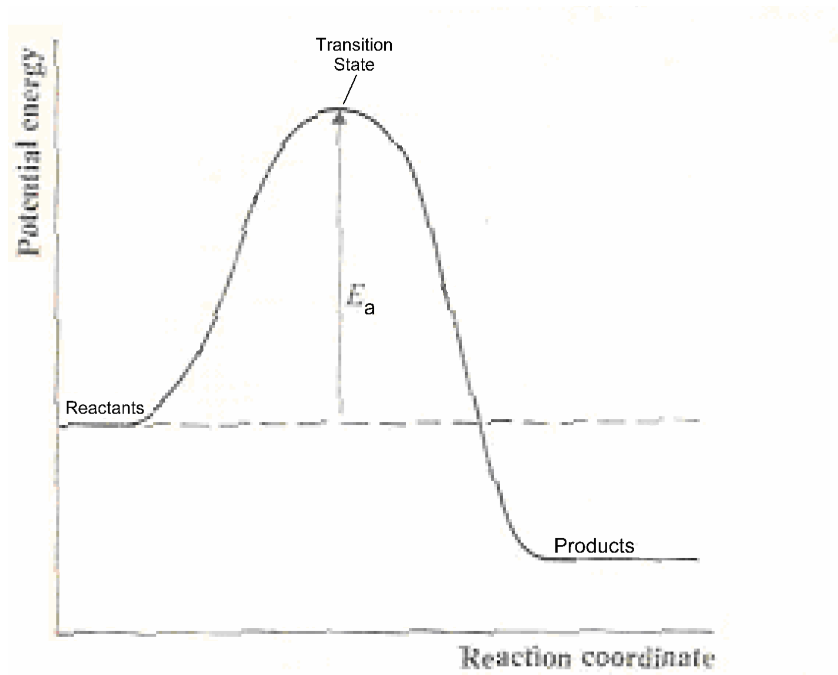
Name ________________________ Student # ________________ Marks ____ /22

CHEMISTRY 225 SEMESTER 04-2011 SECTION 2 (EVENING)
TEST NO. 1: REACTION KINETICS

For full marks you must show your working in numerical questions and display results to the correct number of significant figures.

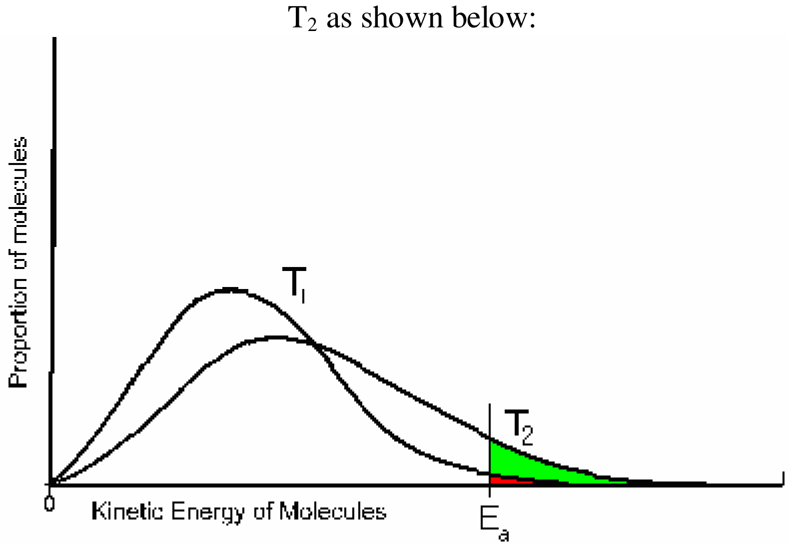
1) Using the axes below, sketch an energy profile diagram for a simple one-step reaction, labelling the axes, and marking reactants, products, E_a, and the transition state, on your diagram. (5)



2) The effect of temperature on reaction rate can be calculated using the Arrhenius equation

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

which may be related to a Boltzmann distribution of molecular energies at (increasing) temperatures T_1 and T_2 as shown below:



a) Mark the activation energy, E_a, for a reaction on the graph above and use it to explain why the rates of chemical reactions are highly temperature dependent. (4)

The red area to the right of E_a shows the proportion of molecules with kinetic energy greater than or equal to E_a at T_1. It shows the proportion of molecules which can react on collision at T_1. The area is much larger at temperature T_2 (green and red area together) than at T_1 meaning that the rate is much higher at higher temperature.

b) What do we call substances which are used up in one step of the mechanism of a reaction but reformed in a later step? (1)

These are catalysts.

3) In the reaction

$$5Fe^{2+}(9aq) + MnO_4^-(aq) + 16H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 8H_2O(l)$$

the initial rate of reaction with respect to Fe^{2+} is 0·30 Ms^{-1}. Calculate

a) the initial rate of reaction with respect to H_2O. (2)

The initial rate of reaction with respect to H_2O = $\frac{8}{5} \times 0.30 = \underline{\underline{0.48 Ms^{-1}}}$

4) The reaction

$$3A + B \rightarrow C + 3D$$

has the following initial rates at a given temperature.

Experiment	**[A]/ M**	**[B] M**	**Initial Rate of disappearance of B/ Ms^{-1}**
i	0.630	0.122	0.306
ii	0.210	0.122	0.0340
iii	0.210	0.244	0.0340
iv	0.105	0.488	?

a) Determine the order of the reaction with respect to A and B, showing your reasoning. (3)

since

Since $R = k[A]^m[B]^n$

$$\therefore \frac{R_{ii}}{R_i} = \frac{k([A]_{ii})^m([B]_{ii})^n}{k([A]_i)^m([B]_i)^n} = \left(\frac{[A]_{ii}}{[A]_i}\right)^m \text{ since other terms cancel.}$$

$$\therefore \frac{0.306}{0.0340} = \left(\frac{0.630}{0.210}\right)^m$$

$$\therefore 9 = 3^m$$

$$\therefore m = 2$$

Since $R = k[A]^m[B]^n$

$$\therefore \frac{R_{iii}}{R_{ii}} = \frac{k([A]_{iii})^m([B]_{iii})^n}{k([A]_{ii})^m([B]_{ii})^n} = \left(\frac{[B]_{iii}}{[B]_{ii}}\right)^n \text{ since other terms cancel.}$$

$$\therefore \frac{0.0340}{0.0340} = \left(\frac{0.244}{0.122}\right)^n$$

$$\therefore 1 = 2^n$$

$$\therefore m = 0$$

b) Write down the rate equation for the reaction (1)

$R = k[A]^2[B]^0$ or $R = k[A]^2$

c) Determine the rate constant for the reaction. (2)

$$k = \frac{R}{[A]^2} = \frac{0.306}{(0.630)^2} = 0.770975 \approx \underline{\underline{0.771 M^{-1}s^{-1}}} \text{ to 3 s.f.}$$

For experiment (iv), calculate the initial rate of disappearance of B. (2)

$$R = k[A]^2 = 0.770975 \times (0.105)^2 = \underline{\underline{0.00850 Ms^{-1}}}$$

d) Could the reaction 3A + B → C + 3D occur in a single elementary step? Explain your answer. (2)

This reaction could not occur in one elementary step because it would have to involve the collision of 4 particles. Collisions between 4 particles are extremely rare and so cannot be invoked as elementary steps in mechanisms since they would result in unobservably slow reactions.