Hi everyone,

The real learning in chemistry happens when you actively engage with a problem, balance the equation yourself, and work through every step. Therefore, we strongly encourage you to use this solution key responsibly.

Please attempt all the problems on your own first, giving them your best and most honest effort. These solutions are to help you get unstuck on a problem after you have already tried your best.

Your effort and dedication are the true keys to success.

Chemical Equilibrium — DPP-2

Topic: Equilibrium Constant Expression

NEET Section

1. Assertion (A): The active mass of pure solids and pure liquids is taken as unity.
Reason (R): The active mass of pure solids and pure liquids depends on density and molecular mass. The density and molecular mass of pure solids and pure liquids are constant.

(A) A and R are true; R is the correct explanation of A
(B) A and R are true; R is not the correct explanation of A
(C) A is true, R is false
(D) A is false, R is true

Correct Answer: (A)

Hint

Recall the formula for the active mass of a pure phase. What two intrinsic properties does it depend on, and are these properties variable for a pure substance?

Solution:
The active mass (molar concentration) of a pure solid or pure liquid is defined as:

$$[\mathrm{X}] = \frac{\rho}{M} \times 1000 \quad (\mathrm{mol/L})$$

where ρ is the density and M is the molar mass. For any pure substance at a given temperature, both ρ and M are intrinsic, fixed properties, so the active mass is a constant. By convention, this constant is absorbed into the equilibrium constant K, and the active mass is taken as 1 in the equilibrium expression.

- Assertion (A): **True** — pure solids and liquids are taken as unity.
- Reason (R): **True** — their active mass depends on ρ and M, both constant.
- R correctly explains A: a constant value is conventionally set to 1.

Common Student Mistake

Students often pick option (B), thinking R does not explain A. In fact, the constancy of ρ and M *is* the reason the active mass is set to unity — without that constancy, the substitution would be invalid.

2. 8.5 g of ammonia is present in a vessel of 0.5 L. Find the active mass (molar concentration) of NH_3. **Correct Answer:** 1 **M**

Hint

Active mass for a gas or a solution is simply molar concentration. Convert grams to moles first using the molar mass of NH_3 (= 17 g/mol), then divide by the volume in litres.

Solution:
Step 1 — Moles of NH_3:

$$n_{NH_3} = \frac{\text{mass}}{\text{molar mass}} = \frac{8.5}{17} = 0.5 \text{ mol}$$

Step 2 — Molar concentration:

$$[NH_3] = \frac{n}{V} = \frac{0.5}{0.5} = 1 \text{ M}$$

3. Active mass of 2 mol NaCl kept in a 4 L vessel at NTP is:

(a) 1 (b) 2 (c) $\frac{1}{2}$ (d) Not defined

Correct Answer: (a)

Hint

Before reaching for n/V, check the *phase* of NaCl at NTP. The active-mass rule for pure phases overrides the moles-per-litre formula.

Solution:
At NTP, NaCl is a **pure solid**. The active mass (molar concentration) of any pure solid or pure liquid is, by convention, taken as unity — irrespective of mass or volume.

$$[NaCl_{(s)}] = 1$$

Common Student Mistake

A very common mistake is to compute $n/V = 2/4 = 0.5$ and pick option (c). The n/V formula applies only to gases and solutions — never to a pure solid or pure liquid.

4. Active mass of 5 g CaO is:

(a) 56 (b) 1 (c) 3.5 (d) 2

Correct Answer: (b)

Hint

CaO is a pure solid. What is the active mass of *any* pure solid, regardless of the mass given?

Solution:
CaO is a pure solid. The active mass of any pure solid is unity:

$$[CaO_{(s)}] = 1$$

The given mass (5 g) is irrelevant.

5. Ratio of active masses of 22 g CO_2, 3 g H_2 and 7 g N_2 in a gaseous mixture is:

(a) 22 : 3 : 7 (b) 2 : 3 : 1 (c) 1 : 2 : 1 (d) 1 : 3 : 0.5

Correct Answer: (d)

Hint

Active mass is moles per litre. Since all three gases share the same vessel (same volume), the ratio of active masses reduces to the ratio of moles — so convert each mass to moles first.

Solution:
All three gases occupy the same vessel volume V, so the volume cancels and:

$$[\mathrm{CO_2}] : [\mathrm{H_2}] : [\mathrm{N_2}] = n_{\mathrm{CO_2}} : n_{\mathrm{H_2}} : n_{\mathrm{N_2}}$$

Computing moles:

$$n_{\mathrm{CO_2}} = \frac{22}{44} = 0.5, \quad n_{\mathrm{H_2}} = \frac{3}{2} = 1.5, \quad n_{\mathrm{N_2}} = \frac{7}{28} = 0.25$$

Therefore:

$$0.5 : 1.5 : 0.25 \xrightarrow{\div 0.5} 1 : 3 : 0.5$$

Common Student Mistake

Picking $22 : 3 : 7$ (option a) treats mass as if it were active mass. Mass and moles are not the same — always convert to moles, then take the ratio.

6. Equilibrium constant is:

(a) k_b/k_f (b) k_f/k_b (c) $k_f k_b$ (d) $1/(k_f k_b)$

Correct Answer: (b)

Hint

At equilibrium, the forward and backward rates are equal. Set $r_f = r_b$, write each in terms of its rate constant and concentrations, and isolate the products-to-reactants concentration ratio.

Solution:
At equilibrium:

$$\begin{aligned} r_f &= r_b \\ k_f[\text{Reactants}] &= k_b[\text{Products}] \\ \Rightarrow \frac{[\text{Products}]}{[\text{Reactants}]} &= \frac{k_f}{k_b} = K \end{aligned}$$

7. In a chemical equilibrium, $k_b = 7.5 \times 10^{-4}\ \mathrm{s^{-1}}$ and $K = 1.5$. The forward rate constant k_f is:

(a) 2×10^{-3} (b) 2.5×10^{-4} (c) 1.12×10^{-3} (d) 9.0×10^{-4}

Correct Answer: (c)

Hint

Rearrange the relation $K = k_f/k_b$ to solve for k_f. It's a one-step multiplication.

Solution:
From $K = k_f/k_b$:

$$\begin{aligned} k_f &= K \times k_b = 1.5 \times 7.5 \times 10^{-4} \\ &= 11.25 \times 10^{-4} \\ &= 1.125 \times 10^{-3}\ \mathrm{s^{-1}} \approx 1.12 \times 10^{-3}\ \mathrm{s^{-1}} \end{aligned}$$

8. For $A \rightleftharpoons B$, the equilibrium concentration $[B]_e$ equals:

(a) $K_c[A]_e^{-1}$ (b) $k_f/k_b\,[A]_e$ (c) $k_f k_b^{-1}\,[A]_e$ (d) $k_f k_b\,[A]^{-1}$

Correct Answer: (b)

Hint

Write the equilibrium expression for $A \rightleftharpoons B$ directly: $K_c = [B]_e/[A]_e$. Rearrange to isolate $[B]_e$, then substitute $K_c = k_f/k_b$.

Solution:
For $A \rightleftharpoons B$:

$$K_c = \frac{[B]_e}{[A]_e} \quad \Rightarrow \quad [B]_e = K_c\,[A]_e = \frac{k_f}{k_b}\,[A]_e$$

Options (b) and (c) are algebraically identical (since $k_f/k_b = k_f \cdot k_b^{-1}$); option (b) is listed as the standard form.

Common Student Mistake

Option (a), $K_c[A]_e^{-1} = K_c/[A]_e$, *divides* by $[A]_e$ instead of multiplying. The definition gives $[B]_e = K_c \cdot [A]_e$, not $K_c \div [A]_e$. Sign of the exponent matters.

9. For $2A + 3B \rightleftharpoons 2C$, the correct expression for K_c is:

(a) $\dfrac{[A]^2[B]^3}{[C]^2}$ (b) $\dfrac{[C]}{[A][B]}$ (c) $\dfrac{[C]^2}{[A]^2[B]^3}$ (d) $\dfrac{[C]^2}{[A]^3[B]^2}$

Correct Answer: (c)

Hint

Two rules: (i) products go in the numerator, reactants in the denominator; (ii) each coefficient in the balanced equation becomes the power of that species. Match the coefficients $2, 3, 2$ with A, B, C.

Solution:
For the general reaction $aA + bB \rightleftharpoons cC$:

$$K_c = \frac{[\text{products}]^{\text{coefficients}}}{[\text{reactants}]^{\text{coefficients}}} = \frac{[C]^c}{[A]^a[B]^b}$$

With $a = 2, b = 3, c = 2$:

$$K_c = \frac{[C]^2}{[A]^2[B]^3}$$

Common Student Mistake

Option (a) has reactants in the numerator — this is the expression for the *reverse* reaction. Always write K_c in the direction of the equation as given.

10. For $Ag^+ + 2NH_3 \rightleftharpoons Ag(NH_3)_2^+$ at 298 K, with $[Ag^+] = 10^{-1}$ M, $[NH_3] = 10^{-3}$ M, $[Ag(NH_3)_2^+] = 10^{-1}$ M at equilibrium, the value of K_c is:

(a) 10^6 (b) $10^{6.5}$ (c) 2×10^3 (d) 2×10^6

Correct Answer: (a)

Hint

The coefficient of NH_3 in the balanced equation is 2, so $[NH_3]$ enters the expression as $[NH_3]^2$. Carefully apply this power before computing.

Solution:
The equilibrium expression is:

$$K_c = \frac{[\mathrm{Ag(NH_3)_2^+}]}{[\mathrm{Ag^+}]\,[\mathrm{NH_3}]^2}$$

Substituting the values:

$$K_c = \frac{10^{-1}}{(10^{-1})(10^{-3})^2} = \frac{10^{-1}}{10^{-1}\cdot 10^{-6}} = \frac{10^{-1}}{10^{-7}} = 10^6$$

Common Student Mistake

Forgetting the squared power on $[\mathrm{NH_3}]$ leads to $(10^{-3})^1 = 10^{-3}$ and a wildly wrong answer. The coefficient *must* become the exponent.

11. For $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ at 527°C with $[A_2] = 3.0 \times 10^{-3}$ M, $[B_2] = 4.2 \times 10^{-3}$ M, $[AB] = 2.8 \times 10^{-3}$ M at equilibrium, the value of K_c is:

(a) 0.62 (b) 4.5 (c) 2.0 (d) 1.9

Correct Answer: (a)

Hint

Powers of 10 in the numerator and denominator will cancel. Separate the 10^{-x} factors from the numerical coefficients and simplify the two parts independently.

Solution:

$$K_c = \frac{[AB]^2}{[A_2][B_2]} = \frac{(2.8\times10^{-3})^2}{(3.0\times10^{-3})(4.2\times10^{-3})}$$
$$= \frac{7.84\times10^{-6}}{12.6\times10^{-6}} = \frac{7.84}{12.6} \approx 0.62$$

12. For $2A + B \rightleftharpoons BA_2$ with $[A] = 4$, $[B] = 2$, $[BA_2] = 2$ (mol $\mathrm{L^{-1}}$) at equilibrium, the value of K_c is:

(a) 0.0625 (b) 0.625 (c) 6.280 (d) 6.250

Correct Answer: (a)

Hint

Apply the power to $[A]$ *before* multiplying by anything else: $[A]^2 = 4^2 = 16$, not $4 \times 2 = 8$.

Solution:

$$K_c = \frac{[BA_2]}{[A]^2\,[B]} = \frac{2}{(4)^2\times 2} = \frac{2}{16\times 2} = \frac{2}{32} = 0.0625$$

Common Student Mistake

Computing $[A]^2$ as $4 \times 2 = 8$ instead of $4^2 = 16$ leads to $K_c = 2/16 = 0.125$ — not an option. Always evaluate the exponent first.

13. $2A + B \rightleftharpoons 3C + D$ starts with $[A]_0 = [B]_0 = 1.00$ M. At equilibrium, $[D] = 0.25$ M. The equilibrium constant K_c equals:

(a) $\dfrac{(0.75)^3(0.25)}{(0.50)^2(0.75)}$ (b) $\dfrac{(0.75)^3(0.25)}{(1.00)^2(0.75)}$ (c) $\dfrac{(0.50)^2(0.25)}{(0.75)^3(0.75)}$ (d) $\dfrac{(1.00)^2(0.25)}{(0.75)^3(0.75)}$

Correct Answer: (a)

Hint

Set up an ICE table. The change in each species equals its stoichiometric coefficient times the extent of reaction x. Since $[D] = 0.25$ and D has coefficient 1, $x = 0.25$.

Solution:
Let x be the extent of reaction so that $[D]$ formed equals x. Given $[D] = 0.25$, we have $x = 0.25$.
ICE Table:

	A	B	C	D
Initial	1.00	1.00	0	0
Change	$-2x$	$-x$	$+3x$	$+x$
Equilm.	$1-2x$	$1-x$	$3x$	x

Substituting $x = 0.25$:

$$[A] = 1.00 - 0.50 = 0.50, \quad [B] = 1.00 - 0.25 = 0.75$$
$$[C] = 3 \times 0.25 = 0.75, \quad [D] = 0.25$$

Therefore:

$$K_c = \frac{[C]^3[D]}{[A]^2[B]} = \frac{(0.75)^3(0.25)}{(0.50)^2(0.75)}$$

Common Student Mistake

Option (b) substitutes $(1.00)^2$ for $[A]^2$ — this is the initial concentration of A, not its equilibrium value. K_c must always be evaluated at equilibrium concentrations.

JEE Section

1. What is the active mass of 5.6 L of O_2 at STP? **Correct Answer:** $\dfrac{1}{22.4} \approx 0.0446$ **M**

Hint

At STP, 22.4 L of any ideal gas contains 1 mol. Find the moles of O_2 in 5.6 L, then divide by the volume to get the concentration.

Solution:
At STP, 22.4 L of any ideal gas $\equiv$ 1 mol.

$$n_{O_2} = \frac{5.6}{22.4} = 0.25 \text{ mol}$$
$$[O_2] = \frac{n}{V} = \frac{0.25}{5.6} = \frac{1}{22.4} \approx 0.0446 \text{ M}$$

Note: any ideal gas at STP has concentration $1/22.4 \approx 0.0446$ M, regardless of the volume considered, because the volume cancels in n/V.

2. Molar concentration of 96 g of O_2 in a 2 L vessel is:

(a) 16 mol L^{-1} (b) 1.5 mol L^{-1} (c) 4 mol L^{-1} (d) 24 mol L^{-1}

Correct Answer: (b)

Hint

Two-step: convert 96 g of O_2 to moles ($M_{O_2} = 32$ g/mol), then divide by the 2 L vessel volume.

Solution:

$$n_{O_2} = \frac{96}{32} = 3 \text{ mol}$$
$$[O_2] = \frac{n}{V} = \frac{3}{2} = 1.5 \text{ mol/L}$$

3. In $A + B \rightleftharpoons C + D$, $k_f = 2 \times 10^{-4}$ s^{-1} and $k_b = 5 \times 10^{-5}$ s^{-1}. Find the equilibrium constant K. **Correct Answer:** $K = 4$

Hint

$K = k_f/k_b$. When dividing powers of 10, subtract the exponents: $10^{-4}/10^{-5} = 10^{-4-(-5)} = 10^1$.

Solution:

$$K = \frac{k_f}{k_b} = \frac{2 \times 10^{-4}}{5 \times 10^{-5}} = \frac{2}{5} \times 10^{-4-(-5)} = 0.4 \times 10^1 = 4$$

4. In a reversible reaction $A \rightleftharpoons B$, initial concentrations are a and b mol L^{-1}. Rate constants are k_1 (forward) and k_2 (backward). At equilibrium, concentrations are $(a - x)$ and $(b + x)$. Express x in terms of k_1, k_2, a, b.

(a) $\frac{k_1 a - k_2 b}{k_1 + k_2}$ (b) $\frac{k_1 a - k_2 b}{k_1 - k_2}$ (c) $\frac{k_1 a - k_2 b}{k_1 k_2}$ (d) $\frac{k_1 a + k_2 b}{k_1 + k_2}$

Correct Answer: (a)

Hint

At equilibrium, forward rate = backward rate, so $k_1(a - x) = k_2(b + x)$. Expand both sides, collect all x-terms on one side, and factor.

Solution:
At equilibrium, $r_f = r_b$:

$$k_1(a - x) = k_2(b + x)$$
$$k_1 a - k_1 x = k_2 b + k_2 x$$
$$k_1 a - k_2 b = k_1 x + k_2 x$$
$$k_1 a - k_2 b = x(k_1 + k_2)$$
$$\Rightarrow x = \frac{k_1 a - k_2 b}{k_1 + k_2}$$

Common Student Mistake

A frequent error is choosing option (b) with $k_1 - k_2$ in the denominator. When factoring $-k_1 x - k_2 x$, the signs combine to give $-x(k_1 + k_2)$ — the denominator is always a *sum*, never a difference.

5. Gas-phase hydration: $(CF_3)_2CO(g) + H_2O(g) \rightleftharpoons (CF_3)_2C(OH)_2(g)$. At 76°C, $k_f = 0.15$ M^{-1}s^{-1}, $k_r = 6 \times 10^{-4}$ s^{-1}. Calculate K_c. **Correct Answer:** $K_c = 250$ **M**$^{-1}$

Hint

Use $K_c = k_f/k_r$. Convert 6×10^{-4} to its decimal form (0.0006) for easy division, or divide the powers of 10 separately.

Solution:

$$K_c = \frac{k_f}{k_r} = \frac{0.15}{6 \times 10^{-4}} = \frac{0.15}{0.0006} = 250 \text{ M}^{-1}$$

Unit check: k_f has units $\text{M}^{-1}\text{s}^{-1}$ (second-order forward, two reactants) and k_r has units s^{-1} (first-order backward, one product). Their ratio carries M^{-1}, consistent with $\Delta n = -1$ for this reaction.

6. $CH_3Cl(aq) + OH^-(aq) \rightleftharpoons CH_3OH(aq) + Cl^-(aq)$ at 25°C: $k_f = 6 \times 10^{-6}$ $\text{M}^{-1}\text{s}^{-1}$, $K_c = 1 \times 10^{16}$. Find k_r at 25°C. **Correct Answer:** $k_r = 6 \times 10^{-22}$ $\mathbf{M^{-1}s^{-1}}$

Hint

Rearrange $K_c = k_f/k_r$ to get $k_r = k_f/K_c$. Since K_c is enormous, expect k_r to be vanishingly small.

Solution:

$$k_r = \frac{k_f}{K_c} = \frac{6 \times 10^{-6}}{1 \times 10^{16}} = 6 \times 10^{-22} \text{ M}^{-1}\text{s}^{-1}$$

Sanity check: $K_c = 10^{16}$ means the forward reaction is overwhelmingly favoured, so a near-zero backward rate constant is expected — and $\sim 10^{-22}$ certainly qualifies.

7. In a chemical equilibrium, the backward rate constant is 2×10^{-4} s^{-1} and $K = 1.5$. The forward rate constant is:

(a) 2×10^{-3} (b) 5×10^{-4} (c) 3×10^{-4} (d) 9×10^{-4}

Correct Answer: (c)

Hint

$k_f = K \times k_b$. Multiply 1.5 by 2×10^{-4}.

Solution:

$$k_f = K \times k_b = 1.5 \times 2 \times 10^{-4} = 3 \times 10^{-4} \text{ s}^{-1}$$