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CHEMISTRY

WORK SHEET

ACIDS & BASES

Acids and Bases – Lowry Concept

The Bronsted-Lowry theory, which is a fundamental concept in chemistry, defines an

- Acid is a substance that donates a proton (H+)
- Base is a substance that accepts a proton (H+).

An acid-base reaction involves the transfer of a proton from the acid to the base. This transfer of the proton results in the formation of a new acid and a new base.

Please identify the acids and bases mentioned in the table provided below.

Exercise 1

	Acid	Base
i) $H_2O + H_2SO_4 \rightarrow H_3O^+ + HSO_4^+$		
ii) $H_2O + HCl \rightarrow H_3O^+ + Cl^-$		
iii) $HBr + NH_3 \rightarrow NH_4Br + H_2O$		
iv) $CH_3OH + HNO_3 \rightarrow NO_3^+ + CH_3OH_2$		
v) $NH_3 + HCL \rightarrow NH_4Cl$		
vi) $HCO_3^- + OH^- \rightarrow CO_3^{2-} + H_2O$		
vii) $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$		
viii) $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^*$		

Monoprotic & Diprotic acids

Monoprotic acids are acids that release one proton (H+) per molecule.

Examples include hydrochloric acid (HCl), nitric acid (HNO_3), and ethanoic acid (CH_3COOH).

Diprotic acid is an acid that releases two hydrogen ions per molecule.

For instance, H_2SO_4 (sulfuric acid) and $H_2C_2O_4$ (ethanedioic acid) are examples of diprotic acids.

Exercise 2

Moles Of Acid	Moles Of H^+
3 moles of HNO_3	
2 moles of HCL	
4 moles of H_2SO_4	
0.3 moles of HNO_3	
0.3 moles of H_2SO_4	

Calculating PH and [H+] ions.

It is a scale used to specify the acidity or basicity of an aqueous solution.
The formula to calculate the PH is:

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

If the pH is known and [H+] needs to be calculated, use the following formula,

$[H^+] = 1 \times 10^{-ph}$

Exercise 3

$[H^+]$	0.00300		2.50		$1.25*10^{-3}$		$3.5 * 10^{-12}$		
pH		1.75		2.20		11.40		2.55	-0.50

Calculate the pH of Strong Acids

Use the formula mentioned above to calculate the pH of strong acids. Remember that strong acids are going to dissociate fully.

Example:

Calculate the pH of 0.700 mol dm^{-3} $HClO_3$?

As it is a monoprotic strong acid, H^+ concentration would be the same as the acid's.

[H+] = 0.7 mol/dm^3
pH = -log [0.7]
= 0.15

Exercise 4(a)

Calculate the pH of the following solutions

a) 0.7 mol dm^{-3} $HClO_4$

b) 0.15 mol dm^{-3} HNO_3

c) 0.24 mol dm^{-3} HBr

d) 1.75 mol dm^{-3} H_2SO_3

e) 0.45 mol dm^3 HI

Example:

[HNO] with pH 1.20?

$[H^+] = 1 \times 10^{-1.2}$
$= 0.63$ mol dm^{-3}

Exercise 4(b)

Calculate the concentration of the following acids.

a) HBr with pH 2.55

b) H_2SO_4 with pH 1.10

c) $HCLO_4$ with pH 2.25

d) HCl with pH 1.97

e) $HClO_3$ with pH 3.66

f) H_2SO_4 with pH -0.50

PH calculation of diluted solution of a strong acid

Calculate the pH of the solution formed when 200 cm^3 of water is added to 150 cm^3 of 0.200 mol dm^{-3} HCl.

$[H^+]$ in original HCl solution = 0.200

$[H^+]$ in diluted solution = $0.200 \times \frac{\text{old volume}}{\text{new volume}} = 0.200 \times \frac{150}{350} = 0.0857$

pH = -log 0.0857 = 1.067

Exercise 4(c)

Calculate the pH of the solutions formed in the following way.

a) addition of 150 cm^3 of water to 25 cm^3 of 0.400 mol dm^{-3} HBr

b) addition of 250 cm^3 of water to 120 cm^3 of 0.300 mol dm^{-3} HNO3

c) adding water to 110 cm^3 of 4.00 mol dm^{-3} H_2SO_4 to make 700 cm^3 of solution

d) adding water to 25 cm^3 of 1.50 mol dm^{-3} $HClO_4$ to make 650 cm^3 of solution

Calculate the pH of the Solutions

Sometimes, you would be given concentration of acid in grams which needs to be converted to moles, and then you would be asked to calculate the pH.

Exercise 4(d)

Calculate the pH of the following solutions.

a) 20 g dm^{-3} HBr

b) 70 g dm^{-3} H_2SO_4

c) 0.04 mol dm^{-3} **HCl**

c) 140 g dm^{-3} HNO_3

d) 100 g dm^{-3} $HClO_4$

Ionic Product of water

The Ionic Product of Water, also known as Kw, refers to the equilibrium constant of the self-ionization reaction of water.

In simpler terms, it is the reaction between two water molecules resulting in the formation of hydronium (H_3O^+) and hydroxide (OH^-) ions.

The value of Kw always remains constant at 25°C and equals $1.0 \times 10^{-14.}$

Formula for the ionic product of water is,

$$Kw = [H^+][OH^-]$$

Exercise 4(e)

Calculate the pH of water at 40.C given that Kw = 2.916×10^{-14} $mol^2\ dm^{-6}$

Calculate the pH of water at 30.C given that Kw = 1.471×10^{-14} $mol^2\ dm^{-6}$

Calculate the pH of water at 20.C given that Kw = 0.681×10^{-14} $mol^2\ dm^{-6}$

Calculate the pH of water at 50.C given that Kw = 5.476×10^{-14} $mol^2\ dm^{-6}$

Calculate the pH of water at 100.C given that Kw = 51.3×10^{-14} $mol^2\ dm^{-6}$

Calculate the PH of Strong Bases

- Calculate the pH of a strong base pH of 0.500 mol dm^{-3} KOH?

[OH-] = 0.500

$$[H+] = \frac{Kw}{[OH-]} = \frac{10^{-14}}{0.200} = 2 \times 10^{-14}$$

pH = -log[H+] = -log (2×10^{-14}) = 13.67

Exercise 4(f)

Calculate the concentration of the following bases.

a) KOH with pH 13.20

b) $Ca(OH)_2$ with pH 12.90

c) NaOH with pH 11.20

d) CsOH with pH 10.88

e) LiOH with pH 12.13

- Calculate the concentration of base in the following solutions.

NaOH with a pH of 11.7?

$[H+] = 10^{-pH} = 10^{-11.70} = 1.995 \times 10^{-12}$

$[OH-] = \frac{Kw}{[H+]} = \frac{10^{-14}}{1.995 \times 10^{-12}} = 5 \times 10^{-3}$

$[KOH] = 5 \times 10^{-3}$ mol dm^{-3}

Exercise 4(g)

Calculate the pH of the following solutions.

a) 40 g dm^{-3} LiOH

b) 150 g dm^{-3} NaOH

c) 175 g dm^{-3} $Ba(OH)_2$

d) 225 g dm^{-3} $Ca(OH)_2$

e) 30 g dm^{-3} $Rb(OH)_2$

PH calculation of diluted solution of a strong base

Calculate the pH of the solution formed when 150 cm^3 of water is added to 100 cm^3 of 0.100 mol dm^{-3} NaOH.

$[OH^-]$ in original NaOH solution = 0.100

$$[OH^-] \text{ in diluted solution} = 0.100 \times \frac{\text{old volume}}{\text{new volume}} = 0.200 \times \frac{100}{250} = 0.08$$

$$[H^+] = \frac{K_w}{[OH^-]} = \frac{10^{-14}}{0.08} = 1.25 \times 10^{-13}$$

$$pH = -\log(1.25 \times 10^{-13}) = 12.9$$

Exercise 4(h)

Calculate the pH of the solutions formed in the following way.

a) addition of 200 cm^3 of water to 35 cm^3 of 0.150 mol dm^{-3} KOH

b) addition of 45 cm^3 of water to 200 cm^3 of 0.200 mol dm^{-3} Ca(OH)2

c) adding water to 400 cm^3 of 1.00 mol dm^{-3} LiOH to make 1.5 dm^3 of solution.

d) addition of 175 cm^3 of water to 65 cm^3 of 0.250 mol dm^{-3} CsOH

e) addition of 270 cm^3 of water to 75 cm^3 of 0.150 mol dm^{-3} Sr(OH)2

Calculate the pH of the solutions

Sometimes, you would be given concentration in grams, which need to be converted to moles and then you would be asked to calculate the pH.

Exercise 4(i)

Calculate the pH of the following solutions.

a) 40 g dm^{-3} LiOH

b) 150 g dm^{-3} NaOH

c) 175 g dm^{-3} $Ba(OH)_2$

d) 225 g dm^{-3} $Ca(OH)_2$

e) 30 g dm^{-3} $Rb(OH)_2$

Exam Questions

Which is the concentration of NaOH(aq), in mol dm^{-3}, that has pH = 14.30?

$K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C

A -1.16

B 5.01×10^{-15}

C 2.00×10^{14}

D 2.00

Give the meaning of the term Brønsted–Lowry acid.

Table 1 shows how K_w varies with temperature.

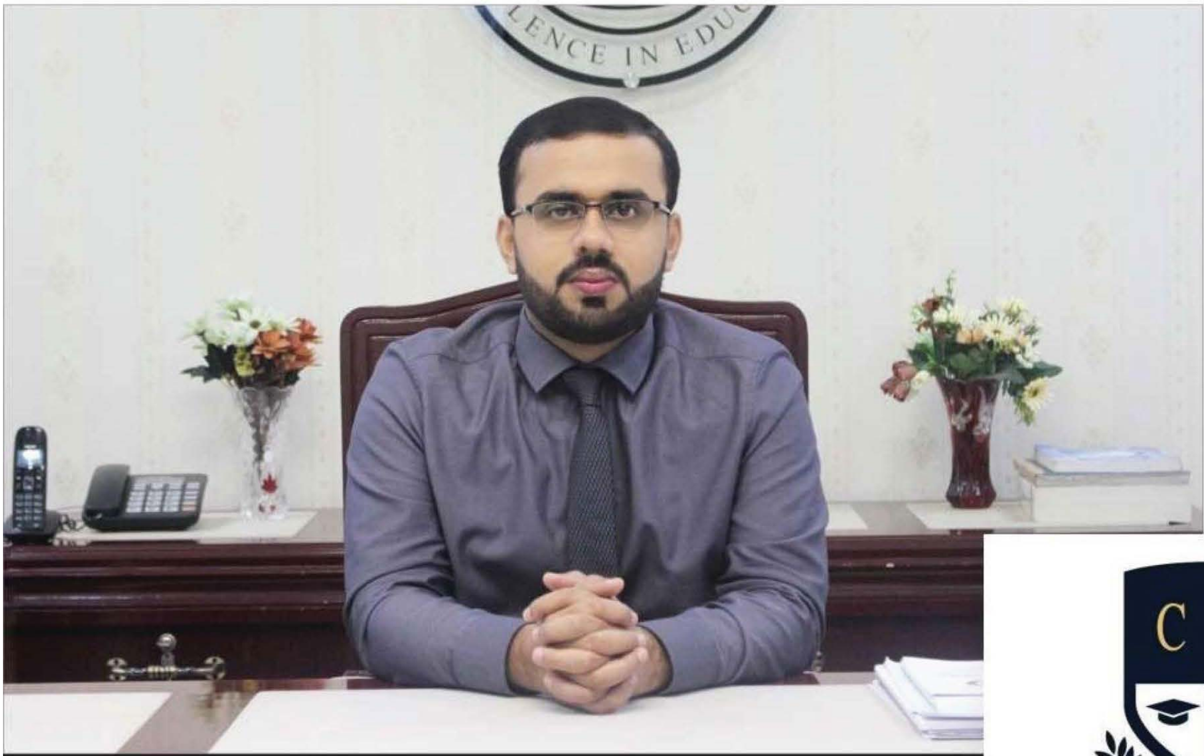
Table 1

Temperature / °C	**K_w / mol² dm⁻⁶**
10	2.93×10^{-15}
20	6.81×10^{-15}
25	1.00×10^{-14}
30	1.47×10^{-14}
50	5.48×10^{-14}

Give the expression for pH.

Calculate the pH of pure water at 50 °C
Give your answer to 2 decimal places.

Explain why water is neutral at 50 °C



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