CHEMISTRY

103

Subject Final Exam - Chapter Sixteen

تحذير: محاضراتنا (الملخصات) متوفرة فقط لدى:
1) أكاديمية القصور بفروعها. 2) جمعية التصوير الطبية (مدرج التمريض).

للإستفسار والتسجيل

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Chapter 16: Acids and Bases

Review:

** Properties of Acids & Bases

Acids	Bases
- taste sour طعمه حامض	- taste bitter طعمه مر
- blue to red litmus paper	- red to blue litmus paper
- ex. Coffee, vinegar	- ex. bleach

16.2: Acids-Bases Definitions

- Arrhenius →
- Bronsted-Lowery →
- Lewis (most general) →

قاعدة	حمض
مادة تزيد من تركيز الهيدروكسيد OH⁻ إذا أذيبت في الماء NaOH / $Ba(OH)_2$	* مادة تزيد من تركيز أيون الهيدروجين H^+ عند إذابتها في الماء HBr / HCl
* مادة قادرة على كسب البروتون من مادة أخرى "مستقبل للبروتون" NH_3	* مادة قادرة على إعطاء البروتون لمادة أخرى في التفاعل "مانح للبروتون" HNO_3
* مادة قادرة على منح زوج أو أكثر من الالكترونات غير الرابطة لمادة أخرى لتكوين رابطة تساهمية * تحتوي على أزواج غير رابطة	* مادة قادرة على استقبال زوج أو أكثر من الالكترونات "يحتوي فلك فارغ"

1- Arrhenius

Acid: proton (H^+) donor in aqueous (water) media

Base: hydroxide (OH^-) donor in aqueous (water) media

2- Bronsted-Lowey

Acid: proton (H^+) donor, must have H

Base: proton (H^+) acceptor, must have lone pair to bind H^+

Ex. قاعدة حمض

تعطي بروتون

$$\underset{\text{Base}}{NH_3} + \underset{\text{Acid}}{CH_3COOH} \longrightarrow NH_4^+ + CH_3COO^-$$

تكسب بروتون

Q. Identify the acid and base in each of the following reactions:

1. $HCl\,(aq) + OH^-\,(aq) \Rightarrow H_2O\,(l) + Cl^-\,(aq)$

2. $NH_3\,(aq) + CH_3COOH\,(aq) \Rightarrow NH_4^+\,(aq) + CH_3COO^-\,(aq)$

3. $H_2O\,(l) + NH_3\,(aq) \Rightarrow OH^-\,(aq) + NH_4^+(aq)$

Ans. 1- HCl 2- CH_3COOH 3- H_2O

H_2O is **amphoteric**: can accept & donate a proton (i.e. act as an acid & as a base)

يسلك سلوك حمض و قاعدة.

1. $\underset{\text{acid}}{HCl\,(aq)} + \underset{\text{base}}{H_2O\,(aq)} \Rightarrow H_3O^+\,(aq) + Cl^-\,(aq)$

2. $\underset{\text{acid}}{H_2O\,(l)} + \underset{\text{base}}{NH_3\,(aq)} \Rightarrow OH^-\,(aq) + NH_4^+(aq)$

التفاعلات المعاكسة.

Reversible Acid-Base Reactions:

Can proceed in both forward and reverse directions.

- In any acid-base equilibrium, both the forward & reverse reaction involve proton transfer في كلا التفاعلين الأمامي والعكسي يتضمن انتقال بروتون.

Conjugate Acids & Conjugate Bases

- Consider the general acid-base reaction:

$$\underset{\text{acid}}{HX} + \underset{\text{base}}{H_2O} \rightleftharpoons \underset{\text{conjugate-acid}}{H_3O^+} + \underset{\text{conjugate-base}}{X^-}$$

زوج مرافق

Conjugate acid-Base Pair.

Rules:

1- Conjugate base of a strong acid is (Neutral)
2- Conjugate base of a weak acid is (Basic)

3- Conjugate acid of a strong base is (Neutral)
4- Conjugate acid of a weak base is (Acidic)

قاعدة مرافقة لحمض قوي → متعادل
قاعدة مرافقة لحمض ضعيف → قاعدي
حمض مرافق لقاعدة قوية → متعادل
حمض مرافق لقاعدة ضعيفة → حمضي

Strong Acids

- HCl, HBr, HI
- HNO_3
- H_2SO_4
- $HClO_4$

Strong Bases

- Hydroxides (OH^-) of G1A & G2A, except Be &
  Ex. NaOH, KOH, $Ca(OH)_2$,………
- Nitrides (N^{-3}) : Na_3N
- Oxides (O^{-2}) : MgO
- Hydrides (H^-) : NaH

*** **Other than these in table are weak acids or weak bases:**

Ex. HF : weak acid NH_3 : weak base

Ex. Find the conjugate acids & bases in each of the following:

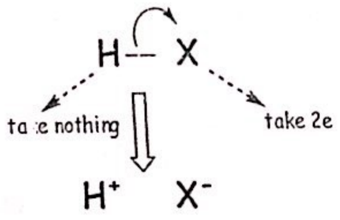
acid	conj-base
HCO_3^-	CO_3^{-2}
OH^-	O^{-2}
NH_3	NH_2^-
$H_2PO_4^-$	HPO_4^{-2}

(loss H^+ & add -ve to oxidation no.)

base	conj-acid
HCO_3^-	H_2CO_3
OH^-	H_2O
F^-	HF
PO_4^{-3}	HPO_4^{-2}

(accept H^+ & remove -ve from oxidation no.)

Note:



Relative Strengths of Acids & Bases:

الاتزان مفضلة

- In every acid-base reaction, the position of equilibrium favors transfer of the proton H^+ from the stronger acid to the stronger base:

ينتقل بروتون من الحمض القوي
إلى القاعدة القوية.

$$HX + H_2O \rightleftharpoons H_3O^+ + X^-$$

Strong acid $\rightleftharpoons$ weak conj-acid

The magnitude of reaction from left $\longrightarrow$ right

$$A \rightleftharpoons B$$

Strong acid

Left $\longleftarrow$ right

*** We study before the strong acids in table (page 2)

Q. Predict whether the equilibrium lies to the left or to the right for each of the following reactions:

a. $HCl\,(aq) + H_2O(l) \rightleftharpoons H_3O^+\,(aq) + X^-\,(aq)$ to the ________

b. $HF\,(aq) + NO_3^-\,(aq) \rightleftharpoons HNO_3\,(aq) + F^-\,(aq)$ to the ________

c. $NH_4^+\,(aq) + Cl^-\,(aq) \rightleftharpoons NH_3\,(aq) + HCl\,(aq)$ to the ________

Ans:

a. to right b. to left c. to left

16.3: The Auto-ionization of Water:

In pure water, H_2O dissociates to H^+ ions (protons) & OH^- ions (hydroxide):

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

The molar concentration of H^+ equals the molar concentration of OH^- :

$$[H^+] = [OH^-] = 1 * 10^{-7}\ M$$

In turn, the ion product of water (at 25°C) is

$$Kw = [H^+] * [OH^-]$$
$$= 1 * 10^{-14}$$

Note:

If $[OH^-] > [H^+]$ basic solution
$[OH^-] < [H^+]$ acidic solution
$[OH^-] = [H^+]$ neutral solution

Ex. Given the following $[H^+]$ in water, calculate $[OH^-]$, then predict if acidic, basic or neutral solution:

a. $[H^+] = 1.4 \times 10^{-6}$ M $\qquad [OH^-] = 7.14 \times 10^{-9}$ M

b. $[OH^-] = 3.7 \times 10^{-8}$ $\qquad [H^+] = 2.7 \times 10^{-7}$ M

16.4: The pH Scale: measures of Acidity:

pH < 7: acidic **pH = 7: neutral** **pH > 7: basic**

pH: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

strongly acidic — weakly acidic — neutral — weakly basic — strongly basic

$$\boxed{pH = -\log [H^+]} \qquad \boxed{pOH = -\log [OH^-]}$$

$pKw = -\log Kw$
$= -\log 1\times10^{-14} \qquad = 14$
$pH + pOH = pK_w$

$$\boxed{[H^+] = 10^{-pH}}$$

At calculator type (Shift, log-pH)

$$\boxed{pH + pOH = 14}$$

Q1. Solve for pH & indicate if the solution is acidic or basic:

a. $[H^+] = 3.2 \times 10^{-4}$ M $\qquad pH = 3.49$ >>> acidic

b. $[H^+] = 7.95 \times 10^{-6}$ M $\qquad pH = 5.1$ >>> acidic

c. $[H^+] = 4.0 \times 10^{-9}$ M $\qquad pH = 8.4$ >>> basic

Q2. Solve for pH & indicate if the solution is acidic or basic:

a. pH = 7.35 M $[H^+]$ =

b. pH = 4.25 M $[OH^-]$ =

c. pH = 6.8 M $[H^+]$ =

d. pOH = 5.7 M $[H^+]$ =

e. pH = 2.35 M $[OH^-]$ =

Ans.:

a. 4.47×10^{-8} M (basic) b. 1.78×10^{-10} M (acidic) c. 1.6×10^{-7} M (acidic)

d. 5.0×10^{-9} M (acidic) e. 2.2×10^{-12} M (acidic)

16.5: Strong Acids & Strong Bases

- Back to table page.2

Strong acids and bases completely dissociate (~ 100%) in solution. Therefore, the concentration of the solute is the same as the concentration of the $[H^+]$ for acid or $[OH^-]$ for base

$$HCl \longrightarrow H^+ + Cl^-$$

	HCl	H^+	Cl^-
initially	3.5 M	0 M	0 M
Finally	0 M	3.5 M	3.5M

$pH = -\log [H^+]$

$= -\log 3.5 = 0.54$ (st.acid)

Ex. Find pH for 0.25 M $Ca(OH)_2$ solution?

	$Ca(OH)_2$	$\longrightarrow$	Ca^{+2}	+	$2OH^-$
ini.	0.25 M		0		0
fin.	0		0.25 M		2(0.25)=0.5 M

pOH = -log [0.5]
= 0.30

pH = 14 - 0.3
= 13.7 (st.base)

Note:
You can use this way also for strong acids that give more than one proton, but directly find pH without go to pOH

Q. Calculate the pH of a) 0.04 M HCl b) 0.04 M H_2SO_4 solution?

Ans.: a) 1.4 b) 1.31

Q. Calculate the number of moles of KOH in 5.5 mL of a 0.36 M KOH solution?
Ans.: 1.98×10^{-3}

Q. Find pH for a solution prepared by dissolving 5.0 g of NaOH (M.wt= 40g/mol) in enough water to get 500ml of solution?

$$M_{OH^-} = \frac{\text{moles}}{V_L} = \frac{(\text{mass}/\text{M.wt})}{V_L}$$

$$= \frac{(5/40)}{0.5} = 0.25M$$

$$\Rightarrow M_{OH^-} = 0.25M$$

$$\Rightarrow pOH = -\log(0.25)$$

$$= 0.6$$

$$\therefore pH = 14 - 0.6 = 13.4$$

16.6: Weak Acids

Weak acids are weak electrolytes & do not dissociate completely. Equilibrium exists between the reactants & products, and the equilibrium constant (K_{eq}) must be taken into account to solve for the pH value.

When a weak acid (HA) is dissolved in water, the conjugate base (A^-) and conjugate acid (H^+) are formed. The equilibrium constant for an acid is called the acid dissociation constant (K_a).

Ex: What is the pH of a 1.0 M solution of acetic acid? (Ka = 1.78×10^{-5})

Ans.:

$$CH_3CO_2H \rightleftharpoons CH_3CO_2^- + H^+$$

$$K_a = \frac{[CH_3CO_2^-][H^+]}{[CH_3COH]} = 1.78 * 10^{-5}$$

	CH_3CO_2H	$\rightleftharpoons CH_3CO_2^-$	$+H^+$
Initial	1.0	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$1.0 - x$	$+x$	$+x$

$$1.78 * 10^{-5} = \frac{[x][x]}{[1.0 - x]} = \frac{x^2}{1.0} \Rightarrow 1.78 * 10^{-5} = x^2$$

$x = 0.0042 = [H^+]$ $(1.0 - x \approx 1.0 \text{ if x is small})$

$pH = -\log[0.0042] = \underline{2.4}$

Note:

H^+ ions from the ionization of water

- Since $[H^+] = 1x10^{-7}$ M in pure water, we can neglect this contribution for solutions, where $[H^+] \geq 10^{-6}$ M.

>>> If Ka/[HA]ini. ≤ 0.01 (remove x) (i.e. 1 - x = 1)

If not ≤ 0.01 use quadratic equation :

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Ex. The pH for $2x10^{-6}$ M solution of CH_3CO_2H (Ka for at 25°C is 1.75×10^{-5}) is:

Ans.: $CH_3CO_2H \rightleftharpoons CH_3CO_2^- + H^+$

ini.	$2x10^{-6}$	0 M	0 M
equil.	$2x10^{-6} - x$	$+x$	$+x$

$$Ka = \frac{x \, . \, x}{2x10^{-6} - x}$$

Since, $Ka/2x10^{-6} > 0.01$: don't neglect x

$$1.75x10^{-5} = \frac{x^2}{2x10^{-6} - x}$$

$1.75 \times 10^{-5} * (2x10^{-6} - X) = X^2$

$>> X^2 + 1.75x10^{-5} X - 3.5 x10^{-11} = 0$

$$X = \frac{-1.75x10^{-5} \pm \sqrt{(1.75x10^{-5})^2 - (4)(1)(-3.5x10^{-11})}}{2\,(1)}$$

$$X = \frac{-1.75x10^{-5} \pm 2.11x10^{-5}}{2}$$

$X = -1.93x10^{-5}$ M , $\underline{1.8x10^{-6}}$ M

$>>> [H^+] = X = 1.8x10^{-6}$ M

$>>>$ pH = 5.74

Percent dissociation (ionization) for weak acids:

It's measure of the strength of acids. The more dilute a solution of a weak acid, the greater the percent ionization of the acid.

$$\boxed{\% \text{ Dissociation (ionization)} = \frac{\text{X at equilibrium}}{\text{initial [HA] conc.}} \times 100\%}$$

Ex. Find % ionization for the example (page 8):

X at equilibrium = 0.0042 initial conc. = 1.0 M

$$\% \text{ ionization} = \frac{0.0042}{1.0} \times 100\%$$

$$= 0.42\ \%$$

Q. Calculate the pH and pOH of a 1×10^{-3} M solution of acetic acid (Ka= 1.75×10^{-5})?

(Hint: neglect x)

$$HOAc \rightleftharpoons H^+ + OAc^-$$

Ans.: pH = 3.88 , pOH = 10.12

Q. A 0.040 M monoprotic acid solution is 14% ionized. Its K_a value is?

Ans.:

9.2×10^{-4}

Q. For 0.70 M HF solution that have pH of 1.6, Calculate K_a?

Ans.: 8.93×10^{-4}

16.7: Weak Bases

Problems involving weak bases are treated similarly to the problems with weak acids. Weak bases (B) accept a proton from water (H_2O) to produce a conjugate acid (HB^+) and hydroxide ions:

$$\begin{array}{lcccc} B & + H_2O & \rightleftharpoons & HB^+ & + OH^- \\ [C]_{ni.} - x & & & x & x \end{array}$$

$$K_b = \frac{[HB^+][OH^-]}{[B]} = \frac{x^2}{[C]_{ni.} - x}$$

$\Rightarrow x = [OH^-]$

$\Rightarrow pOH = -\log(x)$

$\Rightarrow pH = 14 - pOH$

Q. What is the pH of a 1.25 M solution of ammonia (NH_3) ($K_b = 1.8 * 10^{-5}$)?

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Ans.:
pH = 11.67

Q. For 0.50 M monoprotic weak base solution that has a pH of 12.6, Calculate K_b?

Ans.: 3.2×10^{-3}

16.8: Relationship between K_a & K_b

- We can derive the relationship between K_b for a weak base & K_a for its conjugate acid by combining their equations:

$$HX\,(aq) \rightleftharpoons H^+\,(aq) + X^-\,(aq) \qquad K_a = \frac{[H^+]\,[X^-]}{[HX]}$$

$$X^-\,(aq) + H_2O\,(l) \rightleftharpoons HX\,(aq) + OH^-\,(aq) \qquad K_b = \frac{[HX][OH^-]}{[X^-]}$$

$$H_2O\,(l) \Rightarrow H^+\,(aq) + OH^-\,(aq) \qquad K_w = [H^+]\,[OH^-] = 1.0 \times 10^{-14}$$

Whenever chemical equations for two (or more) reactions are added to get the equation for a net reaction, the equilibrium constant for the net reaction equals the product of the equilibrium constants for the individual reactions:

$K_{net} = K_1 * K_2 * ...$

For any conjugate acid-base pair:

$\boxed{K_a * K_b = K_w}$, $\boxed{pK_a + pK_b = 14}$

Ex. K_b for CHO_2^- is 5.3×10^{-11}, Calculate K_a for $HCHO_2$?

$K_a \times K_b = K_w$
$K_a = K_w/K_b$
$= 1\times10^{-14}/5.3\times10^{-11}$
$= 1.88\times10^{-4}$

Converting pKa & Ka :

$pK_a = - \log K_a$ & $K_a = 10^{-pKa}$

The <u>weaker the acid</u> >>>>> <u>smaller K_a</u> >>>>> <u>larger pK_a</u>

The <u>weaker the base</u> >>>>> <u>smaller K_b</u> >>>>> <u>larger pK_b</u>

Ex. Determine pKa for the following:

a. $HF_{(aq)}$, $Ka = 6.9\times10^{-4}$, pKa = 3.16

b. $NH_4^+{}_{(aq)}$, $Ka = 5.6\times10^{-10}$, pKa = 9.25

>>> HF more acidic than NH_4^+

Q. Arrange the following solutions in order of acidity:

A (pK_a = 12.2) B (pK_a = 3.4) C (pK_b = 11.8)

Ans.:
A > B > C

Polyprotic Weak Acids

Substances containing more than one acidic proton are called polyprotic acids. Diprotic acids contain two acidic protons, & triprotic acids contain three acidic protons. Acid protons dissociate one at a time and have different Ka and pKa

Ex. Carbonic acid (H_2CO_3) is a diprotic acid

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \qquad K_{a1} = 4.67 * 10^{-7}$$

$$HCO_3^- \rightleftharpoons CO_3^{-2} + H^+ \qquad K_{a2} = 5.63 * 10^{-11}$$

Note:
If $K_{a1} > K_{a2}$ By factor of 100, ignore equation 2 & use equation 1 to find pH (same wuy of finding pH of weak acid, you have now one H^+ & one Ka value)

Q.1: Find the pH in the upper example of 0.15 M H_2CO_3 acid?
Ans.:
Since, $Ka_1 > Ka_2$ by factor of 100, you can find pH from equation 1
(i.e., $Ka_1 = 4.67\times10^{-7}$)
>> pH = 3.6

Q.2: Calculate the $[CO_3^{2-}]$
Ans.:
Note: From first step, $[H^+] = [HCO_3^-]$

From second step, $$K_{a2} = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

$$K_{a2} = 5.63 \times 10^{-11}$$

Since $[H^+] = [HCO_3^-]$, they cancel, and $[CO_3^{2-}] = K_{a2}$

16.9: Acid-Base Properties of Salts

Salts: Compounds that gives ions in water

$$NaCl_{(s)} \xrightarrow{H_2O_{(l)}} Na^+_{(aq)} + Cl^-_{(aq)}$$

The following ions do not react appreciably with water to produce either H_3O^+ or OH ions

* Cations from strong bases:

>>> Alkali metal cations of group 1A (Li^+, ...)

>>> Alkaline earth cations of group 2A (Ca^{+2}, ... except for Be^{+2})

* Anions from strong monoprotic acids:

>>> Cl^- , Br^- , NO_3^- , ...

Salts that contain only these ions give neutral solutions in pure water (pH=7)

(Usually, water is slightly acidic because of dissolved atmospheric CO_2)

<u>How to predict if the salt acidic, basic or neutral</u>

+ve ion (conjugate acid) ⇒ originated from base

-ve ion (conjugate base) ⇒ originated from acid

Ex. NaCl salt is acidic, basic, or nuetral

$$\begin{tikzcd}
NaCl_{(s)} \arrow[r, "H_2O_{(l)}"] & \underset{\text{conj-acid}}{Na^+_{(aq)}} \arrow[d, "\text{add}"', "OH^-"] & + & \underset{\text{conj-base}}{Cl^-_{(aq)}} \arrow[d, "\text{add}"', "H^+"] \\
& \underset{\textbf{Strong base}}{NaOH} & & \underset{\textbf{Strong acid}}{HCl}
\end{tikzcd}$$

>>>> NaCl salt is Neutral

Rules:

1- Salts originated from (st.acid) & (st.base) ⟹ Neutral
2- '''''''' '''''''' '''''''' (st.acid) & (w.base) ⟹ Acidic
3- '''''''' '''''''' '''''''' (w.acid) & (st.base) ⟹ Basic

4- '''''''' '''''''' '''''''' (w.acid) & (w.base) ⟹ Depend on K_a & K_b values
(if $K_a > K_b$ ⟹ acidic)
(if $K_a < K_b$ ⟹ basic)
(if $K_a = K_b$ >>>>>> neutral)

Q. Predict each salts is acidic, basic or neutral

a. KNO_2
b. NH_4NO_3
c. $ZnBr_2$

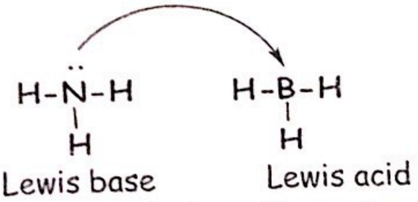
Ans.: a. basic b. acidic c. acidic

16.11: Lewis Acids and Bases

Lewis Acids: Species that accept a pair of electrons (lone pair(..))
Base : Species that donate a pair of electrons (lone pair(..))

Ex. Predict which is lewis acid and lewis base in the NH_3BH_3

First: Draw lewis structure then identify:



To be Simple (use this way):

Common Lewis Acids:

- $B(\ )_3$, $Al(\ )_3$: BH_3, $AlCl_3$,......
- $Be(\ )_2$, $Mg(\ )_2$: $BeCl_2$, $MgCl_2$,......
- Transition Metals (Cr^{3+} , Cr^{2+}, Fe^{3+} , ...etc)

Note:

Oxidation state no. increase, more acidic

Cr^{3+} more acidic than Cr^{2+}

Ex. Identify the Lewis acid & Lewis base in the following:

a. $[Ni(NH_3)_6]^{2+}$

b. $[Fe(CN)_6]^{4-}$

Ans.:

a) Ni^{+2} Lewis acid NH_3 : Lewis base

b) Fe^{+2} Lewis acid CN^- : Lewis base

Note:

If you identify the acid the other must be the base

>>

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Questions

1) Given the following pKa values, the true arrangement of basisity is:

$HF= 2.3$ $HCO_2H= 3.74$ $H_2CO_3= 4.75$ $C_2H_5OH= 6.35$

a. $HF > HCO_2H > H_2CO_3 > C_2H_5OH$

b. $HF > HCO_2H > C_2H_5OH > H_2CO_3$

c. $C_2H_5OH > H_2CO_3 > HCO_2H > HF$

d. $C_2H_5OH > HCO_2H > H_2CO_3 > HF$

2) $ZnCl_2$ Salt is:

a. Acidic b. Basic c. Neutral d. Not enough informations

3) Na_2CO_3 Salt is:

a. Acidic b. Basic c. Neutral d. Not enough informations

4) Predict the direction of the equilibrium in this reaction:

$$H_2SO_{4(aq)} + NH_{3(aq)} \rightleftharpoons NH_4^+{}_{(aq)} + HSO^-{}_{(aq)}$$

a. Shift to left b. Shift to right

c. Left = Right d. No enough information

5) Ka generally increase with:

a. Increasing metal charge
b. Decreasing size of the metal ion
c. a+b
d. Non of them

6) Calculate the H_3O^+ concentration in a lake that has a pH of 4.5:

a. 3.2×10^{-5}
b. 1.5×10^{-5}
c. 3.3×10^{-10}
d. 1.5×10^{-10}

7) Calculate the pH of 0.005 M solution of $Ca(OH)_2$:

a. 9
b. 10
c. 11
d. 12

8) The pH of 0.250 M HF is 2.036. What is the value of Ka for hydrofluoric acid (HF

a. 9.20×10^{-3}
b. 3.52×10^{-4}
c. 0.241
d. 2.6×10^{-6}

Question No.	Answer
1	C $C_2H_5OH > H_2CO_3 > HCO_2H > HF$
2	A Acidic
3	B Basic
4	B Shift to right
5	C a+b
6	A 3.2×10^{-5}
7	D 12
8	B 3.52×10^{-4}