Chapter: Chemical Equilibrium

Multiple Choice Questions:

- **The reversible reaction is shown by**
    - Single-headed arrow
    - **Double-headed arrow**
    - By single and double-headed both
    - None of the above
- **The irreversible reaction is shown by**
    - **Single-headed arrow**
    - Double-headed arrow
    - By single and double-headed both
    - None of the above
- **The reaction in which the reactants are completely consumed and formed products and no amount of reactants left behind are called.**
    - Reversible reaction
    - **Irreversible reaction**
    - Forward reaction
    - None of these
- **The reaction in which products react and go in a backward direction and yield reactants again is called**
    - **Reversible reaction**
    - Irreversible reaction
    - Complete reaction
    - Both a and c

- **The law of mass action was proposed by**
    - Charles
    - P. Waage
    - C.M Gulberg
    - **Both b and c**
- **Which of the following reaction helps to achieve dynamic equilibrium**
    - Irreversible reaction
    - **Reversible reaction**
    - Both a and b
    - Chemical reaction
- **When the rate of forward reaction becomes equal to the rate of backward reaction then this state is called**
    - **Chemical equilibrium**
    - Stable equilibrium
    - Un-stable equilibrium
    - Both a and b
- **The product of ratio of forward reaction and reverse reaction is called**
    - Kn
    - Kp
    - **Kc**
    - Kx

- **The proportionality constant for forward reaction is**
  - Kr
  - **Kf**
  - Kp
  - Kc
- **The proportionality constant of the reverse reaction is**
  - **Kr**
  - Kf
  - Kx
  - Kc
- **Active mass represents the**
  - **Molar concentration of reactants**
  - Reactants and products temperature
  - Reactants and products pressure
  - Reactants and products volume
- **Active Mass of substance is _________ in a dilute solution**
  - KJ
  - **mol/dm3**
  - g/liter
  - Coulomb
- **The concentration of reactants and products can be expressed in terms of**
  - ( )
  - **[ ]**
  - { }
  - None of the above

- **In Kc the small c donates**
  - Direction
  - **Molar concentration**
  - Coefficient
  - Both a and c
- **Kc depends upon the**
  - **Temperature**
  - Pressure
  - Volume
  - None of the above
- **On the initial concentration of reactants and products, one constant is independent**
  - **Kc**
  - Kn
  - Kf
  - Kr
- **Which of the following is not determined by Kc**
  - Chemical reaction's direction
  - Chemical reaction's extent
  - Equilibrium's mixture concentration when the initial concentration of reactants is known
  - **Catalyst used in a reaction**

- **The process by which ammonia is synthesized is called**
  - Contact process
  - **Haber process**
  - Titration
  - Spectroscopy
- **The process by which sulfuric acid is synthesized is called**
  - **Contact process**
  - Haber process
  - Titration
  - Spectroscopy
- **Le Chatellier's principle is used to**
  - **Increase the yield of product**
  - Increase the yield of reactants
  - Decrease the yield of product
  - Decrease the yield of reactants
- **Name the catalyst used for the synthesis of ammonia is**
  - V_2O_5
  - **Fe**
  - Ni
  - Pt

- **Name the catalyst used in the below reaction**

$$2SO_{2(g)} + O_2 \longrightarrow 2SO_{3(g)}$$

  - **V_2O_5**
  - Fe
  - Ni
  - Pt

- **The temperature used in the Haber process is**
  - **400 ^oC**
  - 500 ^oC
  - 450 ^oC
  - 600 ^oC

- **The temperature used in the formation of sulfur-trioxide is**
  - 400 ^oC
  - 500 ^oC
  - **450 ^oC**
  - 600 ^oC

- **The pressure used in the Haber process is**
  - 300 atm
  - **200 atm**
  - 250 atm
  - 350 atm

- **The gas which is dissolved in fizzy drinks under high pressure is**
    - O_2
    - **CO_2**
    - N_2
    - CO
- **The pressure used in the formation of SO_3 is**
    - 100 atm
    - **200 atm**
    - 300 atm
    - 400 atm
- **The percentage of ammonia and sulfuric acid produced by Le Chatellier's principle is**
    - 80 % yield
    - 85 % yield
    - 90 % yield
    - **98 % yield**
- **Law of mass action is directly proportional to the product of active masses of**
    - **Reactants**
    - Products
    - Both a and b
    - None of the above

- **The expression of Kc for the below reaction will be**

$$N_2 + 3H_2 \underset{400^{\circ}C,\ 200\ atm}{\overset{Fe}{\rightleftharpoons}} 2NH_3$$

  - $[N_2]\,[H_2]^3 / [NH_3]^2$
  - $[NH_3]^2\,[N_2] / [H_2]^3$
  - **$[NH_3]^2 / [N_2]\,[H_2]^3$**
  - $[NH_3]^2\,[H_2]^3 / [N_2]$

- **The unit of Kc for the below reaction will be**

$$2SO_{2(g)} + O_2 \underset{450^{\circ}C,\ 200\ atm}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_{3(g)}$$

  - **$mol^{-1}.dm^3$**
  - mol^2 / dm^6
  - dm^3 / mol
  - mol / dm^3

Solution:

$$Kc = \frac{[SO_{3(g)}]^2}{[SO_{2(g)}]^2\ [O_2]}$$

$$Kc = \frac{\cancel{[mol/dm_3]^2}}{\cancel{[mol/dm_3]^2}\ [mol/dm_3]}$$

$$Kc = [mol^{-1}dm_3]$$

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- **For which of the following reaction the Kc will have no unit**

$$(1)\quad SO_2 + O_2 \underset{450\,^{\circ}C,\ 200\ atm}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_3$$

$$(2)\quad N_2 + 3H_2 \underset{400\,^{\circ}C,\ 200\ atm}{\overset{Fe}{\rightleftharpoons}} 2NH_3$$

$$(3)\quad H_2 + I_2 \rightleftharpoons 2HI$$

$$(4)\quad N_2O_4 \rightleftharpoons 2NO_2$$

- 1
- 2
- **3**
- 4

Solution for the first reaction:

$$Kc = \frac{[SO_{3(g)}]^2}{[SO_{2(g)}]^2\ [O_2]}$$

$$Kc = \frac{\cancel{[mol/dm_3]^2}}{\cancel{[mol/dm_3]^2}\ [mol/dm_3]}$$

$$Kc = [mol^{-1}dm_3]$$

Solution for the second reaction:

$$Kc = \frac{[NH_3]^2}{[N_2]\quad [H_2]^3}$$

$$Kc = \frac{\cancel{[mol/dm_3]^2}}{\cancel{[mol/dm_3]}\ [mol/dm_3]^{\cancel{2+1}}}$$

$$Kc = [mol^{-1}dm_3]^2$$

When two moles of product and three moles of reactants are combined in the first reaction, one mole of reactant will remain, and this remaining mole will be the unit of Kc.

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Two moles of the product will cancel with two moles of reactants in the second reaction since there are two moles of reactants and four moles of reactants, and the remaining two moles of reactants will be left behind and create the unit of Kc.

Solution for the third reaction:

$$Kc = \frac{[HI]^2}{[H_2]\quad[I_2]}$$

$$Kc = \frac{\cancel{[mol/dm_3]^2}}{\cancel{[mol/dm_3]}\ \cancel{[mol/dm_3]}}$$

$$Kc = \text{No unit}$$

Solution for the fourth reaction:

$$Kc = \frac{[N_2O_4]}{[NO_2]^2}$$

$$Kc = \frac{\cancel{[mol/dm_3]}}{\cancel{[mol/dm_3]}^{\cancel{1}+1}}$$

$$Kc = mol^{-1}.dm^3$$

There will be no unit of Kc since there are two moles of products and two moles of reactants in the third reaction, canceling each other out and leaving nothing behind.

One mole of the product will cancel with one mole of reactant in the fourth reaction since there are two moles of reactants and one mole of product. The remaining mole of reactant will be the unit of Kc.

- **Which of the following reaction is reversible**

$$(1)\ NaOH + HCl \longrightarrow NaCl + H_2O$$

$$(2)\ SnCl_2 + 2FeCl_3 \longrightarrow 2NH_3$$

$$(3)\ H_2 + I_2 \rightleftharpoons 2HI$$

$$(4)\ 2KClO_3 \longrightarrow 2KCl + 3O_2$$

  - 1
  - 2
  - **3**
  - 4

According to the reactions, reaction 3 is reversible because there is a double-headed arrow between the reactants and products, whereas the other reactions are irreversible since there is only a single-headed arrow between the reactants and products.

- **Which of the following reaction is irreversible**

$$(1)\ NaOH + HCl \longrightarrow NaCl + H_2O$$

$$(2)\ N_2 + 3H_2 \overset{Fe}{\rightleftharpoons} 2NH_3$$

$$(3)\ H_2 + I_2 \rightleftharpoons 2HI$$

$$(4)\ N_2O_4 \rightleftharpoons 2NO_2$$

  - **1**
  - 2
  - 3
  - 4

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Solution: We can see from the reaction arrows that reaction one is represented by a single headed arrow, and we are aware that a single headed arrow signifies an irreversible reaction. Reaction 1 is hence irreversible. While reactions 2, 3, and 4 are reversible, as can be seen from the double-headed arrows used to symbolize them.

- **Initially when the reaction starts then the rate of reverse reaction will be**
  - High
  - Low
  - **Zero**
  - None of the above
- **Initially when the reaction starts then the rate of forward reaction will be**
  - **Highest**
  - Lowest
  - Zero
  - Both b and c
- **When evaporation and condensation rates become equal then it means that the system is at state of**
  - **Equilibrium**
  - Unstable
  - Stable
  - Neutral
- **The below reaction takes place in the presence of which one catalyst?**

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

  - **Fe**
  - V_2O_5
  - Electric spark
  - Ni

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- **[ ] ^{a} [ ] ^{b} the a and b in the superscript on the square bracket represent the**
    - Number of moles of reactants
    - Number of moles of products
    - **Both a and b**
    - None of the above
- **The unit of Kc for the below reaction will be**

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

- $mol^{-1}.dm^3$
- **mol/dm^3**
- mol^2/dm^{-6}
- None of the above

Solution:

$$Kc = \frac{[PCl_3]\ [Cl_2]}{[PCl_5]}$$

$$Kc = \frac{\cancel{[mol/dm_3]}\ [mol/dm_3]}{\cancel{[mol/dm_3]}}$$

$$Kc = [mol/dm_3]$$

Given that there are two moles of products and one mole of reactant in this reaction, one mole of product will cancel out with one mole of reactant, leaving the other mole of product—which corresponds to the unit of Kc—behind.

- **Which statement is true about the state of equilibrium?**
  - Forward reaction stops
  - Reverse reaction stops
  - Forward and reverse both reactions stop
  - **Both forward and reverse reactions continue at the same rate**
- **When a mixture of H_2 and I_2 is sealed in a flask and the temperature is kept at 25 ^oC, the following equilibrium is established.**

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Which substance will be present in the equilibrium mixture?

  - H_2 and I_2
  - HI only
  - H_2 only
  - **H_2 , I_2 and HI**

The reaction can go either way since it is reversible, and we know that reversible reactions can go both ways. Therefore, equilibrium will be reached once the rates of forward and reverse reactions are equal. At this point, the concentrations of the reactants and products will be equal. As a result, the equilibrium mixture will contain both the reactants (H_2, I_2) and the product (HI) at the same concentration.

- **Derive the Kc unit for**

$$N_2 + 2O_2 \rightleftharpoons 2NO_2$$

  - **$mol^{-1}.dm^3$**
  - mol^2 / dm^6
  - dm^3 / mol
  - No unit

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Solution:

$$Kc = \frac{[NO_2]^2}{[N2]\ [O_2]^2}$$

$$Kc = \frac{\cancel{[mol / dm_3]^2}}{[mol / dm_3]\ \cancel{[mol / dm_3]^2}}$$

$$Kc = mol^{-1}.dm^3$$

We can see that there are two moles of products and three moles of reactants in this reaction. As a result, one mole of reactant will be left behind after cutting two moles of reactants into two moles of products, and this will serve as the unit of Kc.

- **For which of the following reactions Kc will have unit less?**

$$(1)\ H_2 + CO_2 \rightleftharpoons H_2O + CO$$

$$(2)\ N_2 + O_2 \rightleftharpoons 2NO_2$$

$$(3)\ 2A + B \rightleftharpoons 3AC$$

  - 1
  - 2
  - 3
  - **All of the above**

Solution:

Because there are the same amounts of reactants and products in each of the three reactions, they all cancel one another out and leave no remaining unit for Kc.

$$K_c = \frac{[H_2O]\ [CO]}{[H_2]\ \ [CO_2]} \qquad K_c = \frac{[NO_2]^2}{[N_2]\ \ [O_2]} \qquad K_c = \frac{[AC]^3}{[A]^2\ \ [B]}$$

$$K_c = \frac{\cancel{[mol/dm_3]}\ \cancel{[mol/dm_3]}}{\cancel{[mol/dm_3]}\ \cancel{[mol/dm_3]}} \qquad K_c = \frac{\cancel{[mol/dm_3]}^2}{\cancel{[mol/dm_3]}\ \cancel{[mol/dm_3]}} \qquad K_c = \frac{\cancel{[mol/dm_3]}^3}{\cancel{[mol/dm_3]}^2\ \ \cancel{[mol/dm3]}}$$

$K_c =$ No Unit $\qquad K_c =$ No Unit $\qquad K_c =$ No Unit

- **The concentration of reactants and products at equilibrium remains unchanged if**
  - The concentration of any reactant or product is not changed
  - The temperature of the reaction is not changed
  - The pressure or volume of the system is not changed
  - **All of the above are observed**
- **Which of the following does not happen when a system is at an equilibrium state?**
  - **Forward and reverse reactions stop**
  - Forward and reverse reaction rates become equal
  - Reactants and products concentration stops changing
  - Reaction occur in both the directions
- **For which one reaction the unit of Kc will be mol/dm^3**

(1) $2NO_2 \rightleftharpoons N_2O_4$

(2) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

(3) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

(4) $2ICl \rightleftharpoons I_2 + Cl_2$

  - 1
  - 2
  - **3**
  - 4

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Solution:

$$Kc = \frac{[PCl_3]\ [Cl_2]}{[PCl_5]}$$

$$Kc = \frac{\cancel{[mol/dm^3]}\ [mol/dm^3]}{\cancel{[mol/dm^3]}}$$

$$Kc = [mol/dm^3]$$

- **How equilibrium established, in an irreversible reaction**
  - Established quickly
  - Established slowly
  - **Never established**
  - Established when reaction stops
- **Active mass can be justified as**
  - Total mass of the reactants
  - Total mass of products
  - Total mass of reactants and products
  - **Mass of substance in mole per dm^3 in a dilute solution**

- **For a reverse reaction**

$$Kc = \frac{[C]^2}{[A]\,[B]}$$

Which substance is the product of the reaction?

- A
- B
- Both A and B
- **C**

Solution: We know that Kc is the product of the ratio of products and reactant concentration in light of the law of mass action. Thus, $[C]^2$ is the end result.