Kinetics Warm-ups

Collision Theory

STATE and EXPLAIN how you think the following would affect the number of collisions and the rate of a reaction?

a. Increasing reactant concentration

more particles = more collisions = faster rate.

b. Increasing Temperature

particles move faster = more collisions = faster rate

Factors Affecting Rates

How does each of the following effect the rate of a reaction?

a. Increasing reactant concentration

↑

b. Increasing Temperature

↑

c. Decreasing particle size (ie powder instead of lumps)

↑

d. Adding a catalyst

↑

Kinetics Warm-ups

Factors Affecting Rates

For each pair of reactions, state which you think would be fastest.

A) i) $Zn^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow ZnS_{(s)}$ (already ions)

ii) $Zn_{(s)} + S_{(s)} \rightarrow ZnS_{(s)}$ Solids are slow.

B) i) $2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(s)}$ Covalent

ii) $Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow 2Ag^{+}_{(aq)} + Cu(NO_3)_{2(aq)}$ ionic in soln

Ag^+ NO_3^-

Pb^{2+} NO_3^- K^+ I^-

C) i) $Pb(NO_3)_{3(aq)} + 2KI_{(aq)} \rightarrow 2PbI_{2(aq)} + KNO_{3(aq)}$ Aq. ionic

ii) $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_3O_{(l)}$ Covalent

Factors Affecting Rates

Predict which reaction will be faster, and explain why

a) 1. $2C_2H_{2(g)} + 5O_{2\,(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$

2. $3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$ less bonds break & make

b) 1. $CaC_{2(s)} + N_{2(g)} \rightarrow CaCN_{2(g)} + C_{(s)}$

2. $CO_{(g)} + NO_{2(g)} \rightarrow CO_{2(g)} + NO_{(g)}$ homogeneous

Kinetics Warm-ups

Average Rates

1. Given the reaction and data, answer the questions that follow.

$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$

Time (s)	Mass of Mg (g)
0	36.2
10	29.6
20	25.0
30	22.0
40	20.1

a. Find the average rate of consumption of Mg in g/s.

$\frac{\Delta g}{\Delta s} = \frac{20.1g - 36.2g}{40s} = 0.4 \frac{g}{s}$

b. Find the average rate of consumption of Mg in mol/s.

$0.4 \frac{g}{s} \times \frac{1 \text{ mol}}{24.3 g} = 0.017 \frac{\text{mol}}{s}$ Mg

c. Use your answer in (b) to find the average rate of consumption of HCl in mol/s

$0.017 \frac{\text{mol}}{s} \times \frac{2}{1} = 0.034 \frac{\text{mol}}{s}$

Measuring Rates

1. Given the following reaction, suggest 2 ways you could monitor the rate of the reaction.

$Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ bubbles

H^+ Cl^- Mg^{2+} Cl^- Cl^-

Δ Pressure vs time (closed)
Δ Mass vs time (open)
Δ pH vs time
Δ conductivity vs time

Kinetics Warm-ups

Rates & Stoichiometry

Given the following reaction, determine the rate of nitrogen disappearance and ammonia production if the rate of disappearance of hydrogen is 0.5mol/Ls

$$3H_{2(g)} + 1\,N_{2(g)} \text{ --> } 2NH_{3(g)}$$

$$\text{Rate}_{H_2} = 0.5\,\frac{mol}{L \cdot s} \times \frac{1}{3} = 0.167\,\frac{mol}{L \cdot s}\ N_2$$

$$\times \frac{2}{3} = 0.33\,\frac{mol}{L \cdot s}\ NH_3$$

Reaction Mechanisms

Given the following mechanism, answer the questions below:

Step 1: $O_3 + NO \text{ --> } NO_2 + O_2$ (slow)

Step 2: $NO_2 + O \text{ --> } NO + O_2$ (fast)

a) Give the equation for the ***overall reaction***.

$O_3 + O \rightarrow 2O_2$

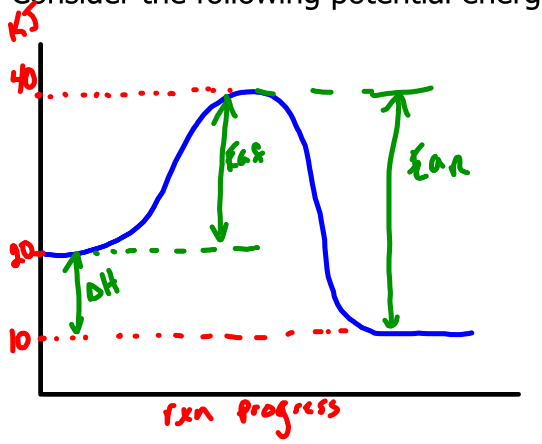
b) What could the ***catalyst*** be in this mechanism? NO

c) What is an ***intermediate*** in this mechanism? NO_2

Kinetics Warm-ups

Coordinate Diagrams

Consider the following potential energy diagram for a reversible reaction:



a) Calculate ΔH for the forward reaction.

- 10 kJ

b) Calculate ΔH for the reverse reaction.

+10 kJ

c) Calculate the Ea for the forward reaction.

20kJ

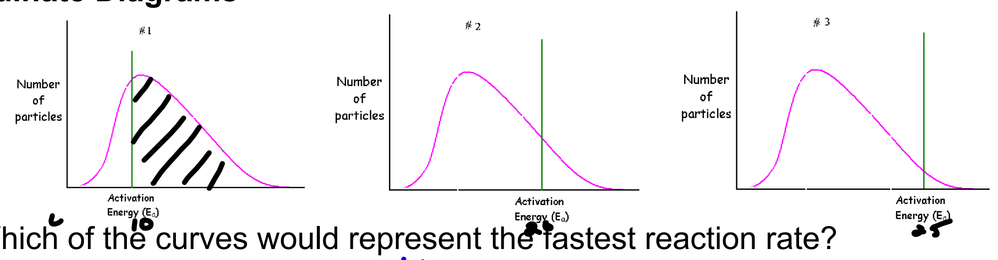
d) Calculate the Ea for the reverse reaction.

30kJ

e) how would the graph look if a catalyst was added?

shorten hill

Coordinate Diagrams



1. Which of the curves would represent the fastest reaction rate?

   #1

2. If you heated the system, how would the graph change?

   shift curve to right

3. If you added a catalyst, how would the graph change? – E_a lower.

Kinetics Warm-ups

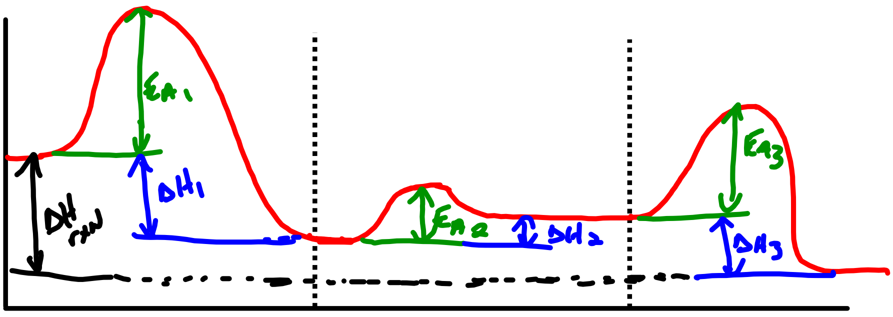
Coordinate Diagrams & Mechanisms

Draw a reaction coordinate diagram for the following mechanism. Label all activation energies and enthalpy changes:

A --> B (slow, exothermic)

C--> D (fast, endothermic)

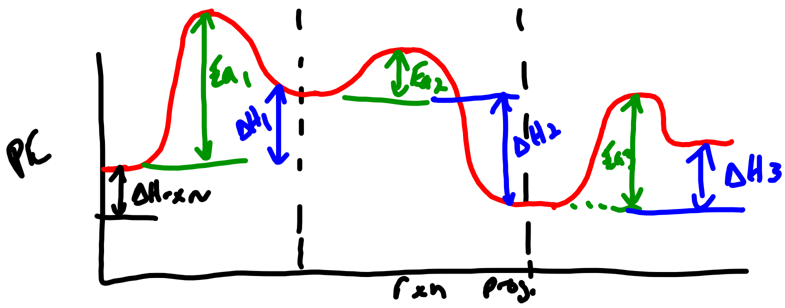
E --> F (medium speed, exothermic)



Coordinate Diagrams

Draw a **neat** reaction coordinate diagram for the following reaction mechanism. ***Label all activation energies and enthalpy changes*.**

A + B --> C + F	*ΔH = endo, slow*
C + B --> X + F	*ΔH = exo, fast*
E + X --> D	*ΔH = endo, medium*



Rate Laws

$$2A_{(g)} + 3B_{(g)} + C_{(g)} \text{ --> } 4D_{(g)} + 2T_{(g)}$$

Trial	[A](mol/L)	[B](mol/L)	[C](mol/L)	Rate(mol/Ls)
1	0.3	0.3	0.3	2.0
2	0.3	0.6	0.3	4.0
3	0.3	0.9	0.3	6.0
4	0.3	0.9	0.6	6.0
5	0.6	0.9	0.6	24.0
6	0.9	0.9	1.5	54.0
7	1.2	0.9	2.0	96.0

×2 ×2 $2^? = 2$

×2 ×1 $2^? = 1$

×2 ×4 $2^? = 4$

a) Determine the **rate law** for the above reaction.

$\text{RATE} = K[A]^2[B]^1[C]^0$

b) Calculate the **value** of the specific rate constant "K"

$\text{RATE} = K[A]^2[B]$

$2 = K(0.3)^2(0.3)$

$(0.3)^2(0.3)$ $(0.3)^2(0.3)$

$2/0.3^2 \times 0.3$

$K = \frac{2}{(0.3)^2(0.3)} = 74.07$

Rate Laws & Mechanisms

Given the reaction:

$$2NO + 2H_2 \text{ --> } 2H_2O + N_2$$

A proposed mechanism for the above reaction is:

Step 1 (Slow): $1NO + 1H_2 \text{ --> } H_2O + N$ ← RDS

Step 2 (med): $NO + N \rightarrow N_2O$

Step 3 (Fast): $N_2O + H_2 \text{ --> } N_2 + H_2O$

$2NO + 2H_2 \rightarrow 2H_2O + N_2$

1. Write the balanced equation for step 2 $NO + N \rightarrow N_2O$

2. What would be the rate law for this reaction?

$\text{RATE} = K[NO]^1[H_2]^1$