Equilibrium

Class 11 Chemistry · 24 NEET MCQs with answers & explanations

Equilibrium covers chemical and ionic equilibrium — Le Chatelier's principle, equilibrium constants (Kp, Kc), pH, buffer solutions, solubility product and the common ion effect. NEET asks both conceptual and numerical questions, especially on pH calculations, buffer action, and predicting the direction of equilibrium shifts.

Key Equilibrium Concepts

Concept	Key Fact
Kc and Kp	Kp = Kc(RT)^Δn; large K → products favoured; K is temperature-dependent only
Le Chatelier	System shifts to oppose the change — pressure, concentration or temperature
pH	pH = −log[H^+]; pOH = −log[OH^-]; pH + pOH = 14 at 25°C
Buffer solutions	Resist pH change; acidic buffer = weak acid + conjugate base (e.g. CH_3COOH + CH_3COONa)
Ksp	Solubility product; precipitation occurs when ionic product > Ksp
Common ion effect	Adding a common ion decreases solubility of a sparingly soluble salt

Questions

Q1. For the equilibrium 2A(g) ⇌ B(g) + C(g), Kc = 4 × 10^{-3}. At a particular instant [A] = [B] = [C] = 2 × 10^{-3} M. What is the tendency of the reaction?

(A) Forward reaction
(B) Reaction has gone to completion
(C) Equilibrium
(D) Backward reaction

Q2. A buffer contains 0.10 M CH_3COOH and 0.20 M CH_3COONa. Given Ka = 1.0 × 10^{-5}, the approximate pH is:

(A) 4.7
(B) 5
(C) 5.3
(D) 6.3

Q3. For $CO_2(g)+C(s)\rightleftharpoons 2CO(g)$, Kp=3.0 at 1000 K. Given R=0.083 L bar $K^{-1}mol^{-1}$, Kc is:

(A) 3.6×10^{-2}
(B) 3.6×10^{-3}
(C) 3.6
(D) 0.36

Q4. Which condition is essential for establishment of equilibrium between liquid and vapour phase?

(A) Closed system
(B) Open system
(C) High temperature only
(D) High pressure only

Q5. At equilibrium, concentration of reactants and products:

(A) Become zero simultaneously
(B) Remain constant but need not be equal
(C) Increase continuously as reaction proceeds
(D) Decrease continuously until equilibrium breaks

Q6. Which type of equilibrium involves all reacting species in the same phase?

(A) Homogeneous equilibrium
(B) Heterogeneous equilibrium
(C) Ionic equilibrium
(D) Dynamic equilibrium

Q7. The solubility product Ksp is correctly defined as:

(A) Product of ion concentrations raised to stoichiometric powers at saturation
(B) Sum of all ionic concentrations at saturation
(C) Ratio of cation to anion concentration
(D) Product of ion concentrations before saturation

Q8. According to the law of mass action, the rate of a chemical reaction is proportional to:

(A) Product of molar concentrations of reactants each raised to their stoichiometric coefficients
(B) Sum of molar concentrations of all species
(C) Difference between product and reactant concentrations
(D) Product of concentrations of products only

Q9. For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, decreasing the volume of the container at constant temperature will:

(A) Shift equilibrium toward PCl_5 (reactant side)
(B) Shift equilibrium toward PCl_3 and Cl_2 (product side)
(C) Have no effect as K is unchanged
(D) Increase K since pressure increases

Q10. Which of the following represents ionic equilibrium?

(A) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ in water
(B) $N_2 + 3H_2 \rightleftharpoons 2NH_3$ at high pressure
(C) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$
(D) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

Q11. At equilibrium for A(g) + B(g) ⇌ C(g) + D(g), [A]=2M, [B]=2M, [C]=4M, [D]=4M. What is Kc?

(A) 1
(B) 2
(C) 8
(D) 4

Q12. For a reaction at equilibrium, if Kc >> 1 (e.g., Kc = 10^{10}), which statement is correct?

(A) Products are predominantly present at equilibrium
(B) Reactants are predominantly present
(C) Equal amounts of reactants and products exist
(D) The reaction has not yet started

Q13. According to Le Chatelier's principle, when a system at equilibrium is subjected to a stress, it will:

(A) Shift to partially counteract the stress
(B) Shift to amplify the disturbance
(C) Reach a new equilibrium with same K
(D) Stop reacting until stress is removed

Q14. The acid dissociation constant Ka for a weak acid HA is correctly expressed as:

(A) $[H^+][A^-] / [HA]$
(B) $[HA] / [H^+][A^-]$
(C) $[A^-] / [HA][H^+]$
(D) $[H^+] / [A^-][HA]$

Q15. pH of a solution is defined as:

(A) $-\log[H^+]$
(B) $+\log[H^+]$
(C) $-\log[OH^-]$
(D) $+\log[OH^-]$

Q16. A buffer solution resists change in:

(A) pH on adding small acid/base
(B) Colour on adding indicators
(C) Conductivity on dilution
(D) Density on adding solutes

Q17. Which of the following correctly defines the common ion effect?

(A) Suppression of ionization by an ion already present in solution
(B) Enhancement of dissociation by added electrolyte
(C) Increase in Ksp when a salt is dissolved
(D) Shift of equilibrium forward by added reagent

Q18. Which of the following is essential for a system to reach chemical equilibrium?

(A) The system must be closed
(B) The system must be at high pressure
(C) The temperature must be constant
(D) A catalyst must be present

Q19. For a gaseous equilibrium reaction, which expression correctly relates Kp and Kc?

(A) Kp = Kc(RT)^Δn
(B) Kp = Kc × RT
(C) Kp = Kc + RT^Δn
(D) Kp = Kc/(RT)^Δn

Q20. For which of the following reactions is Kp equal to Kc?

(A) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
(B) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
(C) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
(D) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Q21. According to the Arrhenius concept, a base is a substance that:

(A) Produces H^+ ions in aqueous solution
(B) Produces OH^- ions in aqueous solution
(C) Accepts a proton
(D) Donates an electron pair

Q22. Salt hydrolysis is best defined as:

(A) Reaction of salt ions with water producing acid or base
(B) Reaction of salt with another salt
(C) Complete ionisation of salt in solution
(D) Reaction of salt with an added acid

Q23. In a closed container, water establishes equilibrium with its vapour. Which statement is correct?

(A) Rates of evaporation and condensation become zero
(B) Rates of evaporation and condensation become equal
(C) Only evaporation occurs at equilibrium
(D) Only condensation occurs at equilibrium

Q24. Which of the following represents phase equilibrium?

(A) N2(g) + 3H2(g) ⇌ 2NH3(g)
(B) H2(g) + I2(g) ⇌ 2HI(g)
(C) H2O(l) ⇌ H2O(g)
(D) CaCO3(s) ⇌ CaO(s) + CO2(g)

Answer key

1-D	**2-C**	**3-A**	**4-A**	**5-B**	**6-A**	**7-A**	**8-A**
9-A	**10-A**	**11-D**	**12-A**	**13-A**	**14-A**	**15-A**	**16-A**
17-A	**18-A**	**19-A**	**20-B**	**21-B**	**22-A**	**23-B**	**24-C**

Answers with explanations

Q1 — Answer: (D) Backward reaction
Qc = [B][C]/[A]² = $(2 \times 10^{-3})^2/(2 \times 10^{-3})^2 = 1$. Since Qc (1) > Kc (0.004), the system must move backward to reduce Qc. Option A traps students who confuse Qc < Kc with forward direction.

Q2 — Answer: (C) 5.3
pKa = $-\log(1.0\times10^{-5}) = 5.00$. Using the Henderson-Hasselbalch equation: pH = pKa + log([salt]/[acid]) = 5.00 + log(0.20/0.10) = 5.00 + log 2 = 5.00 + 0.30 = 5.30. Option A (4.70) would result if the ratio were inverted. Option B is pKa itself, valid only for equal concentrations. Option D is too high and has no basis in the given data.

Q3 — Answer: (A) 3.6×10^{-2}
$\Delta n = 2-1 = 1$ (solid C excluded). $Kc = Kp/(RT) = 3.0/(0.083\times1000) = 3.0/83 \approx 3.6\times10^{-2}$. Options 3.6 and 0.36 arise from incorrect R values or omitting the power of 10.

Q4 — Answer: (A) Closed system
A closed system prevents matter from escaping, allowing vapour to accumulate until rates of evaporation and condensation equalise. An open system allows vapour to escape continuously, so equilibrium is never reached. Temperature and pressure alone cannot establish equilibrium without containment.

Q5 — Answer: (B) Remain constant but need not be equal
Concentrations remain constant at equilibrium because equal rates of forward and reverse reactions balance each other — they need not be equal to each other. Option A is the common misconception that reactants are fully consumed.

Q6 — Answer: (A) Homogeneous equilibrium
Homogeneous equilibrium is defined by all reactants and products existing in a single phase. Heterogeneous equilibrium (Option B) involves species in two or more different phases. Ionic equilibrium (Option C) is a subcategory, not a phase-based classification.

Q7 — Answer: (A) Product of ion concentrations raised to stoichiometric powers at saturation
$K_{sp} = [A^{m+}]^m[B^{n-}]^n$ at saturation — each ionic concentration raised to its stoichiometric coefficient. Option D is the ionic product Q (before saturation), not Ksp. Option B (sum) has no thermodynamic basis; Ksp is always a product expression.

Q8 — Answer: (A) Product of molar concentrations of reactants each raised to their stoichiometric coefficients
For aA + bB → products, rate ∝ [A]^a[B]^b — each reactant's concentration is raised to its stoichiometric coefficient. Option D is wrong because rate depends on reactants, not products; Option B (sum) has no physical basis in mass action.

Q9 — Answer: (A) Shift equilibrium toward PCl_5 (reactant side)
Δn = 2 − 1 = +1; moles increase going forward. Decreasing volume increases pressure, which by Le Chatelier shifts equilibrium toward fewer moles of gas — i.e., the reactant side (PCl_5). Option B is the trap: students confuse "pressure increases" with "forward shift" without checking Δn sign.

Q10 — Answer: (A) $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ in water
Ionic equilibrium involves reversible dissociation into ions in solution. Option D is a heterogeneous chemical equilibrium, not ionic. Options B and C are gaseous chemical equilibria with no ion formation.

Q11 — Answer: (D) 4
Kc = [C][D]/[A][B] = (4×4)/(2×2) = 16/4 = 4. Option A (=1) is the trap when students divide equal-looking numbers incorrectly. Option B arises from adding instead of multiplying concentrations.

Q12 — Answer: (A) Products are predominantly present at equilibrium
Kc >> 1 means the numerator (products) dominates the equilibrium expression — products are heavily favoured. $K_c = 10^{10}$ indicates an almost complete forward reaction. Option B applies when Kc << 1; Option C applies when Kc ≈ 1.

Q13 — Answer: (A) Shift to partially counteract the stress
The system shifts in the direction that opposes the imposed change, minimising its effect — this is Le Chatelier's principle. It does not eliminate the stress entirely, only partially counteracts it. K remains unchanged.

Q14 — Answer: (A) $[H^+][A^-] / [HA]$
$K_a = [H^+][A^-]/[HA]$ — products in numerator, reactant in denominator, as per equilibrium law. Option B is the inverse expression (equilibrium constant for reverse reaction). Pure solids and liquids (including water) are excluded from Ka expressions.

Q15 — Answer: (A) $-\log[H^+]$
pH = $-\log[H^+]$; the negative sign converts small H^+ concentrations into positive, manageable numbers. Option C ($-\log[OH^-]$) defines pOH — the most common one-letter confusion in NEET. Options B and D omit the negative sign entirely.

Q16 — Answer: (A) pH on adding small acid/base
Buffers resist significant pH change on addition of small amounts of acid or base. Option C (conductivity) changes on dilution regardless of buffer presence. Option B and D have no connection to buffer function — included to mirror NEET's property-confusion traps.

Q17 — Answer: (A) Suppression of ionization by an ion already present in solution
The common ion effect is the suppression of ionization of a weak electrolyte when an ion common to it is added externally. Option B is opposite — ionization decreases, not increases. Ksp (Option C) remains constant and is unaffected.

Q18 — Answer: (A) The system must be closed
Equilibrium can only be established in a closed system where neither reactants nor products escape. Temperature constancy is not a requirement — equilibrium can exist at any temperature. A catalyst and high pressure affect rate or position but are not prerequisites for equilibrium itself.

Q19 — Answer: (A) Kp = Kc(RT)^Δn
Kp = Kc(RT)^Δn where R is the gas constant, T is temperature in Kelvin, and Δn is the change in moles of gaseous species. Option D inverts the exponent incorrectly. Option B omits Δn entirely.

Q20 — Answer: (B) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
Kp = Kc(RT)^Δn; Kp = Kc only when Δn = 0. For $H_2 + I_2 \rightleftharpoons 2HI$, Δn = 2−2 = 0. All other options have Δn ≠ 0. Option A (Δn = −2), C (Δn = +1), D (Δn = −1).

Q21 — Answer: (B) Produces OH^- ions in aqueous solution
Arrhenius bases increase $[OH^-]$ in aqueous solution. Option A defines an Arrhenius acid — the primary distractor. Options C and D belong to Brønsted–Lowry and Lewis theories respectively.

Q22 — Answer: (A) Reaction of salt ions with water producing acid or base
Hydrolysis = interaction of cation or anion of a salt with water to regenerate the acid or base it came from. Option C (ionisation) is a trap — dissolution and hydrolysis are different processes; NaCl dissolves but does not hydrolyse. Option D confuses hydrolysis with neutralisation.

Q23 — Answer: (B) Rates of evaporation and condensation become equal
At dynamic equilibrium both evaporation and condensation continue simultaneously at equal rates — the system is not static. Option A is the most common wrong choice: rates do not become zero; they become equal.

Q24 — Answer: (C) H2O(l) ⇌ H2O(g)
Phase equilibrium involves the same substance existing in two different phases — H2O(l) ⇌ H2O(g) is liquid-vapour equilibrium. Option D is a common trap: though it involves solids and gas, CaCO3 decomposition is a chemical equilibrium involving different substances, not a phase change.

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