

---

## 8. IONIC EQUILIBRIUM THEORY OF ACIDS AND BASES

---

### SOLUTIONS

---

### TEACHING TASK

---

### JEE MAINS LEVEL QUESTIONS

#### Single Answer Type

1. In the following reaction  $\text{HC}_2\text{O}_4^- (\text{aq}) + \text{PO}_4^{3-} (\text{aq}) \rightleftharpoons \text{HPO}_4^{2-} (\text{aq}) + \text{C}_2\text{O}_4^{2-} (\text{aq})$ , which are the two Brønsted bases?
- A)  $\text{HC}_2\text{O}_4^-$  and  $\text{PO}_4^{3-}$                       B)  $\text{HPO}_4^{2-}$  and  $\text{C}_2\text{O}_4^{2-}$   
C)  $\text{HC}_2\text{O}_4^-$  and  $\text{HPO}_4^{2-}$                       D)  $\text{PO}_4^{3-}$  and  $\text{C}_2\text{O}_4^{2-}$

**Answer: D**

Solution: A Brønsted base is a proton acceptor. In the reaction,  $\text{PO}_4^{3-}$  accepts a proton to form  $\text{HPO}_4^{2-}$ , and  $\text{C}_2\text{O}_4^{2-}$  is the deprotonated form of  $\text{HC}_2\text{O}_4^-$  (which acts as an acid here).

2. Boric acid  $\text{H}_3\text{BO}_3$  is a :  
A) Arrhenius acid                      B) Brønsted acid    C) Lewis acid                      D) All of these

**Answer: C**

Solution: Boric acid ( $\text{H}_3\text{BO}_3$ ) does not donate a proton (Brønsted acid) but accepts an  $\text{OH}^-$  (Lewis acid) to form  $[\text{B}(\text{OH})_4]^-$ .

3. Identify the amphoteric species from the following :  
(I)  $\text{H}_2\text{O}$                       (II)  $\text{NH}_3$                       (III)  $\text{H}_2\text{PO}_4^-$                       (IV)  $\text{HCO}_3^-$   
A) I, II                      B) III, IV                      C) I, II, III                      D) I, II, III, IV

**Answer: D**

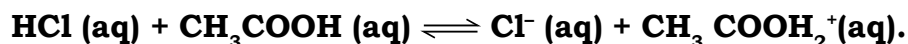
Solution:  $\text{H}_2\text{O}$  (I): Can donate (acid) or accept (base) a proton.

$\text{NH}_3$  (II): Can accept a proton (base) or donate one (acid) in some cases.

$\text{H}_2\text{PO}_4^-$  (III): Can donate or accept a proton.

$\text{HCO}_3^-$  (IV): Can act as an acid (forming  $\text{CO}_3^{2-}$ ) or a base (forming  $\text{H}_2\text{CO}_3$ ).

4. The following equilibrium is established when hydrogen chloride is dissolved in acetic acid



The set that characterises the conjugate acid-base pairs is

- A)  $(\text{HCl}, \text{CH}_3\text{COOH})$  and  $(\text{CH}_3\text{COOH}_2^+, \text{Cl}^-)$   
B)  $(\text{HCl}, \text{CH}_3\text{COOH}_2^+)$  and  $(\text{CH}_3\text{COOH}, \text{Cl}^-)$   
C)  $(\text{CH}_3\text{COOH}_2^+, \text{HCl})$  and  $(\text{Cl}^-, \text{CH}_3\text{COOH})$   
D)  $(\text{HCl}, \text{Cl}^-)$  and  $(\text{CH}_3\text{COOH}_2^+, \text{CH}_3\text{COOH})$ .

**Answer: D**

Solution: Conjugate pairs differ by a proton.  $\text{HCl}$  donates a proton to form  $\text{Cl}^-$ , and  $\text{CH}_3\text{COOH}$  accepts a proton to form  $\text{CH}_3\text{COOH}_2^+$ .

5. In the equilibrium  $\text{CH}_3\text{COOH} + \text{HF} \rightleftharpoons \text{CH}_3\text{COOH}_2^+ + \text{F}^-$ , which of the following statement(s) is/are correct:

A)  $\text{F}^-$  is the conjugate acid of  $\text{CH}_3\text{COOH}$

B)  $\text{F}^-$  is the conjugate base of  $\text{HF}$

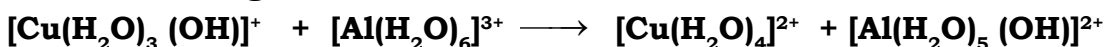
C)  $\text{CH}_3\text{COOH}$  is the conjugate acid of  $\text{CH}_3\text{COOH}_2^+$

D)  $\text{CH}_3\text{COOH}_2^+$  is the conjugate acid of  $\text{CH}_3\text{COOH}$

**Answer: B**

Solution:  $\text{F}^-$  is formed when  $\text{HF}$  loses a proton (so it's the conjugate base of  $\text{HF}$ ).  $\text{CH}_3\text{COOH}_2^+$  (incorrectly written as  $\text{CH}_3\text{COOH}_2^+$  in option C/D) is not relevant here.

6. In the following reaction:



A)

B)

C)

D)

A) A) is an acid and B) is a base

B) A) is a base and B) is an acid

C) C) is the conjugate acid of A)

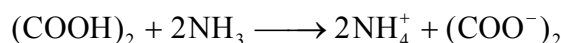
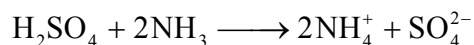
D) A) is the conjugate base of B)

**Answer: B**

Solution:  $\text{OH}^-$  group is transferred from Cu to Al

So A acts as base (donates  $\text{OH}^-$ ), B as acid (accepts  $\text{OH}^-$ )

7. Consider the complete ionization of  $\text{H}_2\text{SO}_4$  (strong acid) and  $(\text{COOH})_2$ , oxalic acid (weak acid) in liquid  $\text{NH}_3$ .



Liquid  $\text{NH}_3$  is called :

A) proton-acceptor

B) leveling solvent

C) both

D) none of these.

**Answer: B**

Solution: In liquid  $\text{NH}_3$ , strong and weak acids fully ionize, making it a leveling solvent (all acids appear equally strong).

8. Which statement is/are correct:

A) All Brønsted bases are also Lewis bases

B) All Brønsted acids are not Lewis acids

C) All cations are acids and anions are bases

D) All of these

**Answer: A**

Solution: Brønsted bases (proton acceptors) must have a lone pair (Lewis base).

Not all Brønsted acids are Lewis acids (e.g.,  $\text{HCl}$  is Brønsted but not Lewis).

Not all cations are acids (e.g.,  $\text{Na}^+$  is neutral).

9. The conjugate base of  $\text{H}_2\text{PO}_4^-$  is [AIEEE-2004]  
A)  $\text{PO}_4^{3-}$  B)  $\text{P}_2\text{O}_5$  C)  $\text{H}_3\text{PO}_4$  D)  $\text{HPO}_4^{2-}$

Answer:D

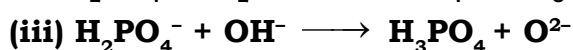
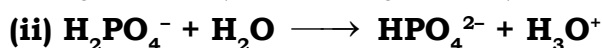
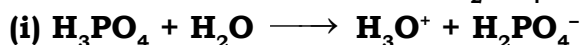
Solution: The conjugate base of  $\text{H}_2\text{PO}_4^-$  is formed by losing a proton, giving  $\text{HPO}_4^{2-}$ .

10. What is the conjugate base of  $\text{OH}^-$ ? [AIEEE-2005]  
A)  $\text{O}_2$  B)  $\text{H}_2\text{O}$  C)  $\text{O}^-$  D)  $\text{O}^{2-}$

Answer:D

Solution:  $\text{OH}^-$  loses a proton ( $\text{H}^+$ ) to form  $\text{O}^{2-}$ .

11. Three reactions involving  $\text{H}_2\text{PO}_4^-$  are given below : [AIEEE-2010]



In which of the above does  $\text{H}_2\text{PO}_4^-$  act as an acid ?

- A) (ii) only B) (i) and (ii) C) (iii) only D) (i) only

Answer:A

Solution: In (ii),  $\text{H}_2\text{PO}_4^-$  donates a proton ( $\text{H}^+$ ) to form  $\text{HPO}_4^{2-} \rightarrow$  acts as an acid (Brønsted acid).

In (i),  $\text{H}_2\text{PO}_4^-$  is formed (product) when  $\text{H}_3\text{PO}_4$  acts as an acid.

In (iii),  $\text{H}_2\text{PO}_4^-$  accepts a proton (from  $\text{OH}^-$ ) to form  $\text{H}_3\text{PO}_4 \rightarrow$  acts as a base.

12. Select the species which can act as an acid and as Base

- A)  $\text{SO}_4^{2-}$  B)  $\text{HS}^-$  C)  $\text{HCO}_3^-$  D)  $\text{HSO}_4^-$

Answer:B,C

Solution: Both  $\text{HS}^-$  (hydrogen sulfide ion) and  $\text{HCO}_3^-$  (bicarbonate ion) are amphoteric, meaning they can act as both Brønsted acids (donate a proton) and Brønsted bases (accept a proton).

13. Which of the following statements is/are correct?

A) Arrhenius acids are also Brønsted acids but all Arrhenius bases are not Brønsted bases

B) All Brønsted bases are also Lewis bases

C) All Brønsted acids are also Lewis acids

D) A strong acid has a weak conjugate base but a strong base has a strong conjugate acid

Answer:B

Solution:

(A) Incorrect: All Arrhenius acids are Brønsted acids, but all Arrhenius bases (e.g.,  $\text{NaOH}$ ) are Brønsted bases (since they accept  $\text{H}^+$  in water).

(B) Correct: Brønsted bases must have a lone pair to accept  $\text{H}^+ \rightarrow$  hence, they are also Lewis bases.

(C) Incorrect: Brønsted acids (e.g.,  $\text{HCl}$ ) donate  $\text{H}^+$  but may not accept electrons (not Lewis acids).

(D) Incorrect: A strong base has a weak conjugate acid, not a strong one.

**14. Which of the following statements is/are correct regarding Lewis acids?**

- A) Molecules having a central atom with an incomplete octet in it can act as Lewis acids**  
**B) Molecules in which atoms of dissimilar electronegativity are joined by multiple bonds can act as Lewis acids**  
**C)  $\text{SiF}_4$ ,  $\text{PF}_5$  and  $\text{FeCl}_3$  are Lewis acids**  
**D) Neutral species having at least one lone pair of electrons can act as Lewis acids**

**Answer: A, B, C**

Solution:

(A) Correct: Molecules with incomplete octets (e.g.,  $\text{BF}_3$ ,  $\text{AlCl}_3$ ) accept electrons  $\rightarrow$  Lewis acids.

(B) Correct: Molecules with polar multiple bonds (e.g.,  $\text{CO}_2$ ,  $\text{SO}_3$ ) can accept electrons.

(C) Correct:  $\text{SiF}_4$  (Si has empty d-orbitals).

$\text{PF}_5$  (can expand octet).

$\text{FeCl}_3$  (electron-deficient metal center).

(D) Incorrect: Lone-pair-bearing species (e.g.,  $\text{NH}_3$ ) are Lewis bases, not acids.

**15. Which of the following behave as Brønsted acids as well as Brønsted bases?**

- A)  $\text{H}_2\text{O}$**                       **B)  $\text{HS}^-$**                       **C)  $\text{H}_2\text{SO}_4$**                       **D)  $\text{HCO}_3^-$**

**Answer: A, B, D**

Solution:  $\text{H}_2\text{O}$  (water),  $\text{HS}^-$  (hydrogen sulfide ion) and  $\text{HCO}_3^-$  are amphoteric, meaning they can act as both Brønsted acids (proton donors) and Brønsted bases (proton acceptors).

**16. Which of the following is wrong?**

- A) Arrhenius theory could explain relative strength of acids and bases.**  
**B) Brønsted theory could explain relative strength of acids and bases.**  
**C) Lewis theory could explain relative strength of acids and bases**  
**D) Lewis theory cannot explain relative strength of acids and bases.**

**Answer: C**

Solution: (A) & (B) Correct: Arrhenius and Brønsted theories explain relative acid/base strength via dissociation constants ( $K_a/K_b$ ).

(C) Incorrect: Lewis theory does not quantify acid/base strength (no  $pK_a/pK_b$  scale).

(D) Correct: Lewis theory lacks a quantitative measure for strength.

## JEE ADVANCED LEVEL QUESTIONS

**Multi correct answer type:**

**17. Which of the following aqueous solutions of compounds are acidic in nature**



**Answer: C, D**

Solution:  $Cu^{2+}$  (from  $CuSO_4$ ) is a Lewis acid (electron-deficient).

In water,  $Cu^{2+}$  hydrolyzes to form  $H^+$  ions, making the solution acidic

$Fe^{3+}$  (from  $FeCl_3$ ) is a strong Lewis acid.

Hydrolyzes in water to produce  $H^+$  ions, making the solution acidic

**18. Which of the following are amphoteric solvents**



**Answer: A, B**

Solution: Amphoteric solvents are substances that can act as both proton donors (acids) and proton acceptors (bases).

Water ( $H_2O$ ) is a classic example, as it can donate a proton to form  $OH^-$  (hydroxide) or accept a proton to form  $H_3O^+$  (hydronium).

Ammonia ( $NH_3$ ) also exhibits amphoteric behavior. It can donate a proton to form  $NH_2^-$  (amide) and accept a proton to form  $NH_4^+$  (ammonium).

HF (hydrogen fluoride) primarily acts as an acid, donating protons, although it can also act as a base in certain situations.

$CCl_4$  (carbon tetrachloride) is a nonpolar solvent and does not exhibit amphoteric behavior.

**Assertion and Reason Type:**

A) Both A and R are true and R is the correct explanation of A

B) Both A and R are true and R is not the correct explanation of A

C) A is true and R is false

D) A is false and R is true

**19. Assertion (A) : A substance that can either act as an acid as well as a base is called ampholyte.**

**Reason (R) : Bisulphide ion ( $HS^-$ ) and bicarbonate ion ( $HCO_3^-$ ) are ampholytes.**

**Answer: A**

Solution: Assertion (A) is correct because an ampholyte (or amphoteric substance) can behave as both an acid and a base.

Reason (R) provides correct examples ( $HS^-$  and  $HCO_3^-$ ) of ampholytes, directly supporting (A)

**20. Assertion (A) : According to Brønsted concept  $H_2O$  is an amphoteric substance**

**Reason (R) :  $H_2O$  molecule can accept as well as donate a proton**

**Answer: A**

Solution: Assertion (A) is true because  $H_2O$  can act as both a Brønsted acid (donates

H<sup>+</sup> to form OH<sup>-</sup>) and a Brønsted base (accepts H<sup>+</sup> to form H<sub>3</sub>O<sup>+</sup>).

Reason (R) explains why H<sub>2</sub>O is amphoteric (it can both donate and accept protons).

- 21. Assertion (A) : In the reaction,  $I_2 + I^- \rightarrow I_3^-$ ,  $I_2$  acts as Lewis base.**  
**Reason (R) : In this reaction  $I^-$  donates an electron pair for sharing with iodine**

**Answer:D**

Solution:Assertion (A) is false because  $I_2$  acts as a Lewis acid (electron-pair acceptor), not a base.

Reason (R) is true because  $I^-$  donates an electron pair to  $I_2$  to form  $I_3^-$ .

The correct statement would be: " $I_2$  acts as a Lewis acid since it accepts an electron pair from  $I^-$ ."

**Matrix matching type:**

**21. Column I**

**A) OH<sup>-</sup>**

**B) HClO<sub>4</sub>**

**C) H<sub>3</sub>O<sup>+</sup>**

**D) ClO<sub>4</sub><sup>-</sup> is weak conjugate base**

**Column II**

**(p)Conjugate acid of O<sup>-2</sup>**

**(q)Conjugate acid of H<sub>2</sub>O**

**(r)Conjugate base of H<sub>2</sub>O**

**(s)strongest bronsted acid**

**Answer:A-r,B-s,C-q,D-p**

**Solution:**

A) OH<sup>-</sup>

B) HClO<sub>4</sub>

C) H<sub>3</sub>O<sup>+</sup>

D) ClO<sub>4</sub><sup>-</sup> is weak conjugate base

(r)Conjugate base of H<sub>2</sub>O

(s)strongest bronsted acid

(q)Conjugate acid of H<sub>2</sub>O

(p)Conjugate acid of O<sup>-2</sup>

**22. Column-I**

**A. HSO<sub>4</sub><sup>-</sup>**

**B. BF<sub>3</sub>**

**C. NH<sub>3</sub>**

**D. OH<sup>-</sup>**

**Column-II**

**p. Lewis acid**

**q. Lewis base**

**r. Bronsted acid**

**s. Bronsted base**

**Answer:A-r,B-p,C-q,D-s**

**Solution:**

A. HSO<sub>4</sub><sup>-</sup>

B. BF<sub>3</sub>

C. NH<sub>3</sub>

D. OH<sup>-</sup>

r. Bronsted acid

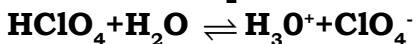
p. Lewis acid

q. Lewis base

s. Bronsted base

**Comprehension type:**

In the reaction  $\text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Cl}^-$ , HCl and  $\text{H}_3\text{O}^+$  are bronsted lowry acids.

**23. Review the equilibrium and choose the correct statement**

A)  $\text{HClO}_4$  is the conjugate acid of  $\text{H}_2\text{O}$

B)  $\text{H}_3\text{O}^+$  is the conjugate base of  $\text{H}_2\text{O}$

C)  $\text{H}_2\text{O}$  is the conjugate acid of  $\text{H}_3\text{O}^+$

D)  $\text{ClO}_4^-$  is the conjugate base of  $\text{HClO}_4$

**Answer:D**

Solution:  $\text{HClO}_4$  donates a proton ( $\text{H}^+$ ) to  $\text{H}_2\text{O}$ , making:

$\text{HClO}_4$  the acid (becomes  $\text{ClO}_4^-$ , its conjugate base).

$\text{H}_2\text{O}$  the base (becomes  $\text{H}_3\text{O}^+$ , its conjugate acid).

**24. Which one of the following can be classified as a bronsted base.**

A)  $\text{NO}_3^-$

B)  $\text{H}_3\text{O}^+$

C)  $\text{NH}_4^+$

D) HCl

**Answer:A**

Solution: Those compound which accept  $\text{H}^+$  is called Bronsted base  $\text{NO}_3^-$  accept  $\text{H}^+$  and form  $\text{HNO}_3$ . So it is a base.

**25. The conjugate base of  $\text{NH}_2^-$  is..**

A)  $\text{NH}_3$

B)  $\text{NH}^{2-}$

C)  $\text{NH}_3^+$

D)  $\text{N}_3$

**Answer:B**

Solution:  $\text{NH}_2^- \rightleftharpoons \text{NH}^{2-} + \text{H}^+$

Conjugate acid, base pair.

## LEARNERS TASK

### CONCEPTUAL UNDERSTANDING QUESTIONS

**1. Arrhenius theory fails to explain the following.**

A) HCl

B)  $\text{CH}_3\text{COOH}$

C)  $\text{H}_2\text{S}$

D)  $\text{SO}_3$

**Answer:D**

Solution: Arrhenius theory defines acids as substances that release  $\text{H}^+$  ions in water.  $\text{SO}_3$  (sulfur trioxide) is a Lewis acid (electron-pair acceptor) but does not contain  $\text{H}^+$ , so it cannot be explained by Arrhenius theory.

**2. Conjugate base of hydrazoic acid is**

A)  $\text{N}_2\text{H}_4$

B)  $\text{N}_2\text{H}_5^+$

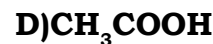
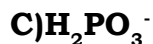
C)  $\text{N}_3^-$

D)  $\text{NH}_2\text{OH}$

**Answer:C**

Solution: Hydrazoic acid ( $\text{HN}_3$ ) loses  $\text{H}^+$  to form its conjugate base,  $\text{N}_3^-$  (azide ion).

3. The following which has no conjugate base



Answer: B

Solution:  $\text{H}_2\text{PO}_2^-$  has no conjugate base because it lacks any acidic hydrogen atoms that can be donated to form a conjugate base.

4. When acid is added to water the concentration of which ions increases

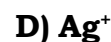


Answer: A, C

Solution: Acids increase  $\text{H}^+$  concentration, which combines with  $\text{H}_2\text{O}$  to form  $\text{H}_3\text{O}^+$  (hydronium ions).

$\text{OH}^-$  decreases due to neutralization.

5. Which of the following is/are Lewis acid(s)?



Answer: B, C, D

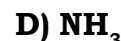
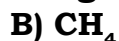
Solution: Lewis acids accept electron pairs:

$\text{Mg}^{2+}$ ,  $\text{Ag}^+$ : Electron-deficient metal ions.

$\text{AlCl}_3$ : Incomplete octet (Al can accept electrons).

$\text{NH}_3$  (A) is a Lewis base (electron-pair donor).

6. Which of the following will qualify as Lewis base?



Answer: C, D

Solution: Lewis bases donate electron pairs:

$\text{NH}_3$  and  $\text{PH}_3$  have lone pairs on N and P, respectively.

$\text{BCl}_3$  (A) is a Lewis acid, and  $\text{CH}_4$  (B) has no lone pairs.

7. Which of the following is not a Lewis acid



Answer: D

Solution:  $\text{BF}_3$ ,  $\text{FeCl}_3$ ,  $\text{SiF}_4$  are Lewis acids (electron acceptors).

$\text{C}_2\text{H}_4$  is a neutral hydrocarbon with no electron deficiency.

8. Which of the following is not Lewis acid



Answer: D

Solution:  $\text{BF}_3$ ,  $\text{AlCl}_3$ ,  $\text{FeCl}_3$  are Lewis acids.

$\text{PH}_3$  is a Lewis base (lone pair on phosphorus).

9.  $\text{Cl}^-$  is the conjugate base of



Answer: B

Solution:  $\text{Cl}^-$  is formed by loss of  $\text{H}^+$  from  $\text{HCl}$

10. Which of the following cannot act as a Lewis or Bronsted acid





**Answer:D**

Solution:  $\text{BF}_3$ ,  $\text{AlCl}_3$ ,  $\text{SnCl}_4$  are Lewis acids (electron acceptors).

$\text{CCl}_4$  has no vacant orbitals or  $\text{H}^+$  to donate, so it cannot act as an acid.

## JEE MAINS LEVEL QUESTIONS

**Single Answer Type**

**11. An acid is a substance which:**

- A) accepts a lone pair of electron (Lewis concept)
- B) donates a proton (Lowry and Bronsted concept)
- C) acts as an acid only in presence of a base
- D) none of the above

**Answer:A,B**

Solution:According to Brønsted-Lowry theory, an acid is a proton ( $\text{H}^+$ ) donor.

Lewis acid  $\rightarrow$  accepts a lone pair

**12. A base is a substance which:**

- A) donates a lone pair of electron (Lewis concept)
- B) accepts a proton
- C) acts as a base only in presence of an acid
- D) none of the above

**Answer:A,B,C**

Solution:In Lewis theory, a base is an electron-pair donor. While B) is correct for Brønsted bases, A) covers both Lewis and some Brønsted bases.

Statement C is also true in a reactive sense (every base needs acid to donate a proton).

**13. Which of the following is a conjugated acid-base pair**

- A)  $\text{HCl}$ ,  $\text{NaOH}$
- B)  $\text{NH}_4\text{Cl}$ ,  $\text{NH}_4\text{OH}$
- C)  $\text{H}_2\text{SO}_4$ ,  $\text{HSO}_4^-$
- D)  $\text{KCN}$ ,  $\text{HCN}$

**Answer: C**

Solution: They differ by one proton ( $\text{H}^+$ ).  $\text{H}_2\text{SO}_4$  (acid)  $\rightarrow$   $\text{HSO}_4^-$  (its conjugate base).

**14. Which of the following can give base  $\text{OH}^-$**

- A)  $\text{H}_2\text{O}$
- B)  $\text{H}_3\text{O}^+$
- C)  $\text{H}_2$
- D)  $\text{HCl}$

**Answer : A**

Solution:Water can dissociate to form  $\text{OH}^-$

**15. Which of the following is not a Bronsted acid**

- A)  $\text{CH}_3\text{NH}_4^+$
- B)  $\text{CH}_3\text{COO}^-$
- C)  $\text{H}_2\text{O}$
- D)  $\text{HSO}_4^-$

**Answer:B**

Solution: $\text{CH}_3\text{COO}^-$  is a conjugate base (of  $\text{CH}_3\text{COOH}$ ) and cannot donate protons.

**16. Which one of the following compounds is a Lewis acid**

- A)  $\text{PCl}_3$
- B)  $\text{BCl}_3$
- C)  $\text{NCl}_3$
- D)  $\text{CHCl}_3$

**Answer:B**

Solution: $\text{BCl}_3$  has an incomplete octet and can accept electron pairs.

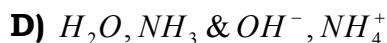
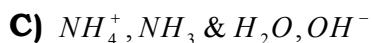
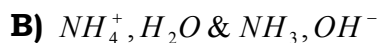
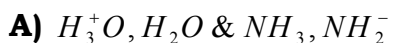
**17. Which of the following is not a Lewis acid**

- A)  $\text{CO}$
- B)  $\text{SiCl}_4$
- C)  $\text{SO}_3$
- D)  $\text{Zn}^{2+}$

**Answer:A**

Solution:CO is a Lewis base (electron-pair donor), not an acid. The others ( $\text{SiCl}_4$ ,  $\text{SO}_3$ ,  $\text{Zn}^{2+}$ ) are Lewis acids.

**18. Conjugate acid base pairs in the aqueous solution of ammonia are**



**Answer:C**

Solution:  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$

$\text{NH}_4^+$  (conjugate acid) is formed when  $\text{NH}_3$  (base) accepts  $\text{H}^+$ .

$\text{OH}^-$  (conjugate base) is formed when  $\text{H}_2\text{O}$  (acid) donates  $\text{H}^+$ .

**19. In the reaction  $\text{AlCl}_3 + \text{Cl}^- \rightarrow \text{AlCl}_4^-$ ;  $\text{AlCl}_3$  is**

**A) Lewis acid**

**B) Lewis base**

**C) Lewis salt**

**D) Arrhenius acid**

**Answer:A**

Solution: $\text{AlCl}_3$  accepts an electron pair from  $\text{Cl}^-$  to form  $\text{AlCl}_4^- \rightarrow$  Lewis acid (electron-pair acceptor).

**20. Which of the following is a weak acid according to protonic concept of acids and bases?**



**Answer:C**

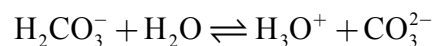
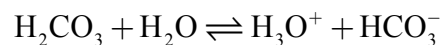
Solution: $\text{NH}_4^+$  (ammonium ion) is a weak acid (partially dissociates to  $\text{NH}_3 + \text{H}^+$ ).

$\text{NO}_3^-$  (neutral, conjugate base of  $\text{HNO}_3$ ).

$\text{ClO}_4^-$  (neutral, conjugate base of  $\text{HClO}_4$ ).

$\text{CO}_3^{2-}$  (base, conjugate base of  $\text{HCO}_3^-$ ).

**21.  $\text{H}_2\text{CO}_3$  ionises in two stages as represented below**



**The number of conjugate acid-base pairs in the above reactions are**

**A) 2**

**B) 4**

**C) 5**

**D) 3**

**Answer:B**

Solution:For the two-stage ionization:

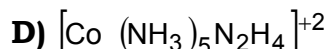
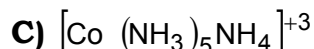
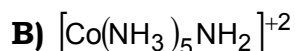
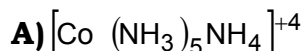
$\text{H}_2\text{CO}_3/\text{HCO}_3^-$  (acid/conjugate base).

$\text{H}_3\text{O}^+/\text{H}_2\text{O}$  (conjugate acid/base from  $\text{H}_2\text{O}$ ).

$\text{HCO}_3^-/\text{CO}_3^{2-}$  (acid/conjugate base).

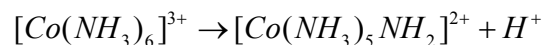
$\text{H}_3\text{O}^+/\text{H}_2\text{O}$  (again, from the second step).

**22. The conjugate base of  $[\text{Co}(\text{NH}_3)_6]^{+3}$  is**

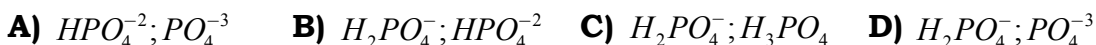
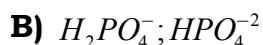
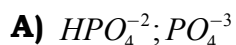


**Answer: B**

Solution: The conjugate base forms by losing  $\text{H}^+$  from one  $\text{NH}_3$  ligand:



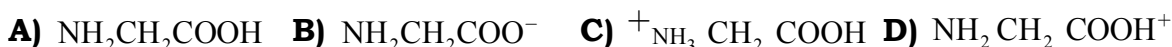
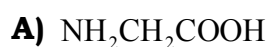
**23. Which of the following is not a conjugate acid-base pair?**



**Answer: D**

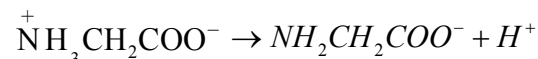
Solution:  $\text{H}_2\text{PO}_4^-; \text{PO}_4^{-3}$  requires losing two protons, not one. Valid pairs must differ by one  $\text{H}^+$

**24. Glycine exists as the zwitter ion (double ion)  $^+\text{NH}_3\text{CH}_2\text{COO}^-$ . its conjugate base is**



**Answer: B**

Solution: Its conjugate base forms by losing  $\text{H}^+$  from the  $\text{NH}_3^+$  group:



## JEE ADVANCED LEVEL QUESTIONS

**Multi correct answer type:**

**25. Which of the following statements are correct**

**A) According to Bronsted concept  $\text{H}_2\text{O}$  is an amphoteric substance.**

**B)  $\text{H}_2\text{O}$  molecule can accept as well as donate a proton.**

**C) According to Lewis concept,  $\text{NaCl}$  is a salt.**

**Answer: A, B**

Solution:

A) True:  $\text{H}_2\text{O}$  can act as both a Brønsted acid (donates  $\text{H}^+$  to form  $\text{OH}^-$ ) and a Brønsted base (accepts  $\text{H}^+$  to form  $\text{H}_3\text{O}^+$ ).

B) True: This is the definition of amphotericism, directly supporting statement (A).

C) False: The Lewis concept focuses on electron-pair donation/acceptance (acids/bases), not salt classification.  $\text{NaCl}$  is an Arrhenius salt (ionic compound), but this classification is unrelated to Lewis theory.

### Assertion and Reason type

- A) Both A and R are true and R is the correct explanation of A
- B) Both A and R are true and R is not the correct explanation of A
- C) A is true and R is false
- D) A is false and R is true

- 25. Assertion (A) : According to lowry – Bronsted theory, a substance can function as an acid as well as a base**  
**Reason (R) : Acid reacts with a base to produce a salt.**

**Answer:B**

Solution:Assertion (A) is true because the Brønsted-Lowry theory defines amphoteric substances (e.g.,  $\text{H}_2\text{O}$ ,  $\text{HCO}_3^-$ ) that can act as both acids (proton donors) and bases (proton acceptors).

Reason (R) is true (neutralization reactions produce salts), but it does not explain why a substance can be both acid and base. It describes a general acid-base reaction, not amphoterism.

- 26. Assertion (A) :  $\text{HCO}_3^-$  is a conjugate acid of  $\text{H}_2\text{CO}_3$ .**  
**Reason (R) :  $\text{HCO}_3^-$  changes to  $\text{H}_2\text{CO}_3$  by accepting a Proton.**

**Answer:D**

Solution:Assertion (A) is false because  $\text{HCO}_3^-$  is the conjugate base of  $\text{H}_2\text{CO}_3$  (not conjugate acid). When  $\text{H}_2\text{CO}_3$  loses  $\text{H}^+$ , it forms  $\text{HCO}_3^-$ .

Reason (R) is true because  $\text{HCO}_3^-$  can accept a proton to revert to  $\text{H}_2\text{CO}_3$ , but this makes it the base in that pair, not the conjugate acid.

- 27. Assertion (A) :  $\text{SF}_4$  can act as Lewis acid.**  
**Reason (R) : The compound which contains vacant d-orbitals can act as Lewis acid.**

**Answer:A**

Solution:Assertion (A) is true because  $\text{SF}_4$  (sulfur tetrafluoride) has a vacant d-orbital on sulfur, allowing it to accept electron pairs (Lewis acid behavior).

Reason (R) is true and directly explains (A): Vacant d-orbitals enable electron-pair acceptance (Lewis acidity).

### Matrix matching type:

28. **List-I**

- A) Protophilic solvents
- B) Aprotic solvents
- C) Protogenic Solvents
- D) Amphiprotic Solvents

**List-II**

- 1) Neither donate nor accept protons
- 2) Generates protons
- 3) Either donate(or) accept protons
- 4) High tendency to accept protons
- 5) Do not have solvent properties

**The correct match:**

	A	B	C	D		A	B	C	D
A)	1	3	2	5	B)	4	1	2	3
C)	4	1	3	2	D)	2	3	1	5

**Answer:B**

Solution:

- |                         |                                      |
|-------------------------|--------------------------------------|
| A) Protophilic solvents | 4) High tendency to accept protons   |
| B) Aprotic solvents     | 1) Neither donate nor accept protons |
| C) Protogenic Solvents  | 2) Generates protons                 |
| D) Amphiprotic Solvents | 3) Either donate(or) accept protons  |

**Comprehension type:**

According to Lewis theory, an acid is any molecule, ion or atom which can accept a pair of electron to form a co-ordinate covalent bond. Base is a substance which can donate a pair of electrons to form a co-ordinate covalent bond.

**29. Which of the following is neither a Lewis acid nor a Lewis base.**

- A)  $\text{HSO}_4^-$                       B)  $\text{ZnCl}_2$                       C)  $\text{NH}_4^+$                       D)  $\text{CH}_3^+$

**Answer:C**

Solution: $\text{NH}_4^+$  – Already has a complete octet, no lone pairs to donate, no vacant orbitals → neither acid nor base

**30. In the reaction  $\text{SnCl}_2 + 2\text{Cl}^- \rightarrow \text{SnCl}_4 + 2\text{e}^-$  the Lewis acid is**

- A)  $\text{SnCl}$                       B)  $\text{SnCl}_3$                       C)  $\text{SnCl}_2$                       D)  $\text{SnCl}_4$

**Answer:C**

Solution:Lewis acid = Electron-pair acceptor.

Here,  $\text{SnCl}_2$  accepts electron pairs from  $\text{Cl}^-$  to form  $\text{SnCl}_4$  (expands its octet).  $\text{SnCl}_4$  is the product, not the acid.

# KEY

			TEACHING TASK							
			JEE MAINS LEVEL QUESTIONS							
1	2	3	4	5	6	7	8	9	10	
D	C	D	D	B	B	B	A	D	D	
11	12	13	14	15	16					
A	B,C	B	A,B,C	A,B,D	C					
			JEE ADVANCED LEVEL QUESTIONS							
17	18	19	20	21	21		22		23	
C,D	A,B	A	A	D	A-r,B-s,C-q,D-p		A-r,B-p,C-q,D-s		D	
24	25									
A	B									
			LEARNERS TASK							
			Conceptual understanding Questions							
1	2	3	4	5	6	7	8	9	10	
D	C	B	A,C	B,C,D	C,D	D	D	B	D	
			JEE MAINS LEVEL QUESTIONS							
11	12	13	14	15	16	17	18	19	20	
A,B	A,B,C	C	A	B	B	A	C	A	C	
21	22	23	24							
B	B	D	B							
			JEE ADVANCED LEVEL QUESTIONS							
25	25	26	27	28	29	30				
A,B	B	D	A	B	C	C				