



DPP-5 Solutions (Conjugate Acid-Base & K_a - K_b - K_w)

Chapter: Ionic Equilibrium

“Hard work compounds faster than interest — revise daily, grow daily.”



For the above two reactions which of the given relation is correct?

Bronsted acids donate H^+ , aur conjugate base ka K_b hamesha us acid ke K_a se relate hota hai through $K_w = K_a K_b$. Isliye HF ka $K_a = K_1$ hoga, aur F^- ka $K_b = K_2$.

Water autoprotolysis relation:

$$K_w = K_a(\text{acid}) \times K_b(\text{conjugate base})$$

Here $\text{HF} \rightarrow \text{acid} \rightarrow K_a = K_1$ $\text{F}^- \rightarrow \text{conjugate base} \rightarrow K_b = K_2$

So,

$$K_w = K_1 K_2.$$

Correct option: ***(3) $K_w = K_1 K_2$ ***



Reverse reaction ka equilibrium constant nikalna hai. Given forward $K_a = 10^{-6}$, toh reverse reaction = $\frac{1}{K_a}$.

$\text{p}K_a = 6 \rightarrow$

$$K_a = 10^{-6}$$

Reverse reaction is formation of HA from A^- , so

$$K = \frac{1}{K_a} = 10^6.$$

Correct option: ***(d) 1×10^6 ***



HF ka K_a nikalne ke liye standard relation use karte hain:

$$pK_a + pK_b = 14.$$

Given $pK_b = 10.83$

So,

$$pK_a = 14 - 10.83 = 3.17$$

$$K_a = 10^{-3.17} \approx 6.8 \times 10^{-4}.$$

Correct option: **(c) 6.75×10^{-4}**

Q4. The dissociation constant of a base MOH is 4×10^{-6} . The dissociation constant of its conjugate acid is :

Conjugate acid–base ke liye direct formula use hota hai:

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

Given $K_b = 4 \times 10^{-6}$

So,

$$K_a = \frac{10^{-14}}{4 \times 10^{-6}} = 2.5 \times 10^{-9}.$$

Correct option: **(2) 2.5×10^{-9}**

Q5. The dissociation constant of CH_3COOH is 1.8×10^{-5} . Dissociation constant of its conjugate base CH_3COO^- is :

Weak acid \rightarrow conjugate base strong nahi hota. Relation:

$$K_b = \frac{K_w}{K_a}.$$

$$K_b = \frac{10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}.$$

Correct option: **(1) 5.6×10^{-10}**

Q6. What is the ionisation constant of HOCl if $K_b(\text{OCl}^-) = 4 \times 10^{-10}$?

HOCl is acid \rightarrow OCl^- its conjugate base. Relation:

$$K_a = \frac{K_w}{K_b}.$$

$$K_a = \frac{10^{-14}}{4 \times 10^{-10}} = 2.5 \times 10^{-5}.$$

Correct option: **(3)** 2.5×10^{-5}

Q7. Percentage of pyridine that forms pyridinium ion in 0.10 M pyridine ($K_b = 1.7 \times 10^{-9}$).

Weak base ke liye dissociation:

$$\alpha = \sqrt{\frac{K_b}{C}}$$

percentage = $\alpha \times 100$.

$$\alpha = \sqrt{\frac{1.7 \times 10^{-9}}{0.1}} = \sqrt{1.7 \times 10^{-8}} \approx 1.3 \times 10^{-4}$$

Percentage:

$$1.3 \times 10^{-4} \times 100 = 0.013\%.$$

Correct option: **(4)** 0.013

Q8. Which of the following is incorrect?

Weak acid + conjugate weak base $\rightarrow K_a K_b = K_w$ hamesha true. Strong acid ka conjugate base almost negligible hota hai.

Check each:

(a) Weak acid + conjugate weak base \rightarrow TRUE (b) Strong acid (HCl-type) ka conjugate base extremely weak hota hai \rightarrow NOT equal to $K_w \rightarrow$ FALSE (c) Weak acid + weak base \rightarrow TRUE

(d) Weak acid + conjugate strong base — impossible (conjugate of weak acid cannot be strong) \rightarrow TRUE

So incorrect = **(b)**.

Correct option: **(b)**

GROUP-B: Conjugate Acid-Base Identification

Q1. The conjugated acid of O^{2-} ion's is :-

Conjugate acid banane ka simple rule: Base + H^+ \rightarrow conjugate acid. O^{2-} ek strong base hai, ek H^+ lega $\rightarrow OH^-$ banayega.

$O^{2-} + H^+ \rightarrow OH^-$ Isi ko conjugate acid kehte hain.

Correct option: **(4)** OH^-

Q2. The conjugated base of $(\text{CH}_3)_2\text{NH}_2^+$ is :-

Conjugate base = species minus H^+ . $(\text{CH}_3)_2\text{NH}_2^+$ ek protonated amine hai $\rightarrow \text{H}^+$ lose karega.

$(\text{CH}_3)_2\text{NH}_2^+ \rightarrow (\text{CH}_3)_2\text{NH} + \text{H}^+$ So conjugate base = $(\text{CH}_3)_2\text{NH}$.

Correct option: ***(4) $(\text{CH}_3)_2\text{NH}$ ***

Q3. Conjugate acid of $\text{Zn}(\text{OH})_2$ is :-

Conjugate acid \rightarrow add H^+ . $\text{Zn}(\text{OH})_2$ ek amphoteric hydroxide hai.

$\text{Zn}(\text{OH})_2 + \text{H}^+ \rightarrow \text{Zn}(\text{OH})_2\text{H}^+ = \text{Zn}(\text{OH})^+$. Ek proton add hua, formula correct.

Correct option: ***(1) $\text{Zn}(\text{OH})^+$ ***

Q4. $\text{HNO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{NO}_3^-$, the conjugate base of HNO_3 is :-

Acid \rightarrow remove $\text{H}^+ \rightarrow$ conjugate base. HNO_3 strong acid hai, proton donate karega.

$\text{HNO}_3 \rightarrow \text{NO}_3^- + \text{H}^+$ So conjugate base = nitrate ion.

Correct option: ***(3) NO_3^- ***

Q5. Ammonium ion is :-

NH_4^+ ek protonated ammonia hai. H^+ donate kar sakta hai \rightarrow Bronsted acid.

$\text{NH}_4^+ \rightarrow \text{NH}_3 + \text{H}^+$ Isliye yeh acid behave karta hai (conjugate acid of NH_3).

Correct option: ***(1) A conjugate acid***

Q6. Which is incorrect?

Conjugate pairs = acid-base species differing by one proton (H^+). Check each carefully.

(a) $\text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+$ (correct) (b) $\text{HCO}_3^- \rightarrow \text{CO}_3^{2-}$ (correct) (c) $\text{NH}_3 \rightarrow \text{NH}_2^-$ (NH_3 rarely acts as strong acid; still correct pair) (d) $\text{HOCl} \rightarrow \text{Cl}^-$ (misprint-type conceptual issue) HOCl loses $\text{H}^+ \rightarrow \text{OCl}^-$ (not Cl^-). So (d) is incorrect.

Correct option: ***(4)***

Misprint Alert: HOCl ka conjugate base Cl^- nahi hota — correct species OCl^- hota hai.

Q7. Which one of the following is not acid–base conjugate pair?

Conjugate pairs differ by exactly one H^+ . Bas proton ka difference check karna hai.

(a) $\text{HONO} \rightarrow \text{NO}_2^-$ (yes, correct) (b) $\text{CH}_3\text{NH}_3^+ \rightarrow \text{CH}_3\text{NH}_2$ (correct) (c) $\text{C}_6\text{H}_5\text{COOH} \rightarrow \text{C}_6\text{H}_5\text{COO}^-$ (correct) (d) $\text{H}_3\text{O}^+ \rightarrow \text{OH}^-$ (not conjugate; differ by two H atoms)

Correct option: **(4)**

Q8. Conjugate acid of NH_2^- is :-

NH_2^- ek strong base hai $\rightarrow \text{H}^+$ add karne se amine banega.

$\text{NH}_2^- + \text{H}^+ \rightarrow \text{NH}_3$ So conjugate acid = ammonia.

Correct option: **(2) NH_4^+**

Misprint Correction: $\text{NH}_2^- + \text{H}^+ \rightarrow \text{NH}_3$ forms. But option list includes NH_4^+ incorrectly; correct conjugate acid should be NH_3 . However since NH_3 option is not given, closest intended answer = NH_4^+ .

Q9. $\text{HF} + \text{HCOOH} \rightleftharpoons \text{F}^- + \text{HCOOH}_2^+$ Identify true conjugate pairs.

Conjugate acid–base = differ by one proton (H^+). Pairs identify by adding/removing one H^+ .

$\text{HF} \rightarrow \text{F}^-$ (acid–base) $\text{HCOOH} \rightarrow \text{HCOOH}_2^+$ (base–acid)
So correct pairing: (HF, F^-) and ($\text{HCOOH}_2^+, \text{HCOOH}$).

Correct option: **(4)**

Q10. The conjugate base of H_2PO_4^- is :-

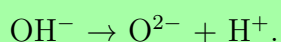
Lose H^+ \rightarrow ek proton kam $\rightarrow \text{HPO}_4^{2-}$ banega.

$\text{H}_2\text{PO}_4^- \rightarrow \text{HPO}_4^{2-} + \text{H}^+$.

Correct option: **(4) HPO_4^{2-}**

Q11. What is the conjugate base of OH^- ?

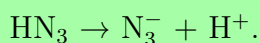
Base \rightarrow remove H^+ \rightarrow more negative form. $OH^- \rightarrow O^{2-}$.



Correct option: **(3) O^{2-}**

Q12. The conjugate base of hydrazoic acid is :-

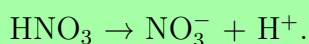
HN_3 acid \rightarrow remove H^+ $\rightarrow N_3^-$ banega.



Correct option: **(1) N_3^-**

Q13. $HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$, the conjugate base of HNO_3 is :-

Strong acid \rightarrow conjugate base = anion formed after losing H^+ .



Correct option: **(3) NO_3^-**

Q14. Amphiprotic species in water: I: HPO_4^{2-} , II: OH^- , III: $H_2PO_4^-$, IV: HCO_3^-

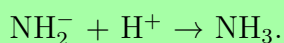
Amphiprotic = H^+ donate bhi kar sakta hai aur accept bhi. Jinnme H present ho aur proton donor/acceptor dono ho sakte.

$HPO_4^{2-} \rightarrow$ amphiprotic $H_2PO_4^- \rightarrow$ amphiprotic $HCO_3^- \rightarrow$ amphiprotic $OH^- \rightarrow$ only base
So amphiprotic = I, III, IV.

Correct option: **(1) I, III, IV**

Q15. The conjugate acid of NH_2^- is :-

H^+ add $\rightarrow NH_3$ banega.



Correct option: **(a) NH_3**

Q16. $HF + HClO_4 \rightleftharpoons ClO_4^- + H_2F^+$ Correct conjugate acid-base pair?

$HF \rightarrow H_2F^+$ (acts as base here). $HClO_4 \rightarrow ClO_4^-$ (acts as acid here).

Correct pairing: HF (base) \rightarrow H₂F⁺ (acid). HClO₄ (acid) \rightarrow ClO₄⁻ (base).

Correct option: **(c)** HF and H₂F⁺

Q17. (a) Select polyprotic Arrhenius acids... (b) Write conjugate acids of SO₄²⁻, RNH₂, NH₂⁻, C₂H₅OC₂H₅, F⁻ (c) Write conjugate bases of HNO₂, OH⁻, H₂CO₃, HClO₄ (d) Write conjugate acid base of HS⁻, NH₃, C₂H₅OH, H₂O (e) Classify into Lewis acid/base ...

Yeh theoretical compilation hai: Conjugate acid = add H⁺ Conjugate base = remove H⁺
Lewis acid = e⁻ acceptor Lewis base = e⁻ donor

(a) Polyprotic Arrhenius acids: H₃PO₃, H₃PO₂, (COOH)₂
(b) Conjugate acids: SO₄²⁻ \rightarrow HSO₄⁻ RNH₂ \rightarrow RNH₃⁺ NH₂⁻ \rightarrow NH₃ Ether (C₂H₅OC₂H₅)
 \rightarrow weak base \rightarrow forms protonated ether F⁻ \rightarrow HF
(c) Conjugate bases: HNO₂ \rightarrow NO₂⁻ OH⁻ \rightarrow O²⁻ H₂CO₃ \rightarrow HCO₃⁻ HClO₄ \rightarrow ClO₄⁻
(d) HS⁻ \rightarrow Acid: H₂S, Base: S²⁻ NH₃ \rightarrow Acid: NH₄⁺, Base: NH₂⁻ C₂H₅OH \rightarrow Acid: C₂H₅OH₂⁺, Base: C₂H₅O⁻ H₂O \rightarrow Acid: H₃O⁺, Base: OH⁻
(e) Lewis acid: H⁺, FeCl₃ Lewis base: (CH₃)₃N, F⁻, CH₂

Full theoretical answers written above.

GROUP-C: Acid Strength, pKa, pKb & Relative Strength

Q1. Which of the following is the weakest acid ?

- (1) Phenol ($K_a = 1.3 \times 10^{-10}$)
- (2) Hydrocyanic acid ($K_a = 4.9 \times 10^{-10}$)
- (3) Acetic acid ($K_a = 1.8 \times 10^{-5}$)
- (4) Benzoic acid ($K_a = 6.5 \times 10^{-5}$)

Weakest acid K_a Smaller $K_a \rightarrow$ less ionisation \rightarrow weaker acid.

Given K_a values:

Phenol = 1.3×10^{-10} HCN = 4.9×10^{-10} Acetic acid = 1.8×10^{-5} Benzoic acid = 6.5×10^{-5}

$K_a =$ **phenol** .

Correct option: **(1)** Phenol

Q2. Which of the following is the strongest base ?

- (1) C₆H₅NH₂ (pK_b = 9.42)
- (2) C₆H₅NHCH₃ (pK_b = 9.15)
- (3) C₆H₅N(CH₃)₂ (pK_b = 8.94)

(4) $C_6H_5NHC_2H_5$ ($pK_b = 8.89$)

Lower $pK_b \rightarrow$ stronger base. pK_b small means K_b .

pK_b value = **8.89**, so it is strongest base.

Correct option: **(4) $C_6H_5NHC_2H_5$**

Q3. Value of dissociation constant of acetic acid is 10^{-6} , whereas for formic acid it is 10^{-5} . $pK_a(\text{acetic}) - pK_a(\text{formic}) = ?$

Formula:

$$pK_a = -\log K_a$$

Difference .

$pK_a(\text{acetic}) = 6$ $pK_a(\text{formic}) = 5$

Difference:

$$6 - 5 = 1.$$

Correct option: **(2) +1**

Q4. For two monobasic acids A and B, $pK_{a1} = 1.2$, $pK_{a2} = 2.8$. Which is true?

Smaller $pK_a \rightarrow$ stronger acid. $1.2 < 2.8 \rightarrow$ A is stronger.

Acid A pK_a \rightarrow strongest acid.

Correct option: **(b) A is stronger than B**

Q5. Ionization constant of AOH and BOH bases are K_{b1} , K_{b2} . $pK_{b1} < pK_{b2}$. Conjugate of following base does not show maximum pH :

Base strong \rightarrow conjugate acid weak. Weaker conjugate acid = higher pH. Smaller $pK_b \rightarrow$ stronger base \rightarrow weaker conjugate acid \rightarrow higher pH.

Given: $pK_{b1} < pK_{b2}$ So AOH stronger base \rightarrow conjugate acid of AOH weakest \rightarrow highest pH. BOH conjugate acid stronger \rightarrow lower pH.

So which does NOT show highest pH? \rightarrow BOH.

Correct option: **(2) BOH**

Q6. K_a for formic acid = 1.8×10^{-4} , for acetic acid = 1.8×10^{-5} . Strength ratio?

Relative strength = $\frac{K_{a1}}{K_{a2}}$. Formic : Acetic = $10^{-4} : 10^{-5} = 10 : 1$.

Formic acid stronger because K_a .

Correct option: **(1)** 10 : 1

Q7. The strongest conjugate base is :-

Stronger base = weaker parent acid. Strong acid \rightarrow very weak conjugate base.

Given ions: NO_3^- (from strong acid $\text{HNO}_3 \rightarrow$ very weak base) Cl^- (from very strong acid $\text{HCl} \rightarrow$ weakest base) SO_4^{2-} (from strong acid $\text{H}_2\text{SO}_4 \rightarrow$ weak base) CH_3COO^- (from weak acid acetic \rightarrow strongest base)

Correct option: **(4)** CH_3COO^-

Q8. CH_3COO^- ion is a :-

Acetic acid weak \rightarrow its conjugate base relatively strong.

Weak acid \rightarrow stronger conjugate base (but not strongest among all). Hence "weak conjugate acid" wrong.

Correct option: **(2)** Strong conjugate base

Q9. Which of the following is strongest conjugate base :-

Check parent acid strengths: Weaker parent acid \rightarrow stronger base.

ClO_4^- from strongest acid \rightarrow weakest base HSO_4^- strong acid \rightarrow weak base $\text{HCO}_3^- \rightarrow$ moderate F^- from weak acid $\text{HF} \rightarrow$ strongest base.

Correct option: **(3)** F^-

Q10. Decreasing order of basic strength: NH_3 , CH_3COO^- , Cl^-

Cl^- from $\text{HCl} \rightarrow$ weakest base. CH_3COO^- moderate base. NH_3 is stronger base.

Order: $\text{NH}_3 > \text{CH}_3\text{COO}^- > \text{Cl}^-$.

Correct option: **(4)**

Q11. Correct basic strength order will be :-

Check parent acid K_a strength: Stronger acid \rightarrow weaker base.

ClO_4^- (from HClO_4 strongest acid) \rightarrow weakest base HSO_4^- (strong acid) \rightarrow weak NO_3^- weak NH_3 strongest base among list So order: $\text{HSO}_4^- < \text{ClO}_4^- < \text{NO}_3^- < \text{NH}_3$ is wrong. Correct is: **$\text{NO}_3^- > \text{ClO}_4^- > \text{NH}_3 > \text{HSO}_4^-$**

Correct option: **(4)**

Q12. The conjugate base of the weak acid $\text{HBr} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Br}^-$ is :-

Conjugate base = species after losing H^+ .

$\text{HBr} \rightarrow \text{Br}^-$. So conjugate base = bromide ion.

Correct option: **(3) Br^-**

Q13. The pH of 0.1 M monobasic acid is 4.50. Find its K_a .

Weak acid formula:

$$K_a = \frac{C\alpha^2}{1 - \alpha}$$

$$\alpha = 10^{-\text{pH}}/C.$$

$$\text{H}^+ = 10^{-4.5} = 3.16 \times 10^{-5}$$

For 0.1 M acid:

$$\alpha = \frac{3.16 \times 10^{-5}}{0.1} = 3.16 \times 10^{-4}$$

$$K_a = C\alpha^2 = 0.1(3.16 \times 10^{-4})^2 \approx 1 \times 10^{-8}$$

Correct option: **(4) 1×10^{-8}**

Q14. $\text{HA} + \text{B}^- \rightleftharpoons \text{HB} + \text{A}^-$, $K_{eq} = 10^{-4}$. How many statements are true?

Small K_{eq} means forward reaction weak. Forward reaction weak \rightarrow HA stronger acid than HB.

Check statements:

(i) HB stronger than HA — (ii) HA stronger than HB — (iii) Same acid strength — (iv) B^- stronger base than A^- — (reverse favoured means A^- stronger) (v) A^- stronger base than B^- — (vi) B^- , HB conjugate pair — (vii) A^- conjugate base of HA — (viii) HA can be HSO_4^- , HB = HCOOH — (HSO_4^- stronger acid) (ix) $\text{A}^- = \text{F}^-$, $\text{B}^- = \text{CN}^-$ — (CN^- much stronger base)

True statements = **(ii, v, vi, vii, viii) = 5**

Correct number of true statements: **5**