Reaction Rate and Equilibrium

(1) Reaction Rate

-2019 I(7)

(7) Which of the descriptions 1) to 4) is not correct to describe a phenomenon that can be observed when a catalyst is introduced in a chemical reaction?

1) The activation energy of a chemical reaction with a catalyst is lower than that of a chemical reaction without a catalyst.
2) The heat of reaction of a chemical reaction with a catalyst is lower than that of a reaction without a catalyst.
3) The rate of forward reaction of a chemical reaction with a catalyst is higher than that of a reaction without a catalyst.
4) The rate of reverse reaction of a chemical reaction with a catalyst is higher than that of a reaction without a catalyst.

(2) Equilibrium (Theories)

-2006 III(2)

In the reaction $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$, the 3 gases attain an equilibrium state. How will the amount of NH_3 be affected in the following situations?

(a) The temperature is increased with the pressure fixed.

(b) The mixture is compressed with the temperature fixed.

Answer the suitable option in the provided spaces.

1) Increase 2) Decrease 3) Remain unchanged

(Note: It is given that the forward reaction is exothermic)

-2010 Q6

Q6 The following reaction is in an equilibrium state.

$$2NO_2 \text{ (brown)} = N_2O_4 \text{ (colorless)} + 57 \text{ kJ}$$

From ①-④ below choose two correct ones out of statements (**a**)-(**d**). **6**

(**a**) As the temperature is increased, the color darkens.

(**b**) As the temperature is increased, the color lightens.

(**c**) As the pressure is increased, the brown color first darkens, and then, after a few seconds, lightens.

(**d**) As the pressure is increased, the brown color first lightens, and then, after a few seconds, darkens.

① **a**, **c** ② **a**, **d** ③ **b**, **c** ④ **b**, **d**

-2012 I(7)

(7) A gaseous mixture of NO_2 and N_2O_4 is sealed in 4 identical vessels with movable pistons. When the conditions are modified as described in 1) to 4), in which condition does the molar ratio of NO_2 to N_2O_4 remain unchanged after a long time enough to reach equilibrium?

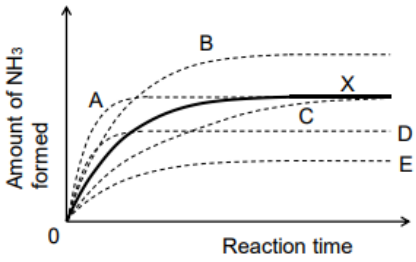
1) Total pressure is increased by moving the piston at a constant temperature.
2) Temperature is increased while keeping the total pressure constant by moving the piston.
3) Additional NO_2 is introduced from outside while keeping the total pressure constant by moving the piston at a constant temperature.
4) Additional N_2 is introduced from outside while keeping the total pressure constant by moving the piston at a constant temperature.

-2020 IV(5)(6)

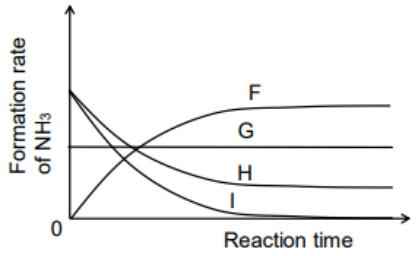
The reaction is given by $N_2(g) + 3H_2(g) = 2NH_3(g)\ \Delta H = -92\ kJ$

(5) Line X in the figure on the right shows the time course of the amount of NH_3 formation. When the reaction conditions are changed as below, which of lines A – E will be obtained, if

1) a catalyst with higher activity is added.
2) the temperature is raised.



(6) The figure on the right shows the time course of the apparent rate of NH_3 formation under the same reaction conditions that give Line X above. Which of lines F–I is correct?



(3) Equilibrium (Calculations)

-2013 IV

IV 1.0 mol of acetic acid and 1.0 mol of ethanol was mixed to react at a constant temperature to reach the equilibrium, and 0.75 mol of water was found in the product. Write the correct answer to the questions below to two significant figures.

(1) Calculate the equilibrium constant of this reaction at the above temperature.

(2) At the same temperature, 1.0 mol of acetic acid, 1.0 mol of ethanol and 4.0 mol of water were initially mixed to react. Calculate the amount of ethylacetate produced after the mixture has reached the equilibrium.

-2015 III

III When dissolved in water, a weak acid HA partially dissociates as shown below;

$$HA \leftrightarrows H^+ + A^-$$

The degree of dissociation, α, is defined as the fraction of HA dissociated in water. The dissociation constant, K_a, is defined as the product $[H^+][A^-]$ divided by [HA], where the brackets denote the concentrations of the respective chemical species. Give the appropriate answers to the following questions.

(1) Setting the initial concentration of HA as C, write an expression of K_a using α and C.

(2) Show an expression of $[H^+]$ using K_a, C and C_{salt} when HA and a corresponding sodium salt NaA is dissolved together in water with initial concentrations of [HA] = C and [NaA] = C_{salt}. Provided that x>>y, you can use an approximate equation: $x \pm y \approx x$.

-2016 III

III 0.80 mol of hydrogen and 0.60 mol of iodine both in gaseous states were kept in a sealed vessel at a constant temperature for long enough to reach an equilibrium according to the reaction below. At the equilibrium, 1.00 mol of hydrogen iodide was found in the vessel.

$$H_2\,(g) + I_2\,(g) \rightleftarrows 2HI\,(g)$$

(1) Answer the amount of hydrogen in the vessel at the equilibrium to the second decimal place.

(2) Calculate the equilibrium constant to the second significant figure.

-2017 III

III In a sealed vessel, 1.0 mol of dinitrogen tetroxide in a gaseous state was initially prepared. After a long enough time at a constant temperature, the reaction below reached equilibrium. At the equilibrium, 1.2 mol of nitrogen dioxide was found, and the total pressure was 1.0×10^5 Pa in the vessel.

$$N_2O_4\ (g) \rightleftarrows 2NO_2\ (g)$$

(1) Calculate the partial pressure of dinitrogen tetroxide in the vessel at the equilibrium to two significant figures.

(2) Calculate the pressure equilibrium constant to two significant figures, and show it with the unit.

-2018 III

There is 10.0 mL of 0.30 mol L^{-1} $AgNO_3$ aqueous solution, which is added to 20.0 mL of 0.30 mol L^{-1} NaCl aqueous solution. This procedure leads to the precipitation of AgCl and equilibrium between solutes and the precipitate is achieved. The concentrations of Ag^+ and Cl^- in the aqueous solution are estimated to be (a) and (b) mol L^{-1}, respectively. Here, the solubility product of AgCl is 1.8×10^{-10} mol^2 L^{-2}.