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

H_3PO_4, fosforsuur, kan twee protone aan water skenk om die monowaterstoffosfaatioon, HPO_4^{2-} te vorm. Is die monowaterstoffosfaatioon 'n suur, 'n basis of amfiproties? / *H_3PO_4, phosphoric acid, can donate two protons to water to form the monohydrogen phosphate ion, 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.*

$HF (aq) + CH_3CO_2^- (aq) \leftrightarrows F^- (aq) + CH_3CO_2H (aq)$

HF / F^- and $CH_3CO_2H / CH_3CO_2^-$

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

$2H_2O (l) \leftrightarrows H_3O^+ (aq) + OH^- (aq)$ $K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$ by/at 25 ^{0}C

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 °C. Low $[H_3O^+]$ and $[OH^-]$. High $[H_2O]$ 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:*

Suur-basis reaksie: ***Acid base reaction:***	**Tipe suur-basis reaksie volgens suur-basis teorieë hierbo gegee:** ***Type of acid-base reaction according to acid-base theories given above.***
$Fe^{2+} + 6H_2O \leftrightarrows [Fe(H_2O)_6]^{2+}$	**Lewis acid-base**
$HCl + NaOH \leftrightarrows NaCl + H_2O$	**Arrhenius acid-base**
$2HCN + Na_2CO_3 \leftrightarrows 2NaCN + H_2O + CO_2$	**Brønsted-Lowry acid-base**

Bereken die pH van 'n 0.015 M natriumasetaat, $NaCH_3CO_2$ oplossing. Die waarde van K_b vir die asetaatioon is 5.6 x 10^{-10} en die gebalanseerde ewewigsvergelyking is as volg: / *Calculate the pH of a 0.015 M sodium acetate, $NaCH_3CO_2$ solution. The value of K_b for the acetate ion is 5.6 x10^{-10} and the balanced equilibrium equation is as follow:*

$$CH_3CO_2^- (aq) + H_2O (l) \leftrightarrows CH_3CO_2H (aq) + OH^- (aq)$$

	$CH_3CO_2^-$ (aq)	**CH_3CO_2H (aq)**	**OH^- (aq)**
A	**0.015**	**0**	**0**
V	**-x**	**+x**	**+x**
E	**0.015 - x**	**x**	**x**

$K_b = 5.6 \times 10^{-10} = [CH_3CO_2H][OH^-] / [CH_3CO_2^-] = x^2 / 0.015 - x$

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

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

$x = [OH^-] = [CH_3CO_2^-] = 2.89 \times 10^{-6}$ M

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pH + pOH = 14

pH = 14 - pOH (pOH = -log 2.89×10^{-6} = 5.54)

pH = 14 - 5.54 = 8.46

OR

$K_w = 1.0 \times 10^{-14} = [H_3O^+][OH^-]$

$[H_3O^+] = K_w / [OH^-] = 1.0 \times 10^{-14} / 2.89 \times 10^{-6} = 3.5 \times 10^{-9}$ M

pH = -log (3.5×10^{-9}) = 8.46

Twee suuroplossings het dieselfde konsentrasie (0.05 mol/dm^3), maar verskillende pH waardes. Gee 'n moontlike verduideliking vir hierdie waarneming. Gebruik asynsuur (CH_3COOH) en soutsuur (HCl) om jou verduideliking te illustreer. / *Two acid solutions have the same concentration (0.05 mol/dm^3), but different pH values. Give a possible explanation for this observation. Use acetic acid (CH_3COOH) and hydrogenchloride (HCl) to Illustrate your explanation.*

If HCl and CH_3COOH have the same concentration of 0.05 mol/L the pH of HCl will be 1.3.
The pH of CH_3COOH will be:
$Ka = 1.8 \times 10^{-5} = X^2 / 0.05$ thus $x = (1.8 \times 10^{-5} \times 0.05)^{½} = 0.000949$ 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.
H_2O or HCO_3^- or HSO_4^-

Poliprotiese bases. / *Polyprotic base.*

A base that can receive more than one H^+ e.g. CO_3^{2-} or SO_4^{2-}

Outoionisasie. / *Autoionization.*

$H_2O + H_2O \leftrightharpoons H_3O^+ + OH^-$ Autoionization is when a substances 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 reaksion below lie predominantly to the left or predominantly to the right?*

CH_3CO_2H (aq)	+	HCO_3^- (aq)	$\leftrightharpoons$	$CH_3CO_2^-$ (aq)	+	H_2CO_3 (aq)
$K_a = 1.8 \times 10^{-5}$		$K_b = 2.4 \times 10^{-8}$		$K_b = 5.6 \times 10^{-10}$	$K_a = 4.2 \times 10^{-7}$	

Predominantly to the right

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

CH_3CO_2H; $Al(OH)_3$; H_3PO_4

NH_4^+; NH_3; HCl

H_2CO_3; CH_3CO_2H; H_3PO_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.*

$$HNO_3\,(aq) + NH_3\,(aq) \leftrightarrows NH_4^+\,(aq) + NO_3^-\,(aq)$$

HNO_3 (aq) = acid; NO_3^- (aq) = conjugated base

NH_3 (aq) = base; NH_4^+ (aq) = conjugated acid

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

pOH = - log 0.0012 = 2.92

pH = 14.00 – 2.92 = 11.08

Wat is die pH en die ioon konsentrasies in 'n oplossing van 0.10 M natriumformaat, $NaCHO_2$? K_b vir die formaatioon, HCO_2^- is 5.6×10^{-11}. Wys al jou berekeninge. / *What are the pH and ion concentrations in a solution of 0.10 M sodium formate, $NaHCO_2$? K_b for the formate ion, HCO_2^- is 5.6×10^{-11}. Show all your calculations.*

	pH	$[Na^+]$	$[CHO_2^-]$	$[OH^-]$
a.	5.63	0.10	0.10	2.4×10^{-6}
b.	**8.37**	**0.10**	**0.10**	**2.4×10^{-6}**
c.	8.22	0.050	0.050	1.7×10^{-6}
d.	5.63	0.10	0.10	4.2×10^{-9}
e.	8.22	0.10	0.050	1.7×10^{-6}

	$NaCHO_2$ (aq) + H_2O (l)	OH^- (aq)	+	CHO_2H (aq)
A	**0.10**	**0**		**0**
V	**-x**	**+x**		**+x**
E	**0.10 – x**	**x**		**x**

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

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

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

Therefor: **$[OH^-]$ at equilibrium = 2.4×10^{-6} M**

$[Na^+]$ at equilibrium = 0.10 M

$[CHO_2^-]$ at equilibrium = 0.10 M

pOH = -log 2.4×10^{-6} = 5.63

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).

CH_3COOH (aq) + $NaHCO_3$ (aq) ⇆ $CH_3COO^-Na^+$ (aq) + H_2CO_3 (aq)

OR

CH_3COOH (aq) + HCO_3^- (aq) ⇆ CH_3COO^- (aq) + H_2CO_3 (aq)

CH_3CO_2H = 1.8×10^{-5} is a stronger acid than H_2CO_3 = 4.2×10^{-7}
HCO_3^- = 2.4×10^{-8} is a stronger base than the acetate ion = $CH_3CO_2^-$ = 5.6×10^{-10}
Therefor: 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.*

$CH_3CH_2CH_2CO_2H$ (aq) + H_2O (l) ⇆ H_3O^+ (aq) + $CH_3CH_2CH_2CO_2^-$ (aq)

$C_{butanoic\ acid}$ = 0.055 mol / 1.0 L = <u>0.055 M</u>
pH = 2.72; $[H_3O^+] = 10^{-pH} = 10^{-2.72}$ = <u>1.9×10^{-3} M (0.0019 M)</u>

	$CH_3CH_2CH_2CO_2H$ (aq) +	H_2O (l)	H_3O^+ (aq)	+	$CH_3CH_2CH_2CO_2^-$ (aq)
I	**0.055**		**0**		**0**
C	**- x**		**+ x**		**+ x**
E	**0.055 – x**		**x**		**x**

At equilibrium the pH = 2.72; therefor the $[H_3O^+]$ = 1.9×10^{-3} M = x
At equilibrium: $[CH_3CH_2CH_2CO_2H]$ = 0.055 – 1.9×10^{-3} = <u>0.0531 M</u>
$[H_3O^+]$ = <u>1.9×10^{-3} M</u>
$[CH_3CH_2CH_2CO_2^-]$ = <u>1.9×10^{-3} M</u>

Ka = $[CH_3CH_2CH_2CO_2^-][H_3O^+] / [CH_3CH_2CH_2CO_2H]$ = $[1.9 \times 10^{-3}]^2$ / [0.0531] = 3.61×10^{-6} / 0.0531
Ka = <u>6.8×10^{-5}</u> (6.79×10^{-5})