



## KINETICS HL PAPER 1A

1. B
2. B
3. B
4. C
5. A
  
6. C
7. C
8. D
9. D
10. C
  
11. C
12. B
13. B
14. B
15. B
  
16. C
17. B
18. B
19. C
20. D
  
21. A
22. C
23. A
24. A
25. A
  
26. A
27. A
28. B
29. B
30. A

## KINETICS HL PAPER 1B

1. (a) Comparing exp 1 to 2,  $[\text{NO}_2]$  doubles while  $[\text{CO}]$  is constant, and the rate quadruples (from 0.0021 to 0.0084). Therefore, it is 2nd order with respect to  $\text{NO}_2$  [1]. Comparing exp 2 to 3,  $[\text{NO}_2]$  is constant while  $[\text{CO}]$  doubles, but the rate stays exactly the same (0.0084). Therefore, it is 0 order with respect to  $\text{CO}$  [2].

(b)  $\text{Rate} = k[\text{NO}_2]^2$  [1].

(c)  $k = \text{Rate} / [\text{NO}_2]^2 = 0.0021 / (0.10)^2 = 0.21 \text{ [1]}$ . Units:  $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  [1].

2. (a) Gradient = rise/run. Choosing points (3.0, -2.5) and (3.4, -5.5). Gradient =  $-3.0 / 0.4 = -7.5 \times 10^3 \text{ K}$  [2].

(b) gradient =  $-E_a / R$ . Therefore,  $E_a = -\text{gradient} \times R$ .  $E_a = 7500 \times 8.31 = 62325 \text{ J mol}^{-1}$  [2].  $E_a = +62.3 \text{ kJ mol}^{-1}$  [1].

3. (a) From Step 2 (slow, RDS):  $\text{Rate} = k_2[\text{N}_2\text{O}_2][\text{H}_2]$  [1]. From equilibrium Step 1:  $K_c = [\text{N}_2\text{O}_2] / [\text{NO}]^2$ , so  $[\text{N}_2\text{O}_2] = K_c[\text{NO}]^2$  [1]. Substituting this intermediate out of the final expression gives  $\text{Rate} = (k_2)(K_c)[\text{NO}]^2[\text{H}_2]$ , which matches  $\text{Rate} = k[\text{NO}]^2[\text{H}_2]$  [1].

## KINETICS HL PAPER 2

1. (a) Successive half-lives are constant for first-order [1]. Therefore, Reaction I is first order [1].

(b) Second order [1].

2. (a) Bimolecular [1].

(b)  $\text{Rate} = k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]$  [1].

(c) The rate will become 1.5 times the original initial rate [1]. (Triple one, half the other  $\rightarrow 3 \times 0.5 = 1.5$ ) [1].

3. (a) It mainly represents the collision geometry requirements (steric factor) and collision frequency constant [1]. These stereochemical characteristics of the molecules do not warp significantly with temperature [1].

4. (a) Zero order [1].

(b) Third order overall ( $1 + 2 = 3$ ) [1].

5. (a) Reaction B (the one with the higher  $E_a$ ) [1]. From the Arrhenius equation, the fractional multiplier exponential term  $e^{-E_a/RT}$  is more sensitive to a change in T when  $E_a$  is large [1]. This mathematically leads to a greater proportional increase in k [1].

6. (a) An intermediate exists in a local potential energy minimum (trough) between two transition state peaks on a multi-step profile [1]. A transition state represents an unstable maximum peak [1].

7. (a) Calculate the ratio  $k_{\text{cat}} / k_{\text{uncat}} = e^{-E_{\text{a(cat)}/RT} / e^{-E_{\text{a(uncat)}/RT} = e^{(E_{\text{a(uncat)}} - E_{\text{a(cat)}})/RT}$  [1]. Exponent value =  $(80000 - 50000) / (8.31 \times 298) = 12.1$  [1]. Rate constant increases by a factor of  $e^{12.1} \approx 1.8 \times 10^5$  [1].