

TEST: RATES OF REACTION

SCH 4UE 05 – 06

Name: _____
(Total Score: /)

Part A: Multiple Choice (5)

1. The rate expression for a reaction is shown below:

$$\text{rate} = k[\text{A}]^2 [\text{B}]^2$$

Which statements are correct for this reaction?

- I. The reaction is second order with respect to both A and B.
- II. The overall order of the reaction is 4.
- III. Doubling the concentration of A would have the same effect on the rate of reaction as doubling the concentration of B.

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

2. The rate of a reversible reaction is altered by the addition of a heterogeneous catalyst. Which statement correctly describes the role of the catalyst?

- A. It alters the enthalpy change of the reaction.
- B. It decreases the activation energy of the forward reaction.
- C. It increases the activation energy of the reverse reaction.
- D. It increases the rate of the forward reaction but decreases the rate of the reverse reaction.

3. Consider the following statements.

- I. The rate constant of a reaction increases with increase in temperature.
- II. Increase in temperature decreases the activation energy of the reaction.
- III. The term A in the Arrhenius equation ($k = Ae^{-E_a/RT}$) relates to the energy requirements of the collisions.

Which statement(s) is/are correct?

- A. I only
- B. II only
- C. I and III only
- D. II and III only

4. The rate of a reaction between two gases increases when the temperature is increased and a catalyst is added. Which statements are both correct for the effect of these changes on the reaction.

Multiple Choice Answer	increasing the temperature	Adding a catalyst
A	collision frequency increases	activation energy increases
B	activation energy increases	activation energy does not change
C	activation energy does not change	activation energy decreases
D	activation energy increases	collision frequency increases

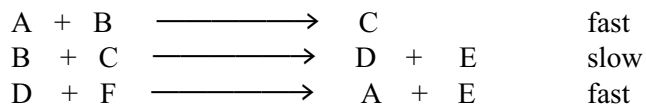
5. The rate equation for the reaction between O_2 and NO is: O_2
 $Rate = k[O_2][NO]^2$

By what factor would the rate of this reaction increase if the concentrations of O_2 and NO are both doubled?

- A. $1/8$ B. 3 C. 4 D. 8

Short Answer and Problems

1. Given the following steps in the mechanism for a chemical reaction:



Identify which species, if any, are:

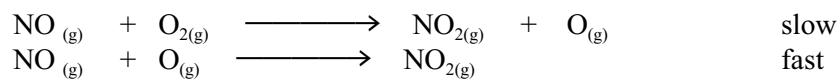
- a. Catalysts in this reaction, 1
- b. Intermediates in this reaction. 1
- c. Write the rate law for this reaction. 1
- d. Deduce the overall order of this reaction. 1
- e. State and explain what would happen to the initial rate if the initial concentration of A was doubled and that of B was halved. 3
- f. Sketch a graph you would expect if concentration of B was plotted against the rate of the reaction, whilst concentration of all the other species were kept constant. 2

2. The following data were obtained for the reaction of nitrogen monoxide gas, $\text{NO}_{(g)}$, with oxygen gas to form nitrogen dioxide gas, $\text{NO}_{2(g)}$, at 25°C .

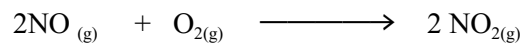
Experiment	[NO] mol dm^{-3}	[O ₂] mol dm^{-3}	Initial rate $(\text{mol dm}^{-3} \text{ s}^{-1})$
1	0.50	0.20	3.0×10^{-3}
2	0.50	0.40	6.0×10^{-3}
3	1.00	0.80	4.8×10^{-3}

- (i) Calculate the order with respect to the two reactants and write the rate expression for the reaction. Show your reasoning. 5

- (ii) Explain why the following mechanism is **not** consistent with the rate expression. 2

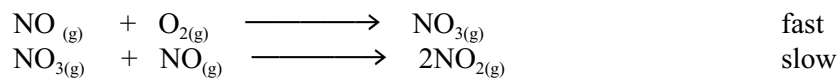


- (iii) Explain why the following mechanism is consistent with the rate expression, but is unlikely. 2



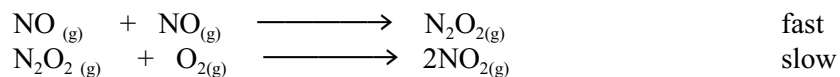
(iv) Explain why the following mechanism is consistent with the rate expression.

3

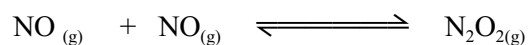


(v) Explain why the following mechanism is also consistent with the rate expression.

2



(vi) It is plausible that the first step in a possible mechanism for the reaction above is:

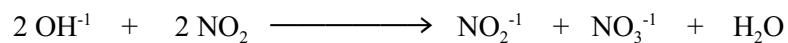


Draw a Lewis structure for NO and N₂O₂. What feature of the electronic structure of NO would suggest that this is a likely first step in the reaction.

4

- (vii) Explain why the enthalpy change for this step is -163 kJ mol^{-1} , given that the average bond energy for the N — N bond in compounds of nitrogen is $+163 \text{ kJ mol}^{-1}$. 2

- (viii) NO_2 reacts with aqueous sodium hydroxide according to the following equation:



What type of reaction is this? Justify your answer.

2

4. Heterogenous catalysis is used in the fight against air pollution. Harmful gases produced in a car engine are passed through a catalytic converter to reduce environmental damage.
- a. (i) Explain the term heterogeneous as applied to a catalytic converter, and briefly explain how the mechanism of heterogeneous catalysis. 4

(ii) Name the products formed when the following compounds are passed through a catalytic converter.

carbon monoxide: 1

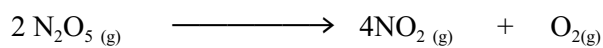
hydrocarbons: 1

(iii) Explain why leaded petrol must not be used in cars fitted with a catalytic converter. 1

- b. (i) In the catalytic converter oxides of nitrogen, NO_x , are converted into nitrogen in an exothermic reaction. Explain using a potential energy diagram, how a catalytic converter increases the rate of conversion of NO_x to nitrogen. 3

- (ii) The conversion of NO_x to nitrogen is extremely *slow* at room temperature as well as being *exothermic*. Explain why NO_x , with respect to nitrogen, may be described as kinetically stable and thermodynamically unstable. 2

5. The following reaction is described as first order with respect to N_2O_5 :



- a. Write the rate expression for the reaction. 1
- b. Explain what is meant by the term half-life for this reaction. 1
- c. State what is characteristic about the half-life of a first order reaction. 1
- d. The rate constant at a certain temperature for this reaction is $5.2 \times 10^{-3} \text{ s}^{-1}$. Calculate the time taken for the concentration of N_2O_5 to decrease from 0.10 mol dm^{-3} to $0.010 \text{ mol dm}^{-3}$. 3
- e. Briefly describe how you would determine the activation energy for the reaction above. 3