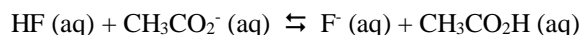


## ANSWERS TO EXTRA PROBLEMS FOR STUDY UNIT 8 (ACIDS AND BASES)

$\text{H}_3\text{PO}_4$ , fosforsuur, kan twee protone aan water skenk om die monowaterstoffsfaatioon,  $\text{HPO}_4^{2-}$  te vorm. Is die monowaterstoffsfaatioon 'n suur, 'n basis of amfiproties? /  *$\text{H}_3\text{PO}_4$ , phosphoric acid, can donate two protons to water to form the monohydrogen phosphate ion,  $\text{HPO}_4^{2-}$ . Is the monohydrogen phosphate ion an acid, a base or amphiprotic?*

- a) suur. / *acid.*
- b) basis. / *base.*
- c) **amfiproties. / *amphiprotic.***

Identifiseer die konjugaat suur/basis pare in die reaksie van HF en asynsuur. / *Identify the conjugate acid/base pairs in the reaction of HF and acetic acid.*



**HF /  $\text{F}^-$  and  $\text{CH}_3\text{CO}_2\text{H} / \text{CH}_3\text{CO}_2^-$**

Beskryf kortliks wat die ewewigskonstante vir water beteken. / *Shortly describe what the equilibrium constant for water means.*

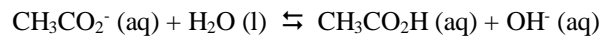


**$K_w$  is smaller than 1; therefor it is a reactant favoured reaction. At equilibrium very little product would have formed and most of the reagents will be unreacted at  $25^\circ\text{C}$ . Low  $[\text{H}_3\text{O}^+]$  and  $[\text{OH}^-]$ . High  $[\text{H}_2\text{O}]$  at equilibrium.**

Gebruik die volgende reaksies om 'n **Brønsted-Lowry** suur-basis reaksie; 'n **Lewis** suur-basis reaksie en 'n **Arrhenius** suur-basis reaksie te identifiseer: / *Use the following reactions to identify a **Brønsted-Lowry** acid-base reaction; a **Lewis** acid-base reaction and an **Arrhenius** acid-base reaction:*

<b>Suur-basis reaksie:</b> <i>Acid base reaction:</i>	<b>Tipe suur-basis reaksie volgens suur-basis teorieë hierbo gegee:</b> <i>Type of acid-base reaction according to acid-base theories given above.</i>
$\text{Fe}^{2+} + 6\text{H}_2\text{O} \rightleftharpoons [\text{Fe}(\text{H}_2\text{O})_6]^{2+}$	<b>Lewis acid-base</b>
$\text{HCl} + \text{NaOH} \rightleftharpoons \text{NaCl} + \text{H}_2\text{O}$	<b>Arrhenius acid-base</b>
$2\text{HCN} + \text{Na}_2\text{CO}_3 \rightleftharpoons 2\text{NaCN} + \text{H}_2\text{O} + \text{CO}_2$	<b>Brønsted-Lowry acid-base</b>

Bereken die pH van 'n 0.015 M natriumasetaat,  $\text{NaCH}_3\text{CO}_2$  oplossing. Die waarde van  $K_b$  vir die asetaatioon is  $5.6 \times 10^{-10}$  en die gebalanseerde ewewigsvergelyking is as volg: / Calculate the pH of a 0.015 M sodium acetate,  $\text{NaCH}_3\text{CO}_2$  solution. The value of  $K_b$  for the acetate ion is  $5.6 \times 10^{-10}$  and the balanced equilibrium equation is as follow:



	$\text{CH}_3\text{CO}_2^- (\text{aq})$	$\text{CH}_3\text{CO}_2\text{H} (\text{aq})$	$\text{OH}^- (\text{aq})$
<b>A</b>	<b>0.015</b>	<b>0</b>	<b>0</b>
<b>V</b>	<b>-x</b>	<b>+x</b>	<b>+x</b>
<b>E</b>	<b>0.015 - x</b>	<b>x</b>	<b>x</b>

$$K_b = 5.6 \times 10^{-10} = [\text{CH}_3\text{CO}_2\text{H}][\text{OH}^-] / [\text{CH}_3\text{CO}_2^-] = x^2 / 0.015 - x$$

$$x^2 / 0.015 = 5.6 \times 10^{-10}$$

$$x = 2.89 \times 10^{-6} \text{ M}$$

$$x = [\text{OH}^-] = [\text{CH}_3\text{CO}_2\text{H}] = 2.89 \times 10^{-6} \text{ M}$$

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

$$\text{pH} = 14 - \text{pOH} \quad (\text{pOH} = -\log 2.89 \times 10^{-6} = 5.54)$$

$$\text{pH} = 14 - 5.54 = 8.46$$

**OR**

$$K_w = 1.0 \times 10^{-14} = [\text{H}_3\text{O}^+][\text{OH}^-]$$

$$[\text{H}_3\text{O}^+] = K_w / [\text{OH}^-] = 1.0 \times 10^{-14} / 2.89 \times 10^{-6} = 3.5 \times 10^{-9} \text{ M}$$

$$\text{pH} = -\log (3.5 \times 10^{-9}) = 8.46$$

Twee suuroplossings het dieselfde konsentrasie ( $0.05 \text{ mol/dm}^3$ ), maar verskillende pH waardes. Gee 'n moontlike verduideliking vir hierdie waarneming. Gebruik asynsuur ( $\text{CH}_3\text{COOH}$ ) en soutsuur ( $\text{HCl}$ ) om jou verduideliking te illustreer. / *Two acid solutions have the same concentration ( $0.05 \text{ mol/dm}^3$ ), but different pH values. Give a possible explanation for this observation. Use acetic acid ( $\text{CH}_3\text{COOH}$ ) and hydrogenchloride ( $\text{HCl}$ ) to illustrate your explanation.*

**If HCl and  $\text{CH}_3\text{COOH}$  have the same concentration of  $0.05 \text{ mol/L}$  the pH of HCl will be 1.3.**

**The pH of  $\text{CH}_3\text{COOH}$  will be:**

$$K_a = 1.8 \times 10^{-5} = \frac{x^2}{0.05} \text{ thus } x = (1.8 \times 10^{-5} \times 0.05)^{1/2} = 0.000949 \text{ mol/L}$$

**The pH of acetic acid is 3.02 for the same concentration.**

**Strong acid dissociates 100% in water and a weak acid of the same concentration only dissociates say 5%.**

Verduidelik die volgende terme kortliks en gee 'n voorbeeld by elk. / *Shortly explain the following terms and give an example of each term.*

Amfiprotiese verbinding. / *Amphiprotic compound.*

**A substance that can act as an acid or a base.**

**$\text{H}_2\text{O}$  or  $\text{HCO}_3^-$  or  $\text{HSO}_4^-$**

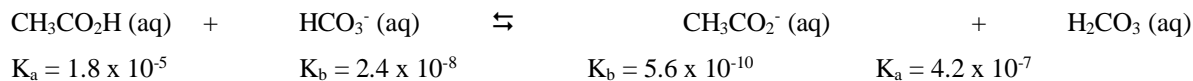
Poliprotiese bases. / *Polyprotic base.*

**A base that can receive more than one  $\text{H}^+$  e.g.  $\text{CO}_3^{2-}$  or  $\text{SO}_4^{2-}$**

Outoionisasie. / *Autoionization.*

**$\text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$  Autoionization is when a substance reacts with itself in an acid-base reaction. The substance that reacts with itself must be amphiprotic.**

Lê die ewewig in die reaksie hieronder hoofsaaklik na links of hoofsaaklik na regs? / *Does the equilibrium in the reaction below lie predominantly to the left or predominantly to the right?*



**Predominantly to the right**

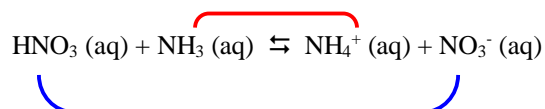
Watter van die volgende is 'n lys van Brønsted-Lowry sure? / Which of the following is a list of Brønsted-Lowry acids?

$\text{CH}_3\text{CO}_2\text{H}$ ;  $\text{Al}(\text{OH})_3$ ;  $\text{H}_3\text{PO}_4$

$\text{NH}_4^+$ ;  $\text{NH}_3$ ;  $\text{HCl}$

**$\text{H}_2\text{CO}_3$ ;  $\text{CH}_3\text{CO}_2\text{H}$ ;  $\text{H}_3\text{PO}_4$**

Skryf die gekonjugeerde suur-basis pare in die volgende reaksie neer en benoem die suur/basis en gekonjugeerde basis/suur. / Write down the conjugated acid-base pairs in the following reaction and name the acid/base and conjugated base/acid.



**$\text{HNO}_3 (\text{aq}) = \text{acid}$ ;  $\text{NO}_3^- (\text{aq}) = \text{conjugated base}$**

**$\text{NH}_3 (\text{aq}) = \text{base}$ ;  $\text{NH}_4^+ (\text{aq}) = \text{conjugated acid}$**

Wat is die pH van 'n 0.0012 M NaOH oplossing by 25 °C? / What is the pH of a 0.0012 M NaOH solution at 25 °C?

**$\text{pOH} = -\log 0.0012 = 2.92$**

**$\text{pH} = 14.00 - 2.92 = 11.08$**

Wat is die pH en die ion konsentrasies in 'n oplossing van 0.10 M natriumformaat, NaCHO<sub>2</sub>? K<sub>b</sub> vir die formaatioon, HCO<sub>2</sub><sup>-</sup> is 5.6 x 10<sup>-11</sup>. Wys al jou berekeninge. / What are the pH and ion concentrations in a solution of 0.10 M sodium formate, NaHCO<sub>2</sub>? K<sub>b</sub> for the formate ion, HCO<sub>2</sub><sup>-</sup> is 5.6 x 10<sup>-11</sup>. Show all your calculations.

	pH	[Na <sup>+</sup> ]	[CHO <sub>2</sub> <sup>-</sup> ]	[OH <sup>-</sup> ]
a.	5.63	0.10	0.10	2.4 x 10 <sup>-6</sup>
<b>b.</b>	<b>8.37</b>	<b>0.10</b>	<b>0.10</b>	<b>2.4 x 10<sup>-6</sup></b>
c.	8.22	0.050	0.050	1.7 x 10 <sup>-6</sup>
d.	5.63	0.10	0.10	4.2 x 10 <sup>-9</sup>
e.	8.22	0.10	0.050	1.7 x 10 <sup>-6</sup>

	NaCHO <sub>2</sub> (aq) + H <sub>2</sub> O (l)	OH <sup>-</sup> (aq)	+	CHO <sub>2</sub> H (aq)
<b>A</b>	<b>0.10</b>	<b>0</b>		<b>0</b>
<b>V</b>	<b>-x</b>	<b>+x</b>		<b>+x</b>
<b>E</b>	<b>0.10 - x</b>	<b>x</b>		<b>x</b>

$$5.6 \times 10^{-11} = x^2 / 0.1$$

$$X^2 = (5.6 \times 10^{-11})(0.10)$$

$$X = \text{square root of } 5.6 \times 10^{-12} = 2.36 \times 10^{-6} \approx 2.4 \times 10^{-6}$$

Therefore: [OH<sup>-</sup>] at equilibrium = 2.4 x 10<sup>-6</sup> M

[Na<sup>+</sup>] at equilibrium = 0.10 M

[CHO<sub>2</sub><sup>-</sup>] at equilibrium = 0.10 M

$$\text{pOH} = -\log 2.4 \times 10^{-6} = 5.63$$

$$\text{pH} = 14.00 - 5.63 = 8.37$$

Skryf 'n gebalanseerde ioniese vergelyking vir die reaksie wat voorkom tussen asynsuur en natriumbikarbonaat neer. Besluit dan of die ewewig hoofsaaklik na links of na regs sal wees. (Soek die  $K_a$  en  $K_b$  waardes self op).  
 Write a balanced, ionic equation for the reaction that occurs between acetic acid and sodium bicarbonate. Decide whether the equilibrium lies predominantly to the left or to the right. (Look the  $K_a$  and  $K_b$  values up yourself).



OR

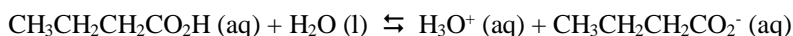


$\text{CH}_3\text{CO}_2\text{H} = 1.8 \times 10^{-5}$  is a stronger acid than  $\text{H}_2\text{CO}_3 = 4.2 \times 10^{-7}$

$\text{HCO}_3^- = 2.4 \times 10^{-8}$  is a stronger base than the acetate ion =  $\text{CH}_3\text{CO}_2^- = 5.6 \times 10^{-10}$

Therefore: Equilibrium are to the right.

'n Oplossing wat voorberei is uit 0.055 mol butanoësuur opgelos in genoeg water om 'n 1.0 L oplossing te gee, het 'n pH van 2.72. Bepaal  $K_a$  vir butanoësuur deur van 'n AVE tabel gebruik te maak. Die suur ioniseer volgens die volgende gebalanseerde vergelyking. / A solution prepared from 0.055 mol of butanoic acid dissolved in sufficient water to give 1.0 L of solution has a pH of 2.72. Determine  $K_a$  for butanoic acid using an ICE table. The acid ionizes according to the following balanced equation.



$$C_{\text{butanoic acid}} = 0.055 \text{ mol} / 1.0 \text{ L} = \underline{0.055 \text{ M}}$$

$$\text{pH} = 2.72; [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-2.72} = \underline{1.9 \times 10^{-3} \text{ M (0.0019 M)}}$$

	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H (aq)}$	+	$\text{H}_2\text{O (l)}$		$\text{H}_3\text{O}^+ \text{ (aq)}$	+	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2^- \text{ (aq)}$
I	0.055				0		0
C	- x				+ x		+ x
E	0.055 - x				x		x

At equilibrium the pH = 2.72; therefor the  $[\text{H}_3\text{O}^+] = 1.9 \times 10^{-3} \text{ M} = x$

At equilibrium:  $[\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}] = 0.055 - 1.9 \times 10^{-3} = \underline{0.0531 \text{ M}}$

$$[\text{H}_3\text{O}^+] = \underline{1.9 \times 10^{-3} \text{ M}}$$

$$[\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2^-] = \underline{1.9 \times 10^{-3} \text{ M}}$$

$$K_a = [\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2^-][\text{H}_3\text{O}^+] / [\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H}] = [1.9 \times 10^{-3}]^2 / [0.0531] = 3.61 \times 10^{-6} / 0.0531$$

$$K_a = \underline{6.8 \times 10^{-5}} \text{ (6.79} \times 10^{-5}\text{)}$$