Reaction Kinetics Test

SCH4UE 20003 - 20004 (TOTAL: / 40) Name: _____

Part A: Multiple Choice (10 Marks)

1. The rate law of the reaction is: rate = k [A] $[B]^2$
   The units of k, with time measured in seconds, is:
   A. s^{-1} B. $M^{-1}s^{-2}$ C. $M^{-2}s^{-1}$ D. M^{-1}

2. The rate law of the reaction: $2\ H_2 + 2NO \longrightarrow N_2 + 2\ H_2O$
   Is second order in [NO] and first order in $[H_2]$. If [NO] is doubled and $[H_2]$ is halved, the rate of the reaction will:

   A. Increase by a factor of 4
   B. Remain the same
   C. Increase by a factor of 6
   D. Increase by a factor of 2

3. Two reactions with different activation energies have the same rate at room temperature. Which statement correctly describes the rates of these two reactions at the same higher temperature?

   A. The reaction with the greater activation energy will be faster.
   B. The reaction with the smaller activation energy will be faster.
   C. The two reactions will have the same rates.
   D. A prediction cannot be made without further information.

4. What can be correctly said about the energy of activation for a reversible exothermic reaction? The energy of activation:

   A. is greater for the reverse reaction than for the forward reaction.
   B. is greater for the forward reaction than for the reverse reaction.
   C. is the same for the reaction in both directions.
   D. For the two directions of this reaction cannot be compared without doing experiments.

5. The rate of the reaction: $2\ NO + Cl_2 \longrightarrow 2NOCl$
   is given by the rate equation: rate = k $[NO]^2$ [Cl].
   The value of the rate constant can be increased by:

   A. increasing the concentration of the NO.
   B. Increasing the concentration of the Cl_2
   C. Increasing the temperature
   D. doing all of these.

6. The rate expression for a second-order reaction could be:

   A. Rate = k [A]
   B. Rate = k $[A]^2$[B]
   C. Rate = k [A] [B]
   D. Rate = k $[A]^2$ $[B]^2$

7. A catalyst that increases the rate of a reaction does so by:

A. Increasing the concentrations of the initial reactants
B. Increasing the temperature.
C. decreasing the temperature
D. Decreasing the activation energy for the process.

8. For the overall chemical reaction shown below, which one of the following statements can you rightly assume?

$$2\,H_2S_{(g)} + O_{2(g)} \longrightarrow 2S_{(s)} + 2H_2O_{(l)}$$

A. The order is third order overall
B. The reaction is second order overall
C. The rate law is: rate = $[H_2S]^2\,[O_2]$
D. The rate law cannot be determined from the information given.

9. Nitric acid reacts with hydrogen to form nitrous oxide and water. Use the following data to determine the rate law for the reaction: $2\,NO + H_2 \longrightarrow N_2O + H_2O$

Expt.#	**[NO] (mol dm^{-3})**	**[H_2] (mol dm^{-3})**	**Initial Rate (mol dm^{-3} min^{-1})**
1	0.021	0.065	1.46
2	0.021	0.260	1.46
3	0.042	0.065	5.48

A. Rate = k [NO]
B. Rate = k $[NO]^2$
C. Rate = k [NO][H_2]
D. Rate = k $[NO]^2[H_2]$

10. A small increase in temperature often produces a large increases in the rate of a chemical reaction because it:

A. Decreases the activation energy of the reaction.
B. Increases the effectiveness of the collisions between the reactant molecules.
C. Decreases the number of collisions per second between the reactant molecules.
D. Decreases the volume of the solution, altering the concentrations of the reactants.

Part B: Short Answer and Problems (30 marks)

1. The peroxodisulphate ion, $S_2O_8^{-2}$ reacts with iodide ions, I^{-1}, to form sulphate ion, SO_4^{-2} and iodine, I_2.

a. Write a balanced equation for the reaction between $S_2O_8^{-2}$ and I^{-1}. 1

b. A kinetic study of the initial stages of this reaction yields the following rate data:

$[I^{-1}]$ (mol dm^{-3})	**$[S_2O_8^{-2}]$ (mol dm^{-3})**	**- d $[S_2O_8^{-2}]$ /dt (mol dm^{-3} s^{-1})**
2.50 (10^{-3})	1.25 (10^{-4})	3.94 (10^{-10})
5.00 (10^{-3})	1.25 (10^{-4})	7.98 (10^{-10})
5.00 (10^{-3})	2.50 (10^{-4})	15.96 (10^{-10})

(i) determine the kinetic order of each reactant and explain your reasoning. 3

(ii) calculate the rate constant and specify its units. 2

(iii) calculate the rate when the concentrations of the iodide and peroxodisulphate ions are 1.20 (10^{-3}) and 7.50 (10^{-4}), respectively. 2

(iv) Select the reaction mechanism(s) which is (are) consistent with the above rate and stoichiometric data. Explain why each of the others is not consistent with the above rate. 6

i. $S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ products

ii. $2\ S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ products

iii. $S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ intermediate slow
intermediate $+ I^{-1} \longrightarrow$ products fast

iv $S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ intermediate fast
intermediate $+ I^{-1} \longrightarrow$ products slow

v. $S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ intermediate slow
intermediate $+ S_2O_8^{-2} \longrightarrow$ products fast

vi. $S_2O_8^{-2} + 2\ I^{-1} \longrightarrow$ intermediate fast
intermediate $+ S_2O_8^{-2} \longrightarrow$ products slow

2.

(a) Write a balanced equation for the decomposition of hydrogen peroxide into oxygen gas and water. 1

(b) give two methods by which you could experimentally determine the rate of decomposition of hydrogen peroxide solution. 2

(c) The activation energy for the decomposition of hydrogen peroxide is 40 kJ mol^{-1} and the enthalpy change is - 100 kJ mol^{-1}. Draw a sketch of energy as a function of reaction coordinate showing the relationship between the energy of the reactants and the products. Estimate the activation energy for the reverse reaction, and label all the relevant sections of the sketch clearly! 5

3. A radioactive isotope decays from an initial count of 160 cpm to 20 cpm in 27 days. What is its half-life? 2

4. The reaction between chloroform and chlorine gas proceeds in a series of elementary steps: 5

I.	$Cl_{2(g)} \longrightarrow 2\ Cl_{(g)}$		Fast
II.	$CHCl_{3(g)} + Cl_{(g)} \longrightarrow CCl_{3(g)} + HCl_{(g)}$		Slow
III.	$CCl_{3(g)} + Cl_{(g)} \longrightarrow CCl_{4(g)}$		Fast

a. State the overall equation.

b. State the:

i. Reactant(s)

ii. Product(s)

iii. Reaction intermediate(s)

iv. Catalyst(s)