

What is Activation Energy?

Worksheet

Activation energy is the energy barrier reactants must overcome. Catalysts lower E, speeding reactions; higher temperature also increases collision energy, raising the reaction rate.

Questions

1. E is high but G is negative. The reaction is

- A) Spontaneous but slow
- B) Spontaneous and fast
- C) Non-spontaneous
- D) At equilibrium

2. Lowering E from 60 to 40 kJ/mol increases rate by

- A) 1.5
- B) 10
- C) 100
- D) 1000

3. An enzyme-catalysed reaction and uncatalysed reaction have the same

- A) E
- B) G (K_{eq})
- C) Rate constant k
- D) All differ

4. At higher temperature, E

- A) Increases
- B) Decreases
- C) Stays the same
- D) Becomes zero

5. A reaction has E = 50 kJ/mol. With a catalyst lowering it to 30 kJ/mol, how much faster?

6. Enzyme lowers E from 80 to 20 kJ/mol (E=60). Compare rates at 37 C.

7. Doubling temperature from 300 to 600 K increases rate 8-fold. Estimate E.

8. Define: Define activation energy.

9. Define: Can a reaction with negative G be slow?

10. Define: How do catalysts work?

Answer Key

1. A) Spontaneous but slow - $G < 0$ = spontaneous (favours products). High E = slow. Both true: spontaneous but slow.
2. C) $100 - k e^{(-E/RT)}$; reducing E by 20 kJ/mol at ~300 K gives ~100-1000 speedup.
3. B) G (K_{eq}) - Enzyme lowers E and increases k , but G and equilibrium constant K remain the same.
4. C) Stays the same - Activation energy is a fixed property of the reaction pathway, independent of temperature.
5. Using Arrhenius: $k e^{(-E/RT)}$ Ratio: $k_{cat}/k_{uncatalysed} = e^{(-30/RT)} / e^{(-50/RT)} = e^{(20/RT)}$ At $T=300$ K, $R=8.314$: $e^{(20/2494)} e^{0.008} 1.008 10^3 1000$ faster (order-of-magnitude)
6. $k_{enzyme}/k_{uncatalysed} = e^{(E/RT)} = e^{(60/(8.314 310))} = e^{(60/2577)} e^{0.0233} 1.023 10^{10} 10$ billion faster
7. $\ln(k/k) = (E/R) (1/T - 1/T) \ln(8) = (E/8.314) (1/300 - 1/600) \ln(8) 2.08 = (E/8.314) (1/600) E 2.08 8.314 600 10,360$ J/mol 10.4 kJ/mol
8. The minimum energy reactants must have to collide and react, forming products.
9. Yes, if E is high. G predicts spontaneity; E predicts kinetics.
10. Catalysts provide an alternative pathway with lower E ; they are not consumed.

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