Chemical Kinetics Practice Items

1. Which of the following describes a first order reaction?

I. The reaction rate is directly proportional to the concentration of a single reagent.
II. Reagent concentration decreases with a half life that is independent of the initial reagent concentration.
III. A linear decrease of reagent concentration with time is observed.

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

2. Which of the following is a homogeneous reaction?

A. $4NH_3 (g) + 5O_2 (g) \longrightarrow 4NO (g) + 6H_2O (g)$
B. $H_2O (g) \longrightarrow H_2O (l)$
C. $Ca (l) + H_2 (g) \longrightarrow CaH_2 (s)$
D. $C (s) + H_2O (g) \longrightarrow CO (g) + H_2 (g)$

3. If the reaction rate is quadrupled by doubling the concentration of a reactant, the order of the reaction with respect to that reactant is

A. 1
B. 2
C. 4
D. cannot be determined except by experiment

4. In the presence of a catalyst

I. Effective collisions among reactant molecules become more likely to occur.
II. Chemical equilibrium will shift toward the products.
III. The activation energy for the reaction is lowered.

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

5. Choose the correct rate expression for the reaction below

$$2MgO + Si \longrightarrow 2Mg + SiO_2$$

A. rate = k [MgO] [Si]
B. rate = k $[MgO]^2$ [Si]
C. rate = 2k [MgO][Si]
D. can't determine from given information

6. In general the rate constant is **not** a function of

A. the activation energy of the reaction.
B. reaction temperature.
C. concentration of reactants.
D. the probability of collision.

7. H_2 and O_2 can be kept together at standard conditions for many years without appreciable reaction to form water. The reaction doesn't occur because

A. equilibrium favors the reagents.
B. the standard free energy change for the reaction is positive.
C. pressure in the reaction vessel is too low.
D. the mixture of gases is kinetically stable.

8. The table below contains experimental data for the reaction

$$2A + 2B \longrightarrow C + 2D$$

Trial #	Initial [A]	Initial [B]	Initial Formation Rate of C
1	2.0×10^{-4} *M*	1.0×10^{-2} *M*	8.0×10^{-5} *M sec*$^{-1}$
2	4.0×10^{-4} *M*	2.0×10^{-2} *M*	6.4×10^{-4} *M sec*$^{-1}$
3	2.0×10^{-4} *M*	3.0×10^{-2} *M*	2.4×10^{-4} *M sec*$^{-1}$

Which of the following is the correct rate equation for the reaction?

A. rate = k $[A]^2 [B]^2$
B. rate = k [A][B]
C. rate = k $[A]^2$ [B]
D. rate = k $[A]^2 [B]^3$

9. The decomposition of N_2O_5 in carbon tetrachloride can be represented

$$N_2O_5 \longrightarrow 4NO_2 + O_2$$

The reaction rate equation was found to be

rate = $(6.9 \times 10^{-4}\ s^{-1})\ [N_2O_5]$

If we begin with 30 g of N_2O_5 in solution, approximately how much time elapses before only 1 g remains?

A. 5.0×10^3 s
B. 1.4×10^4 s
C. 2.0×10^4 s
D. 4.0×10^4 s

The following passage pertains to questions 10-12.

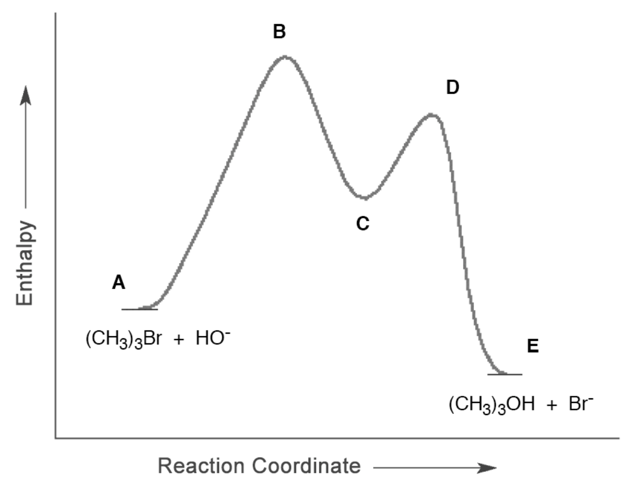
Reaction of an alkyl halide with base can proceed by either a substitution or an elimination pathway. The substitution that tert-butyl bromide would undergo with base is represented by the reaction below.

$$(CH_3)_3Br + OH^- \longrightarrow (CH_3)_3OH + Br^-$$

It has been found that the rate of the substitution reaction by which tert-butyl bromide is converted to tert-butyl alcohol varies directly with the concentration of alkyl halide but does not depend upon the concentration of base. The rate equation for the reaction is as follows:

rate = k $[(CH_3)_3Br]$

Below is the energy diagram representing the reaction mechanism. The energy of the stages from A (reactants) to E (products) is shown.



10. Which of the following best describes the reaction of tert-butyl bromide to form tert-butyl alcohol?

A. endothermic unimolecular
B. exothermic unimolecular
C. endothermic bimolecular
D. exothermic bimolecular

11. The vertical difference on the graph between stages A and B represents

A. the enthalpy change of the reaction.
B. the activation energy of the reaction.
C. the enthalpy of the intermediate.
D. the enthalpy difference between the reagents and the reaction intermediate.

12. Which of the following is the rate determining step in the reaction of tert-butyl bromide to form tert-butyl alcohol?

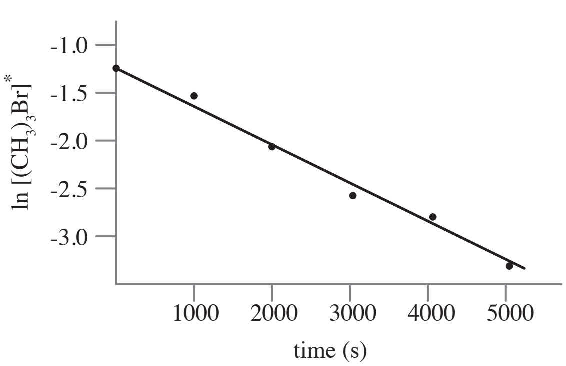
A. formation of the carbocation intermediate.
B. capture of the carbocation intermediate by hydroxide ion.
C. backside displacement of bromide by hydroxide ion.
D. direct displacement of bromide by hydroxide ion.

13. The concentration of trimethylbromide changes with time during the reaction described in the passage according to the following equation.

$$\ln [(CH_3)_3Br] = \ln [(CH_3)_3Br]_0 - kt$$

Experimental data was plotted on the graph below. What is the approximate rate constant for the reaction?

A. $4.0 \times 10^{-4}\ s^{-1}$
B. $1.3 \times 10^{-3}\ s^{-1}$
C. $3.9 \times 10^{-3}\ s^{-1}$
D. $2.0 \times 10^{-2}\ s^{-1}$

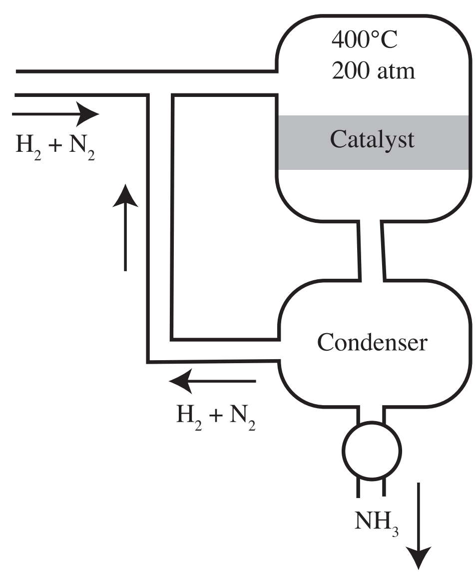


The following passage pertains to questions 14-17.

The Haber Process combines nitrogen from the air with hydrogen derived from methane to form ammonia. The reaction is reversible. The production of ammonia is exothermic.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$
$$\Delta H = -92\ kJ\ mol^{-1}$$

This conversion is typically conducted at 150–250 atm and between 300–550 °C, as the gases are passed over four beds of an iron wool catalyst, with cooling between each pass. The reaction mechanism involving the catalyst involves a number of steps of which the adsorption and cleavage of nitrogen is the rate determining step. Iron is predominantly in the zero oxidation state in the catalyst. Importantly, the rate-limiting step of the catalytic process is N_2 chemisorption and N-N bond cleavage to give surface-bound nitrides (N^{3-}), which react with H_2 to form the N-H bonds in NH_3. On each pass only about 15% conversion occurs, but any unreacted gases are recycled, and eventually an overall conversion of 97% is achieved.



Gaseous ammonia is not removed from the reactor itself, since the temperature is too high. It is removed from the equilibrium mixture of gases leaving the reaction vessel. The hot gases are cooled enough, whilst maintaining a high pressure, for the ammonia to condense and be removed as liquid. Unreacted hydrogen and nitrogen gases are then returned to the reaction vessel to undergo further reaction.

14. Which of the following could we expect to increase the concentration of ammonia in the equilibrium mixture of gases exiting the reaction chamber?

I. Increasing pressure in the reactor.
II. Changes to the catalyst that lower the activation energy for the N_2 adsorption and cleavage steps.
III. Redesigning the reactor to accomodate a reaction temperature of 650 °C.

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

15. The reaction is carried out at high temperatures in order to

A. decrease the equilibrium constant.
B. increase the equilibrium constant.
C. increase the rate constant.
D. decrease the activation energy.

16. Why does the design call for the iron catalyst to be utilized in the form iron wool?

A. increased surface area
B. increased effective concentration
C. increased molar density
D. decreased heat capacity

17. It is believed that three iron atoms in the catalyst cooperate to break the N-N triple bond through a six-electron reduction of the N_2. After the mechanism is complete and the ammonia is released, the iron will be

A. in the Fe_2N form of ferrous nitride.
B. in the Fe_3N_4 form of ferrous nitride.
C. in the zero oxidation state of pure iron.
D. in the +3 ferric oxidation state.