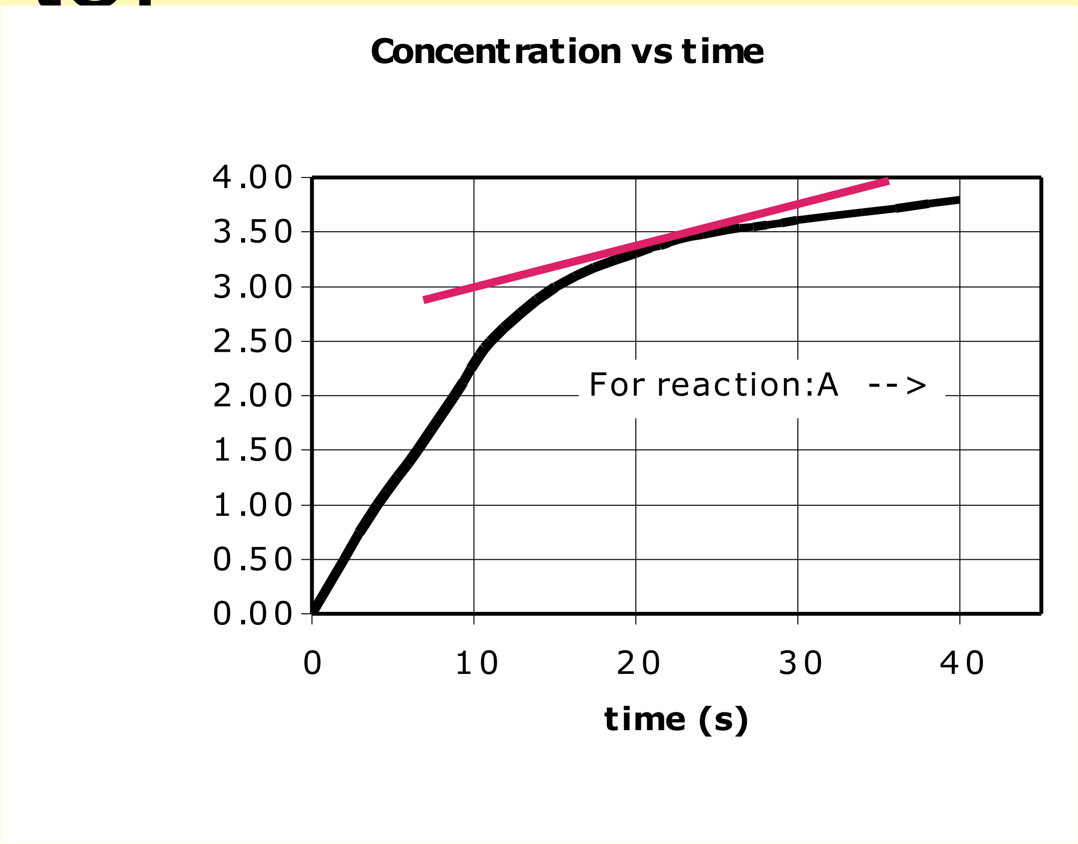
6. 10 mol $L^{-1}s^{-1}$
7. 20 mol $L^{-1}s^{-1}$
8. This question is asking about *instantaneous* rate, not an *average* rate.
9. You should draw a tangent to the curve at 20 sec and determine the slope of the tangent.



The reaction $3O_2 \rightarrow 2O_3$ is proceeding with a rate of disappearance of O_2 equal to -0.60 M/s. What is the rate of appearance of O_3?

1. 0.60 M/s
2. 0.90 M/s
3. 0.40 M/s
4. 1.20 M/s
5. 0.10 M/s

No calculator

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5. 0.10 M/s
6. -0.60 M/s O_2 * $2O_3/3O_2$ =

A reaction has the rate law: rate = $k [A]^2 [B]^2$

What is the overall order of the reaction?

A reaction has the rate law: rate = $k [A]^2 [B]^2$
What is the overall order of the reaction?

- 4th order
- Simply add the exponents

What are the units for the rate constant for a reaction that is second order overall?

(Select all that apply.)

1. s^{-1}
2. M/s
3. L mol^{-1} s^{-1}
4. $M^{-2}s^{-1}$
5. $M^{-1}s^{-1}$
6. s/M
7. L/(mol s)
8. L^2 mol^{-2} s^{-1}

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5. $M^{-1}s^{-1}$
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7. L/(mol s)
8. L^2 mol^{-2} s^{-1}
9. The units on rate are: M/time = $k[M]^2$
10. The k must always have a 1/time unit *and* the amount of M needed to *work with* the M from concentration, thus 1/(M time)

The reaction: $I^{-1} + OCl^{-1} \rightarrow IO^{-1} + Cl^{-1}$ is first order with respect to both reactants. The rate law constant is $0.061 M^{-1}s^{-1}$. What is the rate of the reaction when $[I^{-1}]=0.10M$ and $[OCl^{-1}]=0.20 M$?

no calculator

1. 2.4×10^{-4} M/s
2. 1.2×10^{-4} M/s
3. 1.2×10^{-3} M/s
4. 2.4×10^{-5} M/s
5. 6.1×10^{-3} M/s

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1. 2.4×10^{-4} M/s
2. 1.2×10^{-4} M/s
3. 1.2×10^{-3} M/s
4. simply substitute into the rate law
5. rate = k $[I^{-1}]$ $[OCl^{-1}]$
6. rate = $0.062 M^{-1}s^{-1}$[0.10M][0.20M]

4. 2.4×10^{-5} M/s
5. 6.1×10^{-3} M/s

The rate law for the reaction: $A + B \rightarrow C$

This reaction is second order with respect to A and first order with respect to B. What happens to the rate when the concentration of A is doubled?

1. the rate doubles
2. the rate is halved
3. the rate triples
4. the rate quadruples
5. impossible to determine

The rate law for the reaction: A + B $\rightarrow$ C

This reaction is second order with respect to A and first order with respect to B. What happens to the rate when the concentration of A is doubled?

1. the rate doubles
2. Assuming that the concentration of B is held constant.
2. the rate is halved
3. the rate triples
4. the rate quadruples
5. impossible to determine
1. If you did not make the previous assumption, this would be the appropriate answer.

The table below provides rate data for the reaction: $2A + B \rightarrow C$. What is the rate law for this reaction?

1. rate = $k[A]^2$
2. rate = $k[B]^2$
3. rate = $k[A][B]$
4. rate = $k[A]^2[B]^2$
5. rate = $k[A]^2[B]$
6. rate = $k[A][B]^2$

	[A]	[B]	rate M/s
1	2.0	1.0	0.10
2	2.0	2.0	0.40
3	4.0	4.0	1.6

The table below provides rate data for the reaction: 2A + B → C. What is the rate law for this reaction?

	[A]	[B]	rate M/s
1	2.0	1.0	0.10
2	2.0	2.0	0.40
3	4.0	4.0	1.6

1. rate = $k[A]^2$
2. rate = $k[B]^2$
3. rate = $k[A][B]$
4. rate = $k[A]^2[B]^2$
5. rate = $k[A]^2[B]$
6. rate = $k[A][B]^2$
7. comparing exp 2 to 1: as B is doubled (while A held constant) the rate is quadrupled, thus second order.
8. comparing exp 3 to 2: as B is doubled, and A is doubled, the rate only quadruples, thus A must be having no effect.
9. The only possible solution for x is 0

$$\frac{\text{exp 3:} \quad 1.6 = k[4]^x[4]^2}{\text{exp 2:} \quad 0.40 = k[2]^x[2]^2}$$

The acid catalyzed decomposition of hydrogen peroxide is a first order reaction with the rate constant given below. For an experiment in which the starting concentration of hydrogen peroxide is 0.110 M, what is the concentration of H_2O_2 450 minutes after the reaction begins?

$2\ H_2O_2 \rightarrow 2H_2O + O_2$ $k = 1.33 \times 10^{-4}\ min^{-1}$

yes, calculator

1. 0.0961 M
2. 0.00658 M
3. 0.104 M
4. 0.0156 M
5. 0.117 M

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$2H_2O_2 \rightarrow 2H_2O + O_2$ $\quad k = 1.33 \times 10^{-4}\ min^{-1}$

1. *You may use a calculator for this problem.*
2. 0.0961 M
3. 0.00658 M
4. 0.104 M
5. 0.0156 M
6. 0.117 M
7. Use the integrated rate law and solve for $[H_2O_2]_t$
   - ✓ $\ln[H_2O_2]_t = -kt + \ln[H_2O_2]_0$
   - ✓ $\ln[H_2O_2]_t = -1.33\times10^{-4}min^{-1}(450\ min) + \ln[0.110M]$

What is the rate constant for a first-order reaction in which the half life is 85.0 sec?

1. 0.00814 s^{-1}
2. 0.0118 s^{-1}
3. 4.44 s^{-1}
4. 58.9 s^{-1}
5. 0.170 s^{-1}

yes, calculator

What is the rate constant for a first-order reaction in which the half life is 85.0 sec?

1. *You may use a calculator for this problem.*
2. 0.00814 s^{-1}
3. Use the first order half-life equation which is *not* concentration dependent and solve for k.
4. $t_{½} = 0.693/k$
2. 0.0118 s^{-1}
3. 4.44 s^{-1}
4. 58.9 s^{-1}
5. 0.170 s^{-1}

What fraction of a reactant remains after 3 half-lives of a first order reaction?

1. ½
2. ⅛
3. ⅓
4. 1⁄16
5. 1⁄6

no calculator

What fraction of a reactant remains after 3 half-lives of a first order reaction?

1. ½
2. ⅛
3. Regardless of the amount present, for a first-order reaction, after one half-life, ½ remains, after a second half-life, ¼ remains, and after a third half-life, ⅛th remains.
3. ⅓
4. 1/16
5. 1/6

Assume a reaction occurs by the mechanism given below. What is the rate law for the reaction? *(Select all that apply.)*

$A + B \rightleftarrows C$ fast

$C + B \rightarrow D$ slow

1. Rate = k [A] [B] [C]
2. Rate = k $[A]^2$
3. Rate = k [A] $[B]^2$
4. Rate = k [A] [B]
5. Rate = k [A] [B] / [D]
6. Rate = k [A]
7. Rate = k [C]

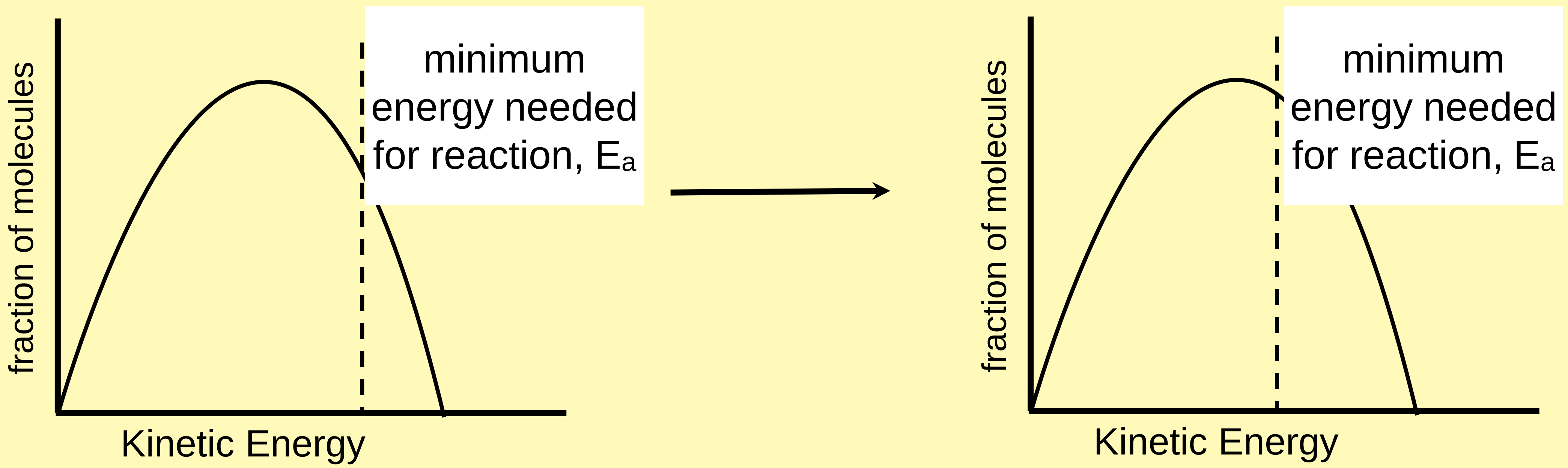
Assume a reaction occurs by the mechanism given below. What is the rate law for the reaction? *(Select all that apply.)*

$A + B \rightleftarrows C$ fast

$C + B \longrightarrow D$ slow

1. Remember, the slow step is the rate determining step. rate = $k_s[C][B]$
2. But we would prefer not to have intermediates in the rate law.
3. *ANSWER - Rate = $k [A] [B]^2$*
4. Whenever a slow step follows a fast step, the fast step is considered to be in equilibrium - meaning the reverse reaction occurs in significant quantity
   - the rate of the reverse reaction will equal the rate of the forward:
     - ★ $rate_f = k_f[A][B] = k_r[C]$
   - solve for $[C] = k_f/k_r[A][B]$ then substitute back into the rate law for the slow, rate determining step. rate = $k[C][B]$
     - ★ rate = $k k_f/k_r[A][B][B]$
     - ★ all 3 of the k are constants, so they can combine to give a constant that we can just call k, so $rate_{overall} = k[A][B]^2$

What could cause the change in the kinetic energy diagram shown? *(Select all that apply.)*



1. decreasing the temperature
2. increasing the surface area of the reactants
3. addition of a catalyst
4. increasing the concentration of a reactant
5. none of the above could cause this change

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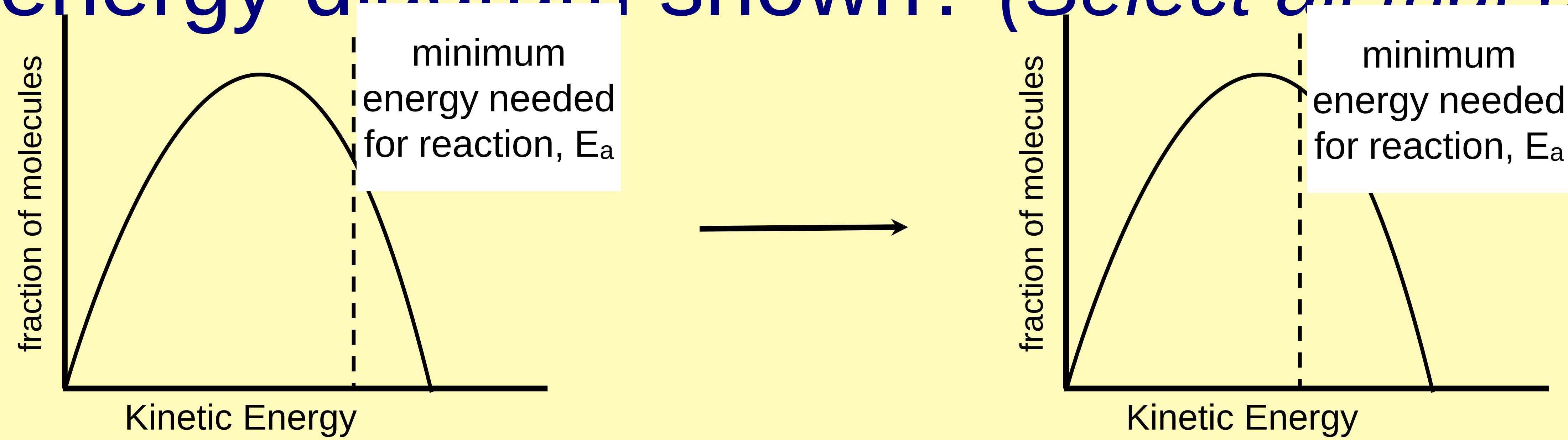
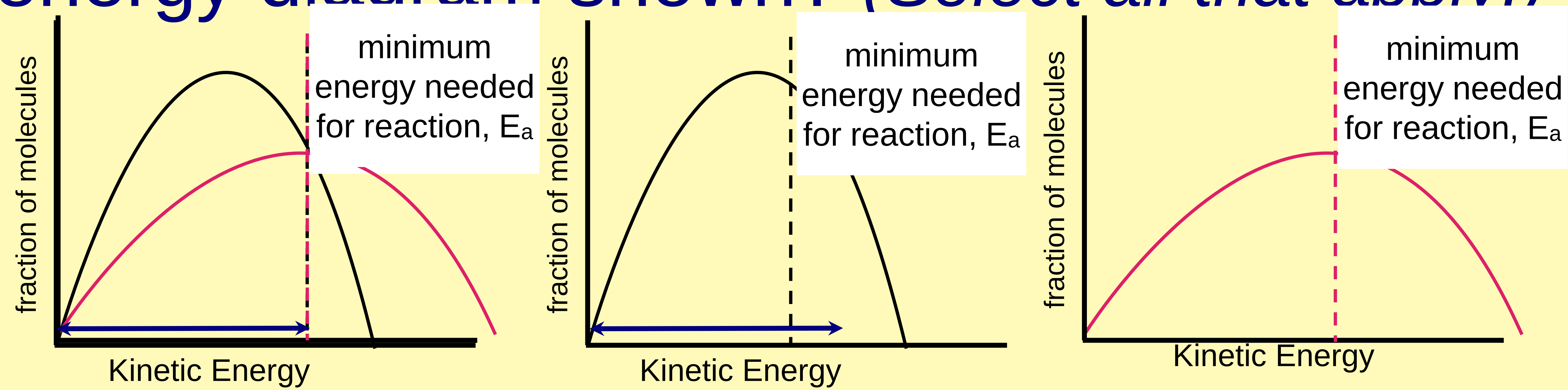


1. decreasing the temperature
2. increasing the surface area of the reactants
3. addition of a catalyst
4. increasing the concentration of a reactant
5. none of the above could cause this change
6. The presence of a catalyst is the only factor that actually changes the E_a.
7. What role does temp play?....see next slide

What could cause the change in the kinetic energy diagram shown? *(Select all that apply.)*



1. *Increasing* temp would cause the line to appear as if it shifts in the second graph, but it actually does not change the value of E_a. What happens is that at higher temperatures, the curve to elongates and flattens resulting in more area under the curve (more molecules) able to achieve the minimum E_a.
2. The third graph is overlaid the first graph to show its effect.
3. In the second graph, the E_a value is actually smaller as evidenced by the blue arrow, which is the same length in the second graph to show the lower E_a
4. So increasing temperature will increase the *number* of molecules that have the minimum activation energy, but not actually change the value of E_a.

All of the following increase the rate of reaction involving a solid EXCEPT
adding more of the solid

1. adding more of the solid
2. increasing the concentration of the solid
3. increasing the temperature
4. adding a catalyst
5. increasing the surface area of the solid

All of the following increase the rate of reaction involving a solid EXCEPT adding more of the solid

1. adding more of the solid
2. increasing the concentration of the solid
3. increasing the temperature
4. adding a catalyst
5. increasing the surface area of the solid

Which of the following is true about a catalyst?

(Select all that apply.)

1. It speeds up the forward reaction
2. It lowers the activation energy
3. It provides a completely different mechanism for the reaction
4. It can act as an inhibitor
5. It speeds up the reverse reaction
6. Can be homogeneous or heterogeneous
7. It does not get used up over the course of the reaction.
8. It can also be called an enzyme
9. May cause the formation of intermediates.

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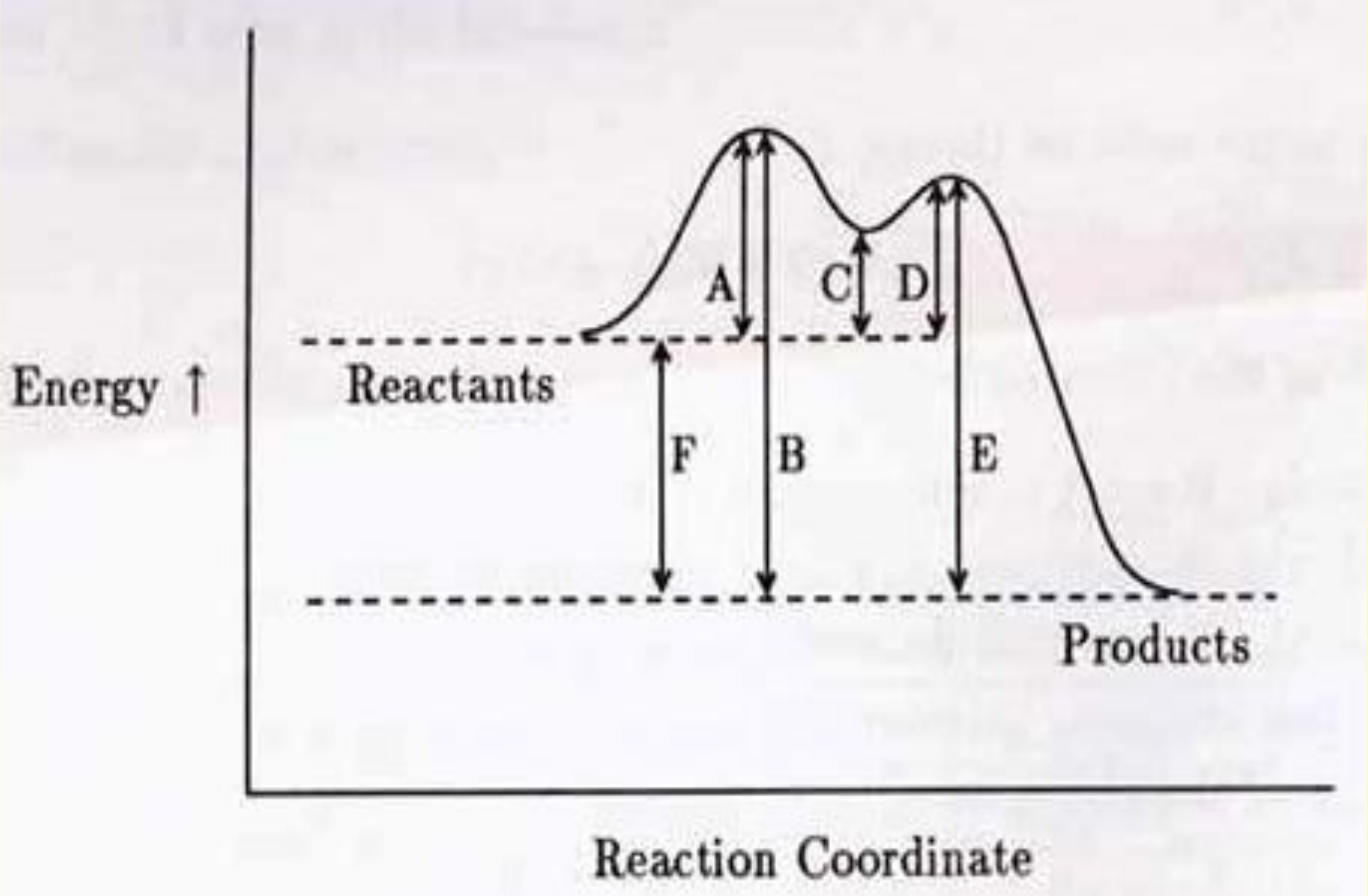
(Select all that apply.)

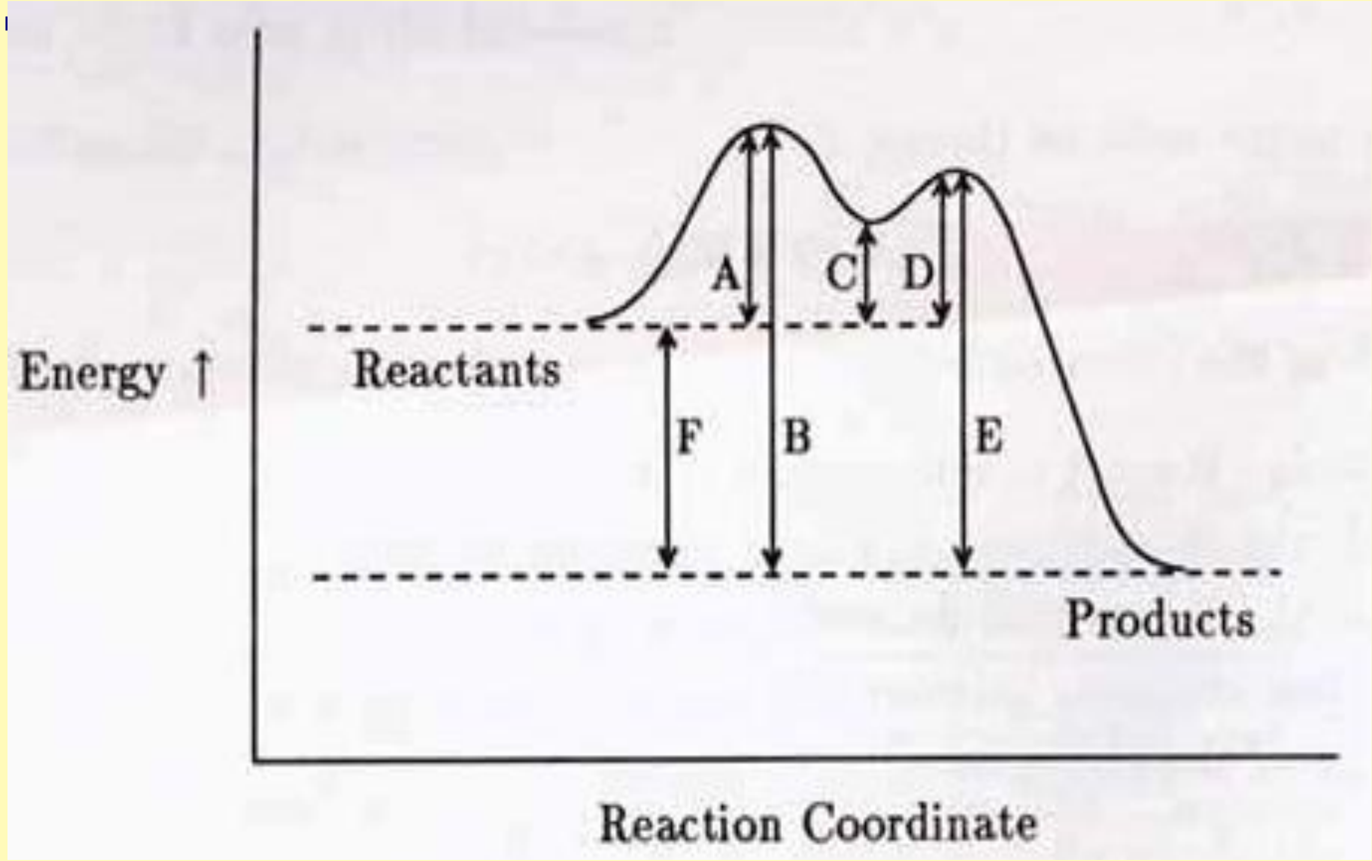
1. It speeds up the forward reaction
2. It lowers the activation energy
3. It provides a completely different mechanism for the reaction
4. It can act as an inhibitor
   - I suppose this could be true if an excess amount were present, and actually began to inhibit the reaction
5. It speeds up the reverse reaction
6. Can be homogeneous or heterogeneous
7. It does not get used up over the course of the reaction.
8. It can also be called an enzyme
   - for a biological reaction
9. May cause the formation of intermediates.

How many steps are involved in the reaction mechanism for this reaction indicated by the energy diagram below.



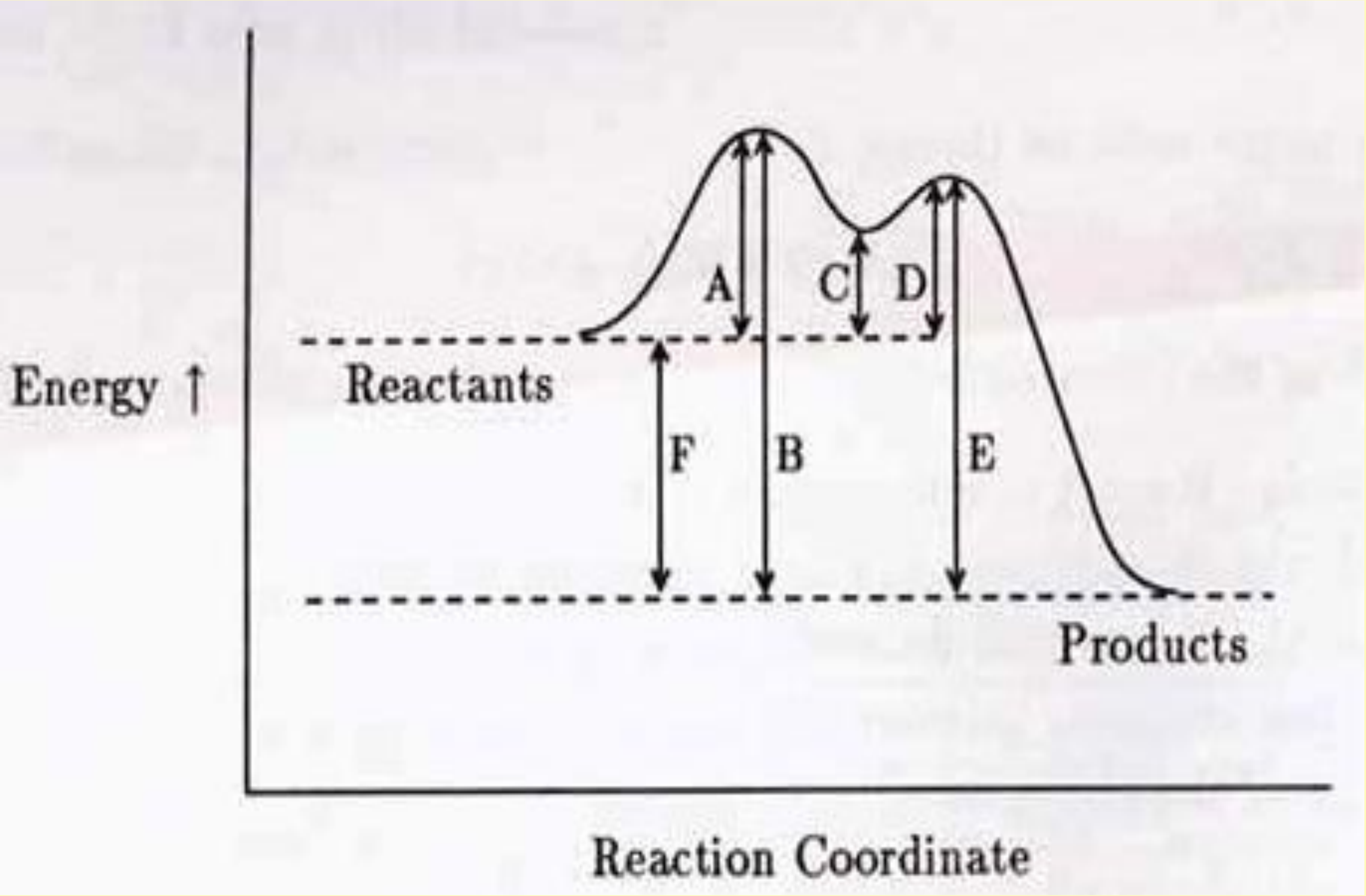
How many steps are involved in the reaction mechanism for this reaction indicated by the energy diagram below.

1. 2 steps
2. The presence of two peaks on the graph that represents the reaction mechanism indicates a two step process.



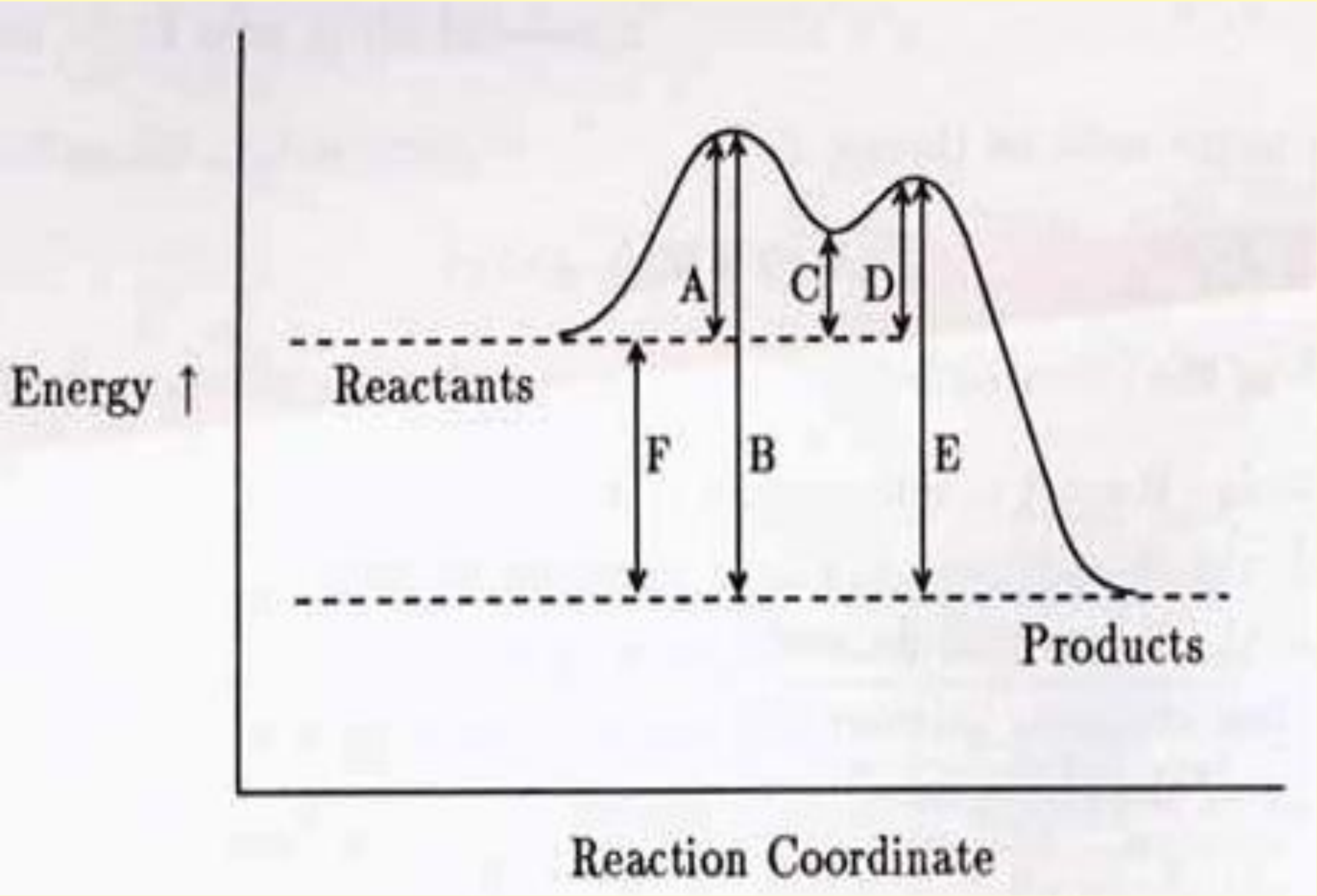
Addition of a catalyst that speeds the forward reaction will also speed the reverse reaction.

1. True
2. False
3. can not be determined



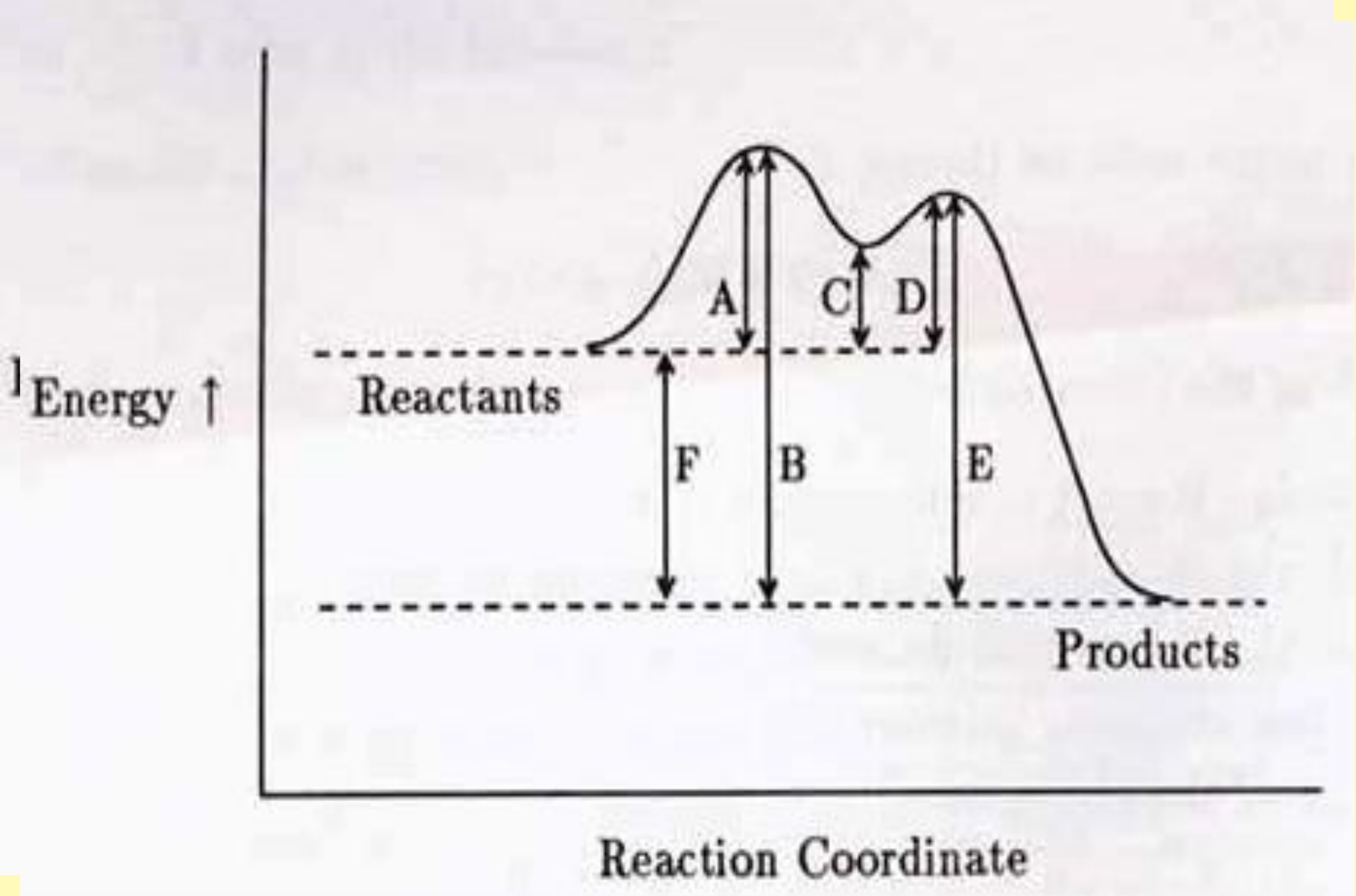
Addition of a catalyst that speeds the forward reaction will also speed the reverse reaction.

1. True
2. False
3. can not be determined
4. Catalysts *generally* provide a completely different mechanism, lowering the overall reaction rate.
5. This affects both the forward and the reverse.



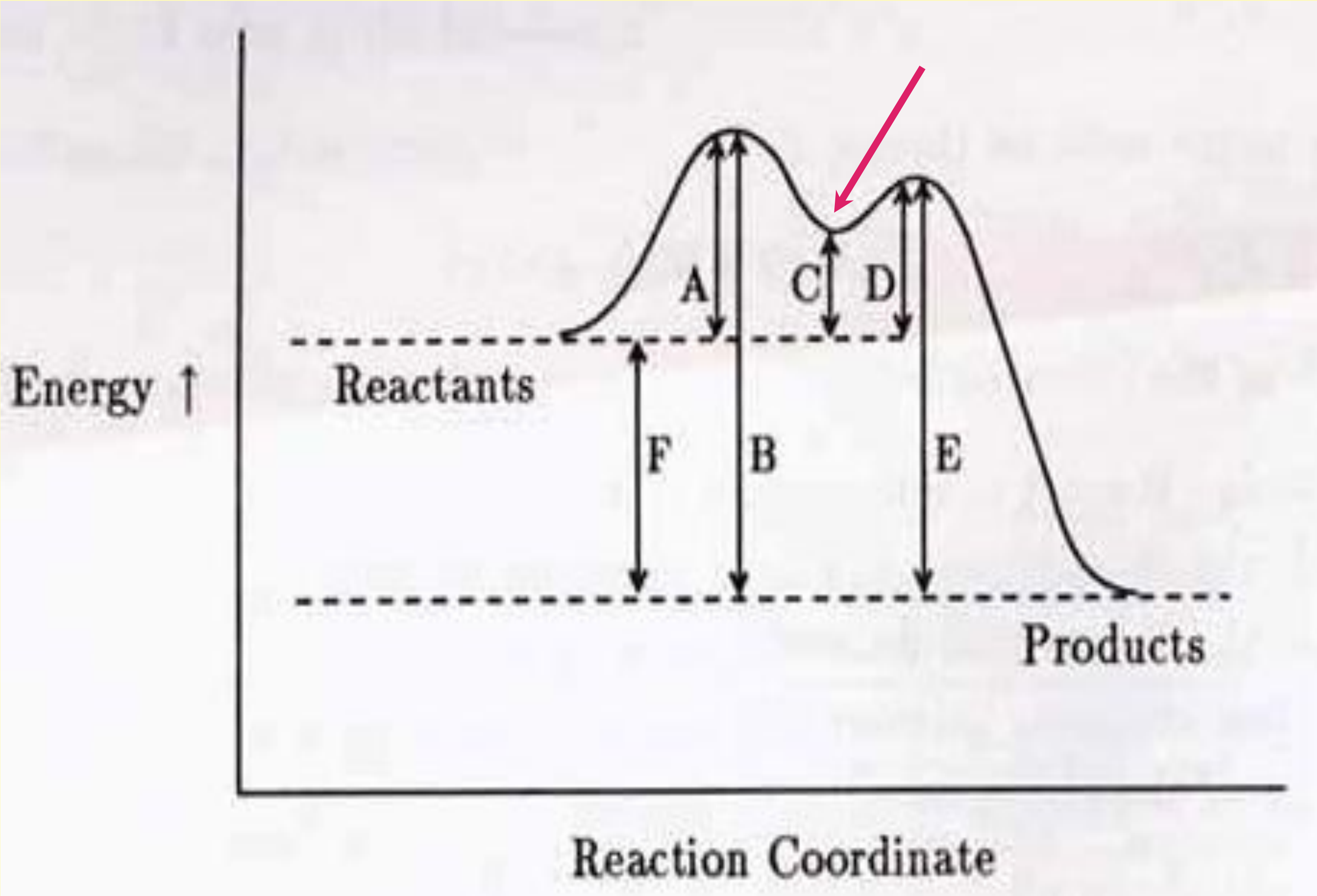
How many reaction intermediates are involved in the reaction indicated in the energy diagram below?

1. 1
2. 2
3. 3
4. 4
5. 5



How many reaction intermediates are involved in the reaction indicated in the energy diagram below?

1. 1
2. The trough in between the two peaks represents the intermediate.



The energy diagram indicates that the second elementary step is the rate determining step.

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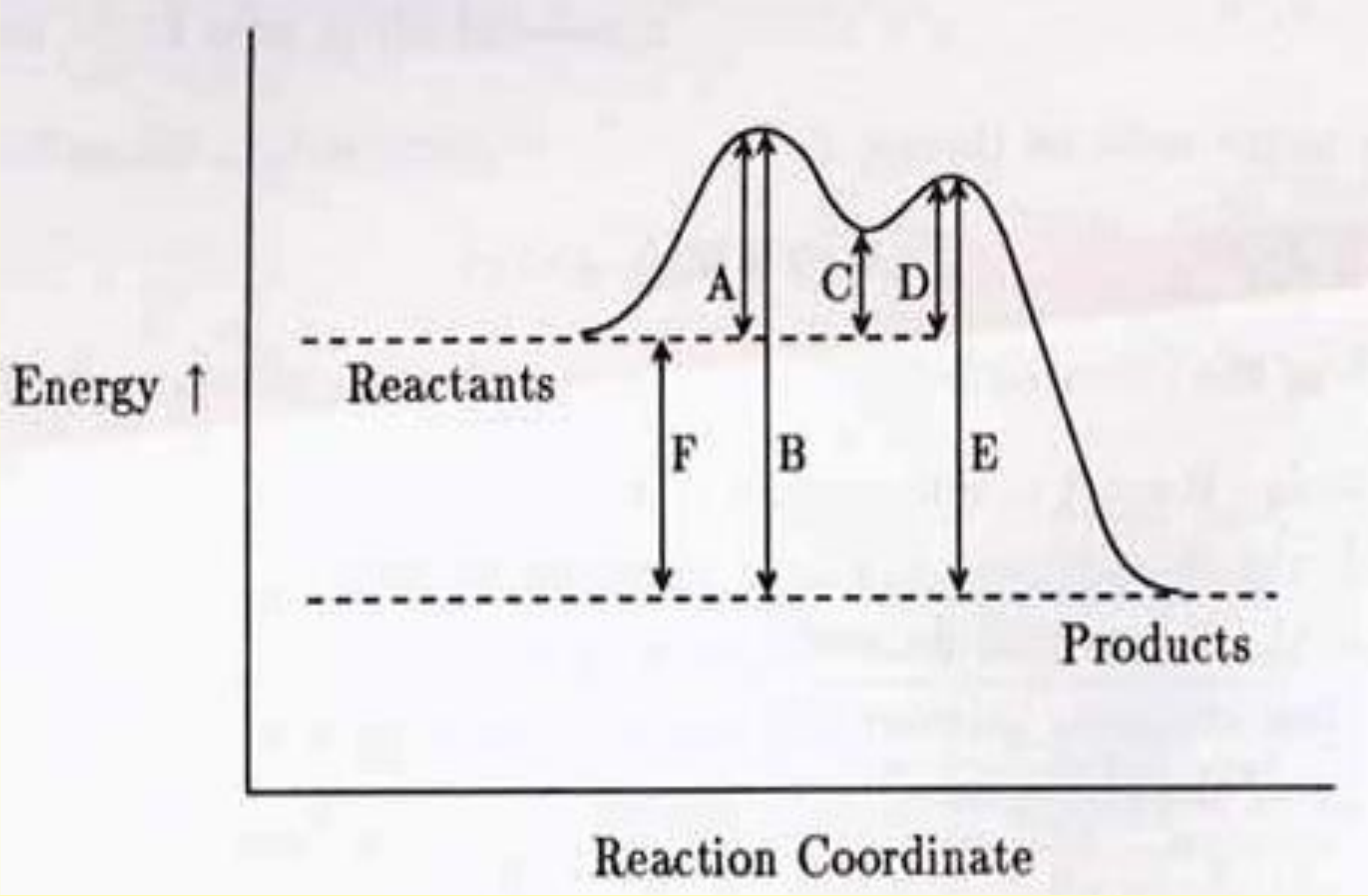
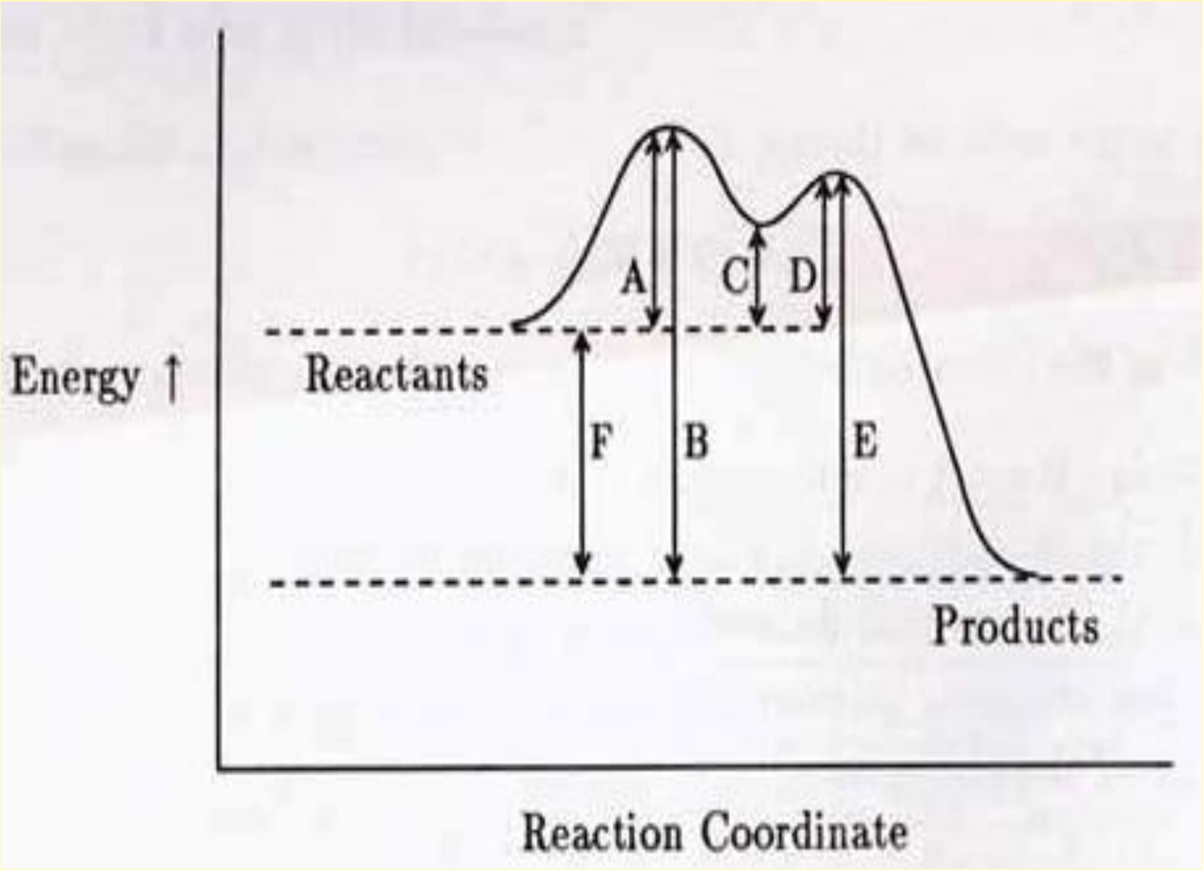
2. False
3. can not be determined



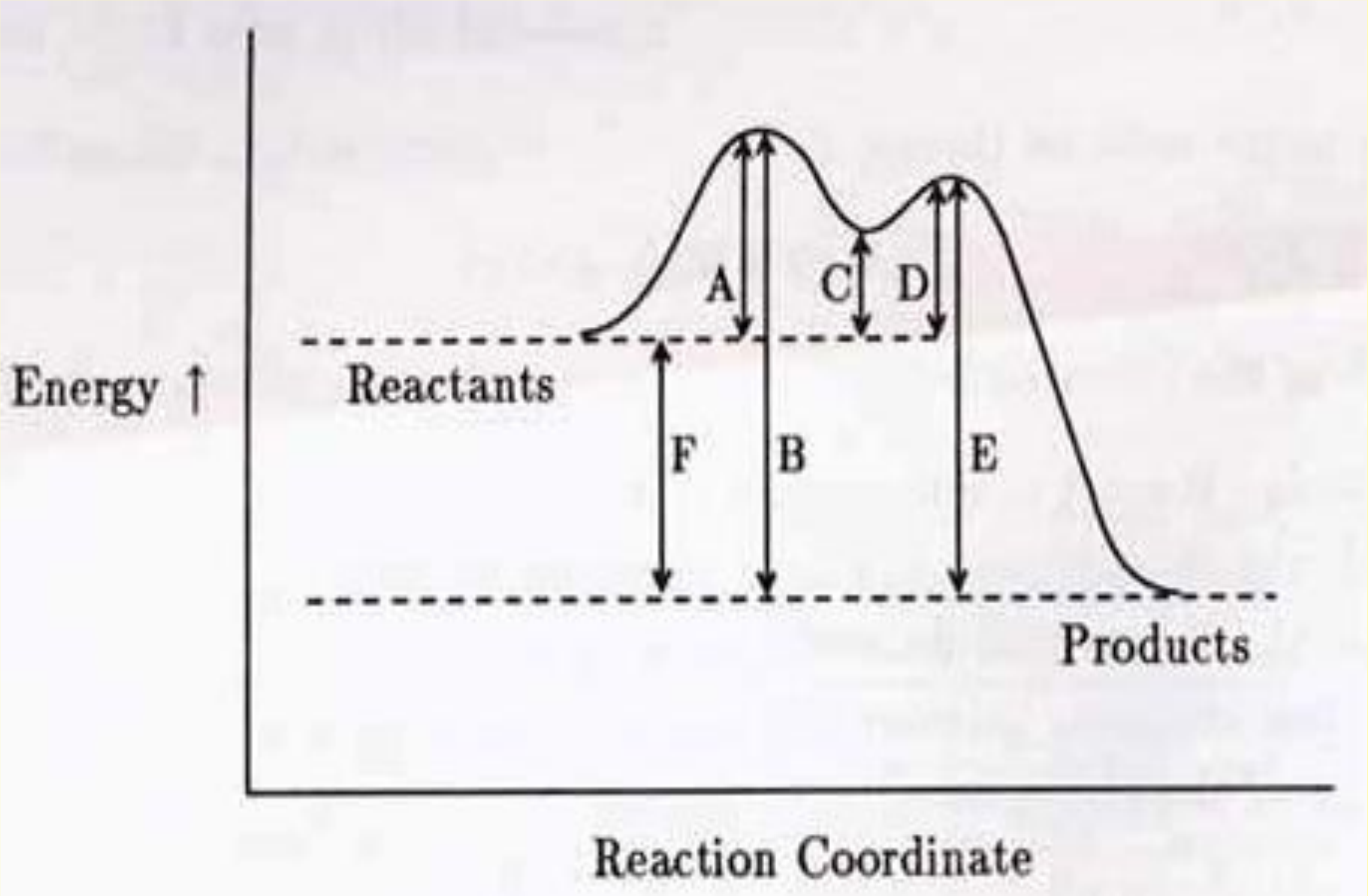
The energy diagram indicates that the second elementary step is the rate determining step.

1. True
2. False
3. can not be determined
4. The rate determining step would be the step with the highest activation energy which is the first peak.



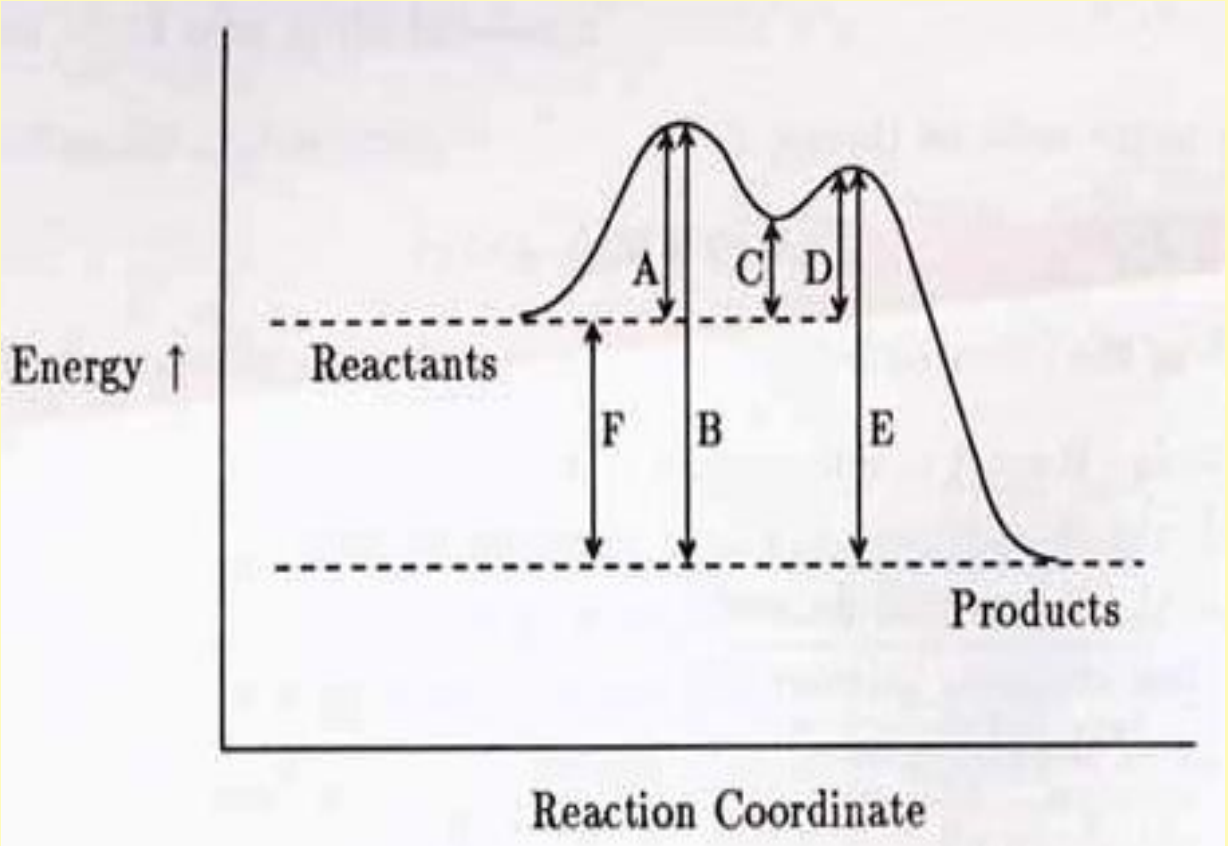
The energy diagram indicates that the reaction is second order.

1. True
2. False
3. can not be determined



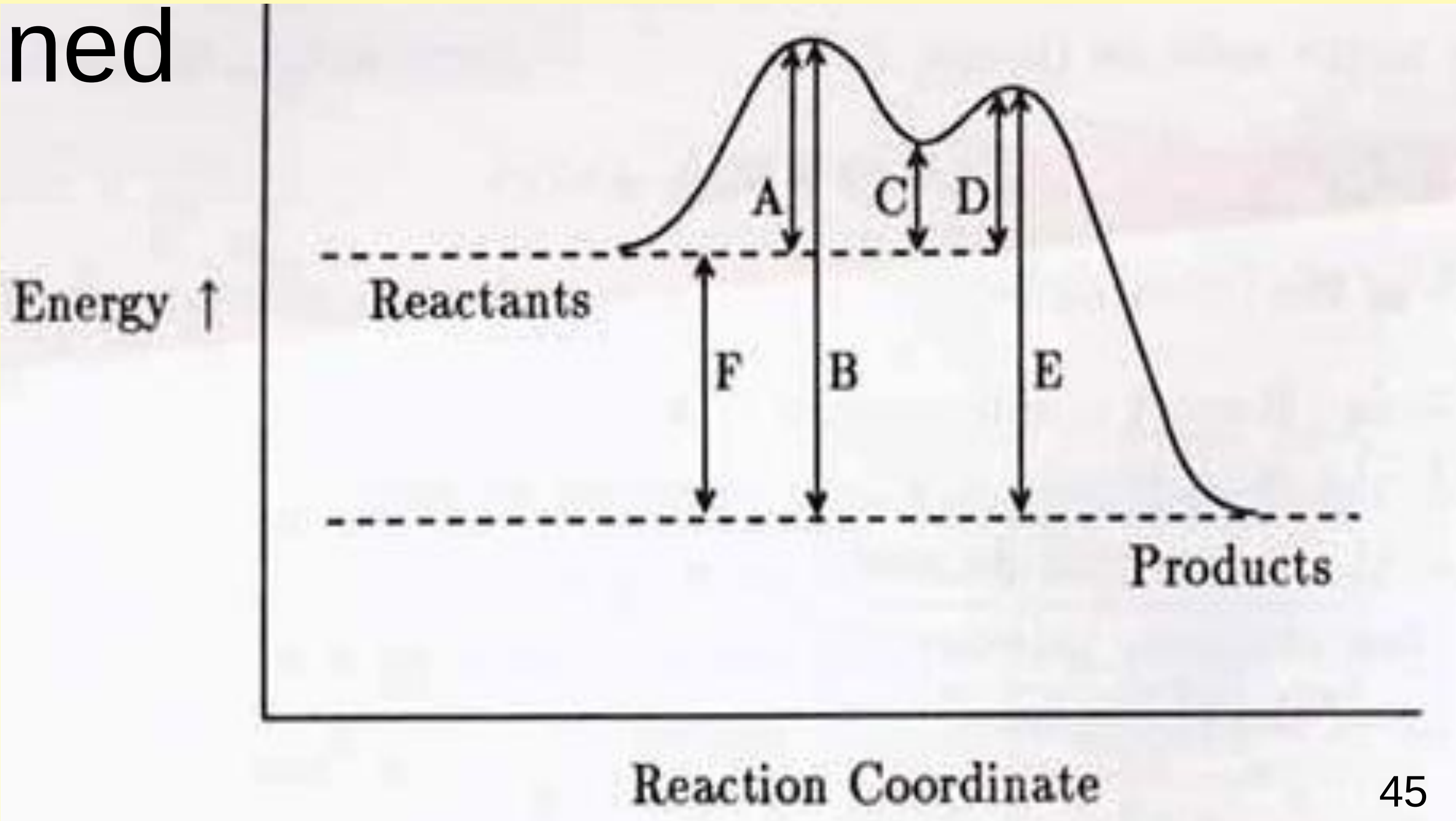
The energy diagram indicates that the reaction is second order.

1. True
2. False
3. can not be determined
4. The order of the reaction can not be determined from the potential energy diagram.



The overall reaction is

1. exothermic, Δ E released = E
2. exothermic, Δ E released = B
3. exothermic, Δ E released = F
4. endothermic, Δ E absorbed = A
5. endothermic, Δ E absorbed = B
6. endothermic, Δ E absorbed = F
7. some other energy value not listed above
8. can not be determined



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