Collision theory, Energy of activation and Arrhenius equation

1. (b) The increase in collision frequency brings in an increase in effective collisions and thus rate of reaction increases.

2. (b) All collisions are not effective and does not result in the formation of the products

3. (b) The increase in collision frequency brings in an increase in effective collisions and thus rate of reaction increases.

4. (c) The increase in collision frequency brings in an increase in effective collisions and thus rate of reaction increases.

5. (a) Slower reaction rate indicates higher energy of activation.

6. (d) Energy of activation decreases, rate of reaction will increases.

7. (d) Number of collision depend upon pressure, concentration and temperature.

8.

Definitions:

  o E_f = Activation energy of the forward reaction
  o E_r = Activation energy of the reverse reaction

Exothermic reaction:

  o Heat of reaction ΔH < 0
  o Relation:

$$E_r = E_f - |\Delta H|$$

Interpretation:

o Since $\Delta H < 0$,

$$E_r = E_f - (-\Delta H) = E_f + |\Delta H|?$$

Wait — careful! Step by step:

For **exothermic reaction**, $\Delta H = H_{products} - H_{reactants} < 0$.

- o E_f = Energy barrier from reactants → transition state
- o E_r = Energy barrier from products → transition state
- o $E_r = E_f - \Delta H (since \Delta H < 0) \rightarrow E_r < E_f$

Conclusion:

$$E_f > E_r$$

Answer: (a) $E_f > E_r$

9. (c) The definition of activation energy.

10. (b) Activation energy is the energy needed by reactant molecules to gain threshold energy level.

11. (d) All other are different forms of Arrhenius equation.

12. (d) Increase in the rate of reaction is determined by the increase in the number of effective collisions.

13. (a) Energy of activation reduced by increasing temperature.

14. (d) The definition of threshold energy.

15. (a) The definition of activation energy.

16. (b) When the temperature is increased, heat energy is supplied which increases the kinetic energy of the reacting molecules. this will increase the number of collisions and ultimately the rate of reaction will be enhanced.

17. (d) In exothermic and endothermic reactions will be more and less than E_a respectively.

19. (b) The value of activation energy for a chemical reaction primarily dependent on the nature of reacting species.

20. (a) Arrhenius equation is $log\,k = log\,A - \dfrac{E_a}{RT}$

21.

Given:

- o Forward reaction: A → B
  - ▪ E_f = 15 kcal/mole
  - ▪ $\Delta H = Energy\,of\,reaction = 5\dfrac{kcal}{mole}(endothermic, \Delta H > 0)$

Relation between forward and reverse activation energies:

$$E_r = E_f - \Delta H$$

Substitute values:

$$E_r = 15 - 5 = 10\,kcal/mole$$

Conclusion:
Activation energy of $B \rightarrow A$ is **10 $kcal/mole$**

Answer: (c) 10 kcal/mole

22. (a) A graph plotted between $log\,k$ vs $\dfrac{1}{T}$ for calculating activation energy.

23. Arrhenius equation:

$$k \,=\, A\,e^{-\frac{E_a}{RT}}$$

where:

- o A = frequency factor (pre-exponential factor)
- o E_a = activation energy
- o R = gas constant
- o T = absolute temperature

Explanation:

- o The exponential factor shows that as T increases, k increases.
- o This is the standard form of the Arrhenius equation.

Answer: (d) $k \,=\, A\,e^{-\frac{E_a}{RT}}$

24. (b) When $E_a = 0$ rate constant is independent of temperature.

25. (a) It is modified form of Arrhenius equation.

26. Given:

- o $E_f = E_r$ (activation energies of forward and reverse reactions are equal)

Relation:

- o For any reaction:
  $E_r \,=\, E_f \,-\, \Delta H$
- o If $E_f \,=\, E_r$, then:
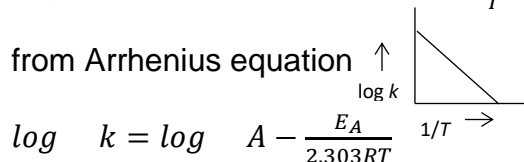 $\Delta H \,=\, 0$

Conclusion:

- o The reaction is **thermoneutral** (no net heat change).

Answer: (a) $\Delta H = 0$

28. (b) A graph plotted between $\log k$ Vs $\frac{1}{T}$ for calculating activation energy is shown as

from Arrhenius equation

$$\log \quad k = \log \quad A - \frac{E_A}{2.303RT}$$

29. (a) Straight line with negative slope

30. (c) It is Arrhenius equation.

31. (b) $\log \frac{K_2}{K_1} = \frac{E_a}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$

If $\frac{K_2}{K_1} = 2$

$$\log 2 = \frac{E_a}{2.303 \times 8.314}\left[\frac{1}{300} - \frac{1}{310}\right]$$

$$E_a = .3010 \times 2.303 \times 8.314 \left(\frac{300 \times 310}{10}\right)$$

$$= 53598.59 \; Jmol^{-1} = 54 \; kJ.$$

32. (d) When $E_a = 0$, the rate of reaction becomes independent of temperature. (E_a= Energy of activation).

33. (c) When *k* increases, rate of reaction also increases, $k = \frac{pz}{e^{\frac{E}{RT}}}$ for k to increase *p*, *z*, *T* should increase and *E* should decrease. ($e \approx 2.7$).

34. (c) Endothermic reactions are those which involve absorption of heat. High activation energy means potential energy of product must be much greater than reactants.

35. (a) For endothermic reaction $\Delta H = +ve$

Then from equation $\Delta H = E_{a_{F.R.}} - E_{a_{B.R.}}; E_{B.R.} < E_{F.R.}$

36. (a) Arrhenius suggested an equation which describes rate constant (K) as a function of temperature.

$$K = Ae^{-\frac{E_a}{RT}}$$

$$\ln K = \ln A - e^{\frac{E_a}{RT}}$$