CHEMISTRY

WORKSHEET-14

STEP

A PROJECT BY PUNJAB GROUP

Worksheet-14

(Physical Chemistry)

Chemical Equilibrium

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Q.1 **Identify the incorrect statement about irreversible and reversible reaction:**

Opt	Irreversible Reaction	Reversible Reaction
A)	It is a chemical reaction which takes place in one direction only under the given conditions	It is a chemical reaction which takes place in both directions i.e. forward as well as reverse only under the given conditions
B)	It almost goes to completion	It never goes to completion
C)	No equilibrium state exists	Equilibrium state is the ultimate goal in this reaction
D)	It can be carried out in isolated system	It can be carried out in open system

Q.2 **Chemical equilibrium is not associated with:**

A) It is macroscopic property

B) At equilibrium the amount of reactant = the amount of product

C) It is established in closed system

D) It can establish from either side of reactant or product

Q.3 **If the reaction A + B $\rightarrow$ AB. If concentration of A and B are doubled, the rate of reaction will:**

A) Increase two times

B) Decrease to one half

C) Increase four times

D) Decrease to one

Q.4 **Which one of the following factors can change the value of Kc?**

A) Temperature

B) Pressure

C) Concentration of reactants

D) Concentration of products

Q.5 **Which of the following principle / rule is applicable at equilibrium?**

A) Law of mass action

B) Pauli's Exclusion Principle

C) Le-Chatelier's Principle

D) Hund's Rule

Q.6 **In which of the following reactions decrease or increase in pressure has no effect in the change of direction of reaction?**

A) $N_2 + O_2 \rightleftharpoons 2NO$ C) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

B) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ D) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

Q.7 **In which of the following reactions, K_c value has no unit?**

A) $H_2 + I_2 \rightleftharpoons 2HI$ C) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

B) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ D) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

Q.8 **Consider the following reaction $2SO_2 + O_2 \overset{V_2O_5}{\rightleftharpoons} 2SO_3$ the unit of K_c is:**

A) mol dm^{-3} C) dm^3mol^{-1}

B) dm^3mol^{-2} D) dm^6mol^{-2}

Q.9 **In which of the following reactions, heterogeneous equilibrium is established?**

A) $H_2 + I_2 \rightleftharpoons 2HI$ C) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

B) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ D) $MgCO_3 \rightleftharpoons MgO + CO_2$

Q.10 **Which one of the following statements is correct about a reaction for which the equilibrium constant is independent of temperature?**

A) The activation energies for both forward and reverse reactions are zero

B) The enthalpy change is zero

C) Its rate constants do not vary with temperature

D) There are equal number of moles of reactants and products in it

Q.11 **Which of the following is the strongest acid?**

A) HI C) $HClO_3$

B) HNO_3 D) H_2SO_4

Q.12 **Which one of the following groups of elements forms strongest bases?**

A) IVA C) IIA

B) IIIA D) IA

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Q.13 Which one of the following statements is incorrect?

A) Strong acid has greater concentration of hydrogen ions

B) Strong acid has low pH value

C) Greater is pK_a value, stronger is the acid

D) Smaller is concentration of OH^- ions weaker is the base

Q.14 Which of the following is not buffer solution?

A) $CH_3COOH + CH_3COONa$

B) $H_2CO_3 + NaHCO_3$

C) $HCl + NaCl$

D) $H_3PO_4 + Na_2HPO_4$

Q.15 If K_a value is 10^{-6} then K_b value is:

A) 10^{-4} C) 10^{-6}

B) 10^{-8} D) 10^{-10}

Q.16 Which one of the following statements is incorrect for K_c?

A) It may or may not have unit

B) It depends on equilibrium concentration

C) It is associated with ΔH

D) It tells us about rate of reaction

Q.17 All of the following are characteristic features of solubility product EXCEPT?

A) If solubility is known, then K_{sp} can be calculated

B) If K_{sp} is known, then solubility can be calculated

C) It is applicable if the molar concentration of ions is greater than 0.1M

D) The term K_{sp} is related with reversible process

Q.18 Which one of the following statements is correct about the effect of a catalyst?

A) It increases the equilibrium constant for the forward reaction

B) It increases the rate constant for the forward reaction but not that of the reverse reaction

C) It increases the yield of product at equilibrium

D) It provides an alternative route for a reaction

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Q.19 **Water dissociates as shown:**

$$H_2O_{(g)} \rightleftharpoons H^+ + OH^-$$

At 25°C the equilibrium value of $[H^+]$ is 10^{-7} mol dm^{-3}, $[H_2O] = \frac{1000}{18}$ mol dm^{-3}. What is the order of increasing numerical value of pH, $_pK_a$ and $_pK_w$ for this equilibrium at this temperature? $[_pK_w = -\log K_w]$

Options	Smallest	Larger	Largest
A)	pH	$_pK_a$	$_pK_w$
B)	pH	$_pK_w$	$_pK_a$
C)	pK_a	$_pK_w$	pH
D)	pK_w	$_pK_a$	pH

Q.20 **In order to get maximum yield of NH_3, all of the following are optimum conditions EXCEPT?**

A) High pressure

B) Continuous withdrawal of NH_3

C) High temperature

D) Use of catalyst

Q.21 **Which of the following is Henderson's equation for acidic buffer solution?**

A) $pH = pK_a + \log\frac{[Salt]}{[Acid]}$ C) $pH = pK_b + \log\frac{[Salt]}{[Acid]}$

B) $pH = K_a + \log\frac{[Salt]}{[Acid]}$ D) $pH = pK_a - \log\frac{[Salt]}{[Acid]}$

Q.22 **Which of the following statements is incorrect about Henderson's equation for acidic buffer solution?**

A) pH = pKa if [Salt] = [Acid]

B) pH > pKa if [Salt] > [Acid]

C) pH < pKa if [Salt] < [Acid]

D) pH = Ka if [Salt] = [Acid]

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Q.23 **The decrease in the solubility of an electrolyte by adding another electrolyte having common ion is called common ion effect. Identify incorrect statement about common ions effect:**

A) It is an application of Le-Chatelier's Principle

B) It is always in the reverse direction

C) The term electrolyte, acid or base is used for it

D) It is used for the purification of a substance

Q.24 **The equilibrium constant for the reaction between acetic acid and ethyl alcohol is 4.0. A mixture of 2.0 moles of acetic acid and 2.0 moles of C_2H_5OH is allowed to come to equilibrium. Calculate the number of moles of ethyl acetate at equilibrium**

$$C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

A) 1.5 moles C) 1.6 moles
B) 1.3 moles D) 1.4 moles

Q.25 **Given that pKa of acetic acid is 4.7, what is pH of solution of 0.01 M acetic acid and 0.1 sodium acetate is:**

A) 3.7 C) 4.7
B) 5.7 D) 2.7

Q.26 **The Le-Chatlier principle states that if a stress is applied to a system at equilibrium, the system acts in such a way so as to nullify as far as possible, the effect of that stress. Which of the following effect of change is not according to this principle:**

Opt.	Change at equilibrium	Effect of change
A)	Increase in concentration of reactant	Reaction moves in the forward direction
B)	Increase in pressure	Reaction moves in that direction which has less number of moles
C)	Increase in temperature	Reaction always moves in the exothermic side
D)	Increase in the concentration of the product	Reaction moves in the reverse direction

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Q.27 **Different relationship between K_c and K_p are given:**

Cond.	Case	Example	Conclusion
I	If $\Delta n = 0$ ($n_p = n_r$)	$H_2 + I_2 \rightleftharpoons 2HI$	$K_p = K_c$
II	If Δn = +ve ($n_p > n_r$)	$PCl_5 \rightleftharpoons PCl_3 + Cl_2$	$K_p > K_c$
III	If Δn = -ve ($n_p < n_r$)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$	$K_p < K_c$

Which of the following relationship between K_c and K_p is/are correct?

A) I only C) III only

B) II only D) I, II, III

Q.28 **pH of an aqueous solution is 10.0 Its pOH is:**

A) 7 C) 4

B) 9 D) 10

Q.29 **Mark the correct statement:**

A) Greater is the Ka value, stronger is the acid

B) Greater is pH value, stronger is the acid

C) Greater is pKa value, stronger is the acid

D) Smaller is H^+ ion concentration, stronger is the acid

Q.30 **The phenomenon of interaction of cations and anions of a salt with water in order to produce acidity or alkalinity is known as salt hydrolysis. Which of the following salts is not hydrolyzed?**

A) $CuSO_4$ C) Na_2SO_4

B) Na_2CO_3 D) $AlCl_3$

Q.31 **Which of the following is acidic salt?**

A) Na_2SiO_3 C) K_2SO_4

B) $Na_2B_4O_7$ D) $FeCl_3$

Q.32 **According to Lewis theory:**

- **Acid is electron pair acceptor**
- **Base is electron pair donor**

All of the following are Lewis acids EXCEPT:

A) H^+ C) BF_3

B) $AlCl_3$ D) PCl_3

Q.33 **Which of the following halide ions is stronger Lewis base?**

A) F^- C) Br^-

B) Cl^- D) I^-

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Q.34 **The solubility of CaF_2 in water at 25°C is found to be $2x10^{-4}$, what is value of K_{sp} at this temperature:**

A) 3.2×10^{-11} C) 4.0×10^{-12}

B) 3.5×10^{-11} D) 4.5×10^{-13}

Q.35 **All of the following are applications of K_c EXCEPT:**

A) It helps to predict direction of reaction

B) It tells about extent of reaction

C) It tells about rate of reaction

D) It tells about effect of change in concentration, temperature and pressure

Q.36 **HCl when added to H_2S solution:**

A) Suppresses the ionization of H_2S

B) Solution becomes coloured

C) Enhances the ionization

D) Does not affect

Q.37 **Kp is more than Kc when the difference of the moles of the products and reactants is:**

A) Zero C) Positive

B) Negative D) One

Q.38 **In which of the following values of Kc, reaction goes to completion in the forward direction:**

A) 10^2 C) 10^{30}

B) 10^{-30} D) 1

Q.39 **Consider the following relationship between Kp, Kc, Kx and Kn:**

I. $Kp = Kc\ (RT)^{\Delta n}$

II. $Kp = Kn\ (P/N)^{\Delta n}$

III. $Kp = Kx\ (RT/V)^{\Delta n}$

A) I only C) II and III only

B) II only D) I, II and III

Q.40 **The value of ionic product of water at 25°C is:**

A) $1.0 \times 10^{-14}\ mol^2dm^{-6}$ C) $1.5 \times 10^{14}\ mol^2dm^{-6}$

B) $1.0 \times 10^{14}\ mol^2dm^{-6}$ D) $1.5 \times 10^{-14}\ mol^2dm^{-6}$

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ANSWER KEY (Worksheet-14)							
1	D	11	A	21	A	31	D
2	B	12	D	22	D	32	D
3	C	13	C	23	C	33	A
4	A	14	C	24	B	34	A
5	C	15	B	25	B	35	C
6	A	16	D	26	C	36	A
7	A	17	C	27	D	37	C
8	C	18	D	28	C	38	C
9	D	19	B	29	A	39	B
10	B	20	C	30	C	40	A

ANSWERS EXPLAINED

Q.1 (D) It is incorrect statement. The correct statement is as follow:

Irreversible Reaction	Reversible Reaction
It can be carried out in open as well as closed container	It can only carried out in closed container

Q.2 (B) At equilibrium the amount of reactant ≠ amount of product. However at equilibrium the rate of forward reaction = rate of reverse reaction.

Q.3 (C) In reaction **A + B → AB**

Rate of forward reaction = k[A][B]

According to condition if concentration of **A** and **B** are **doubled,** then rate of forward reaction will increases four times as shown below.

Rate of forward reaction

= k[A][B] = k [2][2] = 4k

Q.4 (A) The numerical value of K_c and K_p for a reaction changes with change of temperature. There are three possibilities.

- **Case # I** If $\Delta H = 0 \rightarrow K_c$ **remains same** at different **temperature**.
- **Case # II** If $\Delta H = + \rightarrow K_c$ **increases** with the **increase** of **temperature**.
- **Case # III** If $\Delta H = - \rightarrow K_c$ **decreases** with the **increase** of **temperature**.

Q.5 (C) "Le-Chatelier's Principle states that if a stress is applied to system at equilibrium, the system acts in such a way so as to nullify, as far as possible, the effect of that stress.

Q.6 (A) Since the number of moles of reactants = number of moles of products, so there is no effect of increase or decrease in pressure in the given reversible reaction.

Q.7 (A) In this reaction K_c has no unit

$H_2 + I_2 \rightleftharpoons 2HI$

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{(moldm^{-3})^2}{(moldm^{-3})(moldm^{-3})}$$

So K_c has no unit.

Q.8 (C) $2SO_2 + O_2 \overset{V_2O_5}{\rightleftharpoons} 2SO_3$

$$K_c = \frac{[SO^3]^2}{[SO^2]^2[O^2]}$$

$$= \frac{(moldm^{-3})^2}{(moldm^{-3})^2(moldm^{-3})} = dm^3 mol^{-1}$$

Q.9 (D) $MgCO_{3(s)} \rightleftharpoons MgO_{(s)} + CO_{2(g)}$

In this reaction heterogeneous equilibrium is established because **reactant** and **products** are **not** in the **same phase**.

Q.10 (B) $\Delta H = 0$ then the value of K_c is constant, independent of temperature i.e the value of K_c neither **increases** nor **decreases**.

Q.11 (A) **The pKa values of acids HI, $HClO_3$, HNO_3 and H_2SO_4 are -10, -1.0, -1.3 and -3.0 respectively. Smaller** is **pK_a** value **stronger** is the **acid** so **HI** is **stronger acid than that of $HClO_3$, HNO_3 and H_2SO_4.**

Q.12 (D) The elements of IA group form the **strongest bases i.e NaOH, KOH, CsOH etc.**

Q.13 (C) **In fact greater is pKa value, weaker is the acid, as already explained in Q#11.**

Q.14 (C) Acidic buffer solution is prepared by **mixing weak acid** and salt of it with strong base. So **HCl + NaCl cannot** form acidic buffer solution because **HCl** is **strong acid** and it **does not** fulfill the condition of acidic buffer solution.

Q.15 (B) **As we know that** $K_a.K_b = 10^{-14}$

$K_a = 10^{-6}$ $K_b \times 10^{-6} = 10^{-14}$

$$K_b = \frac{10^{-14}}{10^{-6}}$$

$$K_b = 10^{-14+6}$$

$$\therefore K_b = 10^{-8}$$

Q.16 (D) The **equilibrium constant** for a reversible reaction indicates the extent of a reaction. It gives no information about the rate of reaction. K_c tells us how far, but not how fast the reaction goes. In fact, **the extent and the rate of a reaction are quite independent.**

Q.17 (C) In fact, **K_{sp}** concept is valid only for saturated solutions in which the total concentration of ions is no more than about 0.01 $moldm^{-3}$. This means that it is quite inappropriate to use the **solubility product** concept for **soluble compounds** such as **NaCl, $CuSO_4$ etc. It is applicable for sparingly soluble salts.**

Q.18 (D) A catalyst provides an alternative route for a reaction to take place with a **lower activation energy,** so that the **speed** of the **reaction increases**.

Q.19 (B) **$pH = -\log(10^{-7}) = 7$, … i**

$pK_w = -\log(10^{-14}) = 14$, … ii

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$K_a = \frac{[H^+][OH^-]}{[H_2O]} \Rightarrow [H_2O]K_a = [H^+][OH^-] = K_w$$

$$\therefore K_a = \frac{K_w}{[H_2O]} \quad \text{… iii}$$

$$-\log K_a = -\log K_w + \log[H_2O],$$

$$pK_a = pK_w + \log\frac{1000}{18}$$

$$\text{where } \log\frac{1000}{18} = \log 55.5 = 1.74 \quad \text{...iv}$$

$$\therefore pKa = 14 + 1.74 = 15.74 \quad \text{...v}$$

Option	Smallest	Larger	Largest
B	pH	pK_w	pK_a
	7	14	15.74

Conclusion in case (B) the values of pH, pK_w and pK_a increase respectively.

Q.20 (C) **In is not optimum condition in order to get maximum yield of ammonia. In the given reaction as shown below:**

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$\Delta H = -92$ kJ

$\Delta H = -46$ kJ mol^{-1}

Since the forward reaction is exothermic, the temperature should be kept low (400°C), so that reaction should remain in the forward direction.

- **Other optimum condition:**

i. **High pressure (200 – 300 atm):** With increase in pressure reaction moves in the forward direction

ii. **Continuous withdrawal** of **ammonia**

As a result, continuous withdrawal of ammonia the reaction moves in the forward direction because concentration of product decreases continuously. That is why reaction continuously moves in the forward direction.

iii. Use of **catalyst Fe** along with promoters **(MgO, Al_2O_3, SiO_2)** speeds up the reaction.

Q.21 (A) Henderson's equation for acidic buffer solution is $pH=pK_a+\log\frac{[Salt]}{[Acid]}$

Other options B, C and D are incorrect.

Q.22 (D) pH = Ka is incorrect option. All the other options A, B and C are correct because they fulfill the conditions of Henderson's equation for acidic buffer solution.

Q.23 (C) For common ion effect only the term electrolyte is used because for common ion effect that substance is taken which must be ionized in the solution. There are many acids and bases which do not dissociate into ions. So they cannot be treated as electrolytes.

Q.24 (B)

$$C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

$$2\,moles \quad 2\,moles \rightleftharpoons 0\,mole \quad 0\,mole$$

$$2-x \quad 2-x \quad x\,mole \quad x\,mole$$

Eq. molar conc. $\frac{2-x}{v} \quad \frac{2-x}{v} \quad \frac{x}{v} \quad \frac{x}{v}$

$$K_c = \frac{[CH_3COOC_2H_3][H_2O]}{[CH_3COOH][C_2H_5OH]}$$

$$K_c = \frac{\frac{x}{v}\cdot\frac{x}{v}}{\frac{(2-x)}{V}\cdot\frac{(2-x)}{V}} = \frac{x^2}{(2-x)^2}$$

$$4 = \frac{x^2}{(2-x)^2}$$

$$= \frac{x^2}{(2-x)^2} = 4 \ldots (i)$$

By taking under root on both side in equation (i) we get

$$\frac{x}{2-x} = 2$$

$$x = 4 - 2x$$

$$x = 2(2-x)$$

$$x + 2x = 4$$

$$3x = 4$$

$$x = \frac{4}{3} = 1.33\,moles$$

Q.25 (B) Given data pKa = 4.7,

$[CH_3COOH]$ = 0.01moldm^{-3}

$[CH_3COONa]$ = 0.1 moldm^{-3}

$$pH = pKa + \log\frac{[Salt]}{[Acid]}$$

$$pH = pKa + \log\frac{[CH_3COONa]}{[CH_3COOH]}$$

$$pH = pKa + \log\frac{[0.1]}{[0.01]}$$

$$pH = 4.7 + \log \frac{[0.1]}{[0.01]}$$

$$pH = 4.7 + 1 = 5.7$$

Q.26 (C) **It is incorrect statement. In fact, when temperature is increased at equilibrium then reaction always moves towards endothermic side.**

Q.27 (D) **Statements I, II and III are correct as given in the question.**

Q.28 (C) $pH + pOH = 14$

$$pOH = 14 - pH$$
$$= 14 - 10$$
$$= 4$$

Q.29 (A) **Greater is the K_a value, stronger is the acid.**

Q.30 (C) Na_2SO_4 is a **neutral salt** and it **cannot be** hydrolyzed. Such salt which are formed by strong acids and strong bases are not hydrolyzed because their conjugates are weak in nature.

Q.31 (D) $FeCl_3$ is **acidic salt** because it is **formed by neutralization** of **strong acid HCl** and weak base $Fe(OH)_3$.

Q.32 (D) PCl_3 is **Lewis base** because it acts as electron pair donor.

Q.33 (A) **The strength of anions as base can alternatively be expressed in terms of electronegativity of anion. More is the electronegativity of atom carrying negative charge, more will be its basic nature i.e. order of decreasing basic strength of halide ions is as follow:**

- $F^- > Cl^- > Br^- > I^-$
- $NH_2^- > OH^- > SH^-$

Q.34 (A)

$$CaF_2 \rightleftharpoons Ca^{+2} + 2F^-$$
$$2 \times 10^{-4} \quad 4 \times 10^{-4}$$
$$K_{sp} = \left[Ca^{+2}\right]\left[2F^-\right]^2$$
$$= 2 \times 10^{-4} \times 4 \times 10^{-4} \times 4 \times 10^{-4}$$
$$= 3.2 \times 10^{-11}$$

Q.35 (C) **It does not tell about rate of reaction but it tell us about extent of reaction.**

Q.36 (A) **The dissociation of a weak acid H_2S in water can be suppressed by the addition of stronger acid HCl. H^+ is a common ion. H_2S becomes less dissociated in acidic solution. In this way low concentration of S^- ion is developed.**

$$H_2S \rightleftharpoons 2H^+_{(aq)} + S^{2-}_{(aq)}$$

This low concentration of S^{2-} ions helps to do the precipitation of radicals of second group basic radicals during salt analysis.

$$HCl_{(aq)} \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)}$$

Q.37 (C) **Kp is more than Kc when the difference of the moles of the products and reactants is positive. In other words, Kp is more than Kc when number the mole of products is greater than number of mole of reactants e.g. in the decomposition of PCl_5 we get PCl_3 and Cl_2 as shown in the reaction**

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

Number of moles 1mole 1mole 1 mole

As from the reaction it is clear that number of moles of products is 2, while number of moles of reactant is 1. That is why Kp is more than Kc.

Q.38 (C) **When the value of Kc is $I0^{30}$ then the reaction goes to completion in the forward direction.**

Q.39 (B) **It is incorrect relationship. The correct relationship is as follow:**

$$Kp = Kn\,(P/N)^{\Delta n}$$

Q.40 (A) **As water is amphoteric, hence it acts both as a proton donor and proton acceptor. The ionization reaction of water can also be written as:**

$$H_2O_{(\ell)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

Here pure water ionizes into H^+ and OH^-. According to law of mass action, the equilibrium constant for the reaction is:

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

Since water is in excess, and very few of its molecules undergo ionization, so its concentration remains constant. Therefore:

$$K_w = [H^+][OH^-]$$

The equilibrium constant K_w is called ionic product of water and its value at 25°C is always $1.0 \times 10^{-14} mol^2dm^{-6}$ obtained by multiplying together the molar concentrations of H+ ions and OH^- ions present in pure water at room temperature.

Ionic product of water (K_w) = $[H^+][OH^-]$

= $(10^{-7}$ mol $dm^{-3})$ $(10^{-7}$ mol $dm^{-3})$

= 1.0×10^{-14} mol^2dm^{-6}

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