The pH SCALE and NEUTRALIZATION

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Acids & Bases

• When acids are added to water, they form positively charged hydrogen ions (H^+) . The presence of H^+ ions cause the solution to be acidic

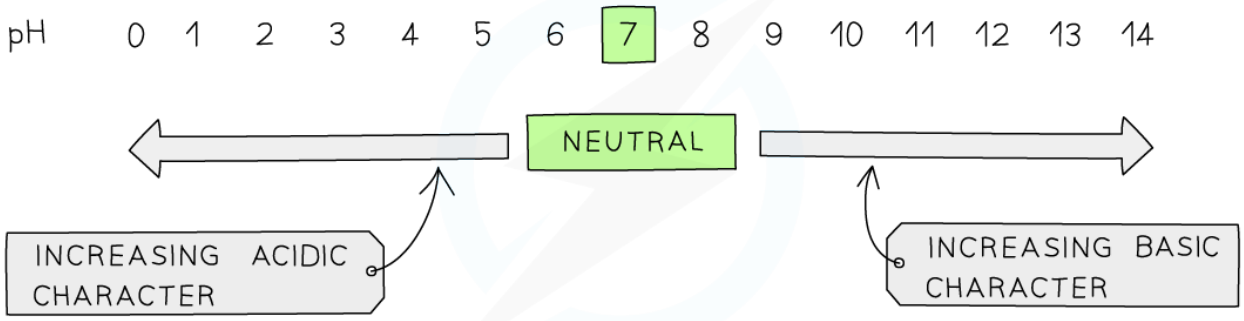
• When alkalis are added to water, they form negative hydroxide ions (OH^-). The presence of OH^- ions are what makes aqueous solutions alkaline

The pH Scale

The pH scale is a numerical scale used to indicate how acidic or alkaline a solution is, as it is a measure of the amount of hydrogen ions present in the solution. The pH scale ranges from 1 to 14.

- All acids have pH value below 7, extremely acidic substances may have a value lower than 1. The lower the pH, the more acidic the solution .
- all alkalis have pH value above 7. The higher the pH, the more alkaline the solution
- pH 7 solution is described as neutral

The pH scale showing acidity, neutrality, and alkalinity



pH Measurement

pH can be measured using **an indicator** or **digital pH meter.**

The pH meter consists of a special electrode with a thin glass membrane that allows hydrogen ions to pass through. The ion changes the voltage recorded by the electrode

An **indicator** is a substance that changes colour depending on the pH of the added solution. There are **natural indicators** and **synthetic indicators** in use. In general, the **natural indicator** is a variety of indicators , which contains a mixture of different plant extracts. Therefore, it can work over a wide range of pH values. Most **synthetic indicators** have a very narrow pH range that works. They have sharp colour changes meaning they change colour quickly and abruptly as soon as a pH specific to that indicator is reached. The indicator is highly coloured and sensitive, so only a few drops are needed.

Neutralization

• A Neutralization reaction takes place when an acid reacts with an alkali. When these substances react together in a neutralization reaction, H^+ ions react with OH^- ions to produce water.

• This is the net ionic equation for acid-base neutralisations, and this is what leads to a neutral solution, since water has a pH of 7:

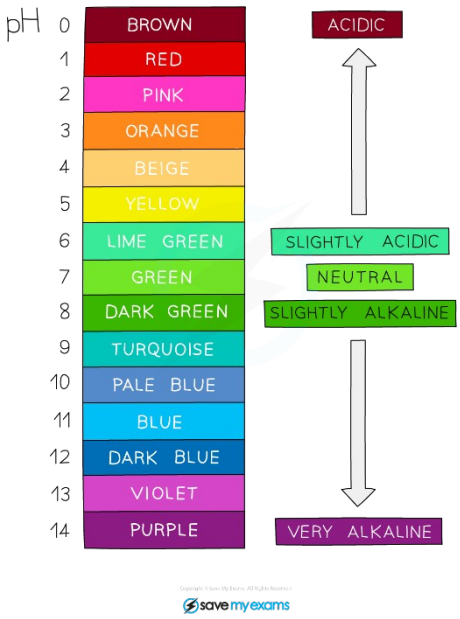
$$H^+ + OH^- \longrightarrow H_2O$$

Not all acid reactions neutralise ; For example, when a metal reacts with an acid, although a salt is produced there is no water formed so it does not fit the definition of neutralisation

• Neutralization is very important in soil treatment to increase pH, as some plants cannot tolerate low pH below 7. This can be done by adding base to the soil, such as limestone and lime

Universal Indicator

- Universal indicator is a wide range indicator and can give only an approximate value for pH
- It is made of a mixture of different plant **indicators** which operate across a broad pH range and is useful for estimating the pH of an **unknown solution**
- A few drops are added to the solution and the colour is matched with a colour chart which indicates the pH which matches with specific colours
- Universal indicator colours vary slightly between manufacturer, so colour charts are usually provided for a specific indicator formulation



ACTIVITY 1

Instruction: Search and find the words listed below in the crossword puzzle.

hydroxide chemical equation word equation product reactant
chemical formula polyatomic monatomic anion cation ion compound
element mass number atomic number nucleus neutron proton
electron atoms neutralisation electron arrangement bases acids

S O T Q D A S S N Z N L M W E C R E A C T A N T
Y D F M N O R H O T E Q C O N O I T A C V T M O
W O M O O L G C I T U M H P D F F F F Z R L G I
N O B M I F I A W C T R E H B Z A P I R U G W Y
I O N H N V C R X U R U M W C D Z T G R Z S I E
C T F Q A X I N R D A Y I H I K K N X R A P Y H
Y O C H F U E N G O L Q C A M H E E C D A H Z K
I N O W I T W O Q R I R A M O U B M G W T T U N
Y U M Z T V N T T P S I L O T U Y E E O O G Y L
G C P Y A T O O M Q A M E N Y K Y G O R M U I E
T L O K L M R R I W T D Q A L M K N B D I E M C
V E U W U D T P B N I X U T O F I A A E C Q Y L
C U N N M Y C Q O E O P A O P I W R H Q N E F L
S S D I R F E N Q U N Y T M T R R E Y U U Z K L
E N J F O B L K G T I M I I V E B N Y A M I J Z
S U V R F V E E Z R E T O C E B P O P T B H P E
A G B S L P B T K O J N N H E M V R I I E E H D
B N I D A K V G C N E E Y Z S U M T J O R Z V I
H P C A C H W N R S W M V Z E N R C H N Z W Z X
Q V A M I X X Q P G L E F I B S C E X Y E V Y O
R I C B M F X U W S G L K O O S L L O R S V C R
L O I E E P T A G M Z E P F N A J E A O T P D D
B H D B H N I P S E N E J D C M L R E N W W W Y
V R S I C L S M O T A S F E Z B P X G N J Q C H

Activity 2

Neutralization Reaction: Acid + Base → Salt + Water H^+ from acid and OH^- from base combine to form H_2O. Leftovers form 'salt'. Remember in salt, write metal first! KCl not ClK!

Write the balanced chemical equations for the neutralization reactions between the listed acid and base.

Example 1: $HI + NaOH \rightarrow H_2O + NaI$
H and OH combine to form water. One atom of I & one of Na leftover. Na is a metal so write NaI (not INa)

1) $Ca(OH)_2$ and H_3PO_4
2) $Zn(OH)_2$ and HNO_3
3) HI and NaOH
4) H_2CO_3 and $Sr(OH)_2$
5) $Al(OH)_3$ and HCl
6) HBr and $Ba(OH)_2$

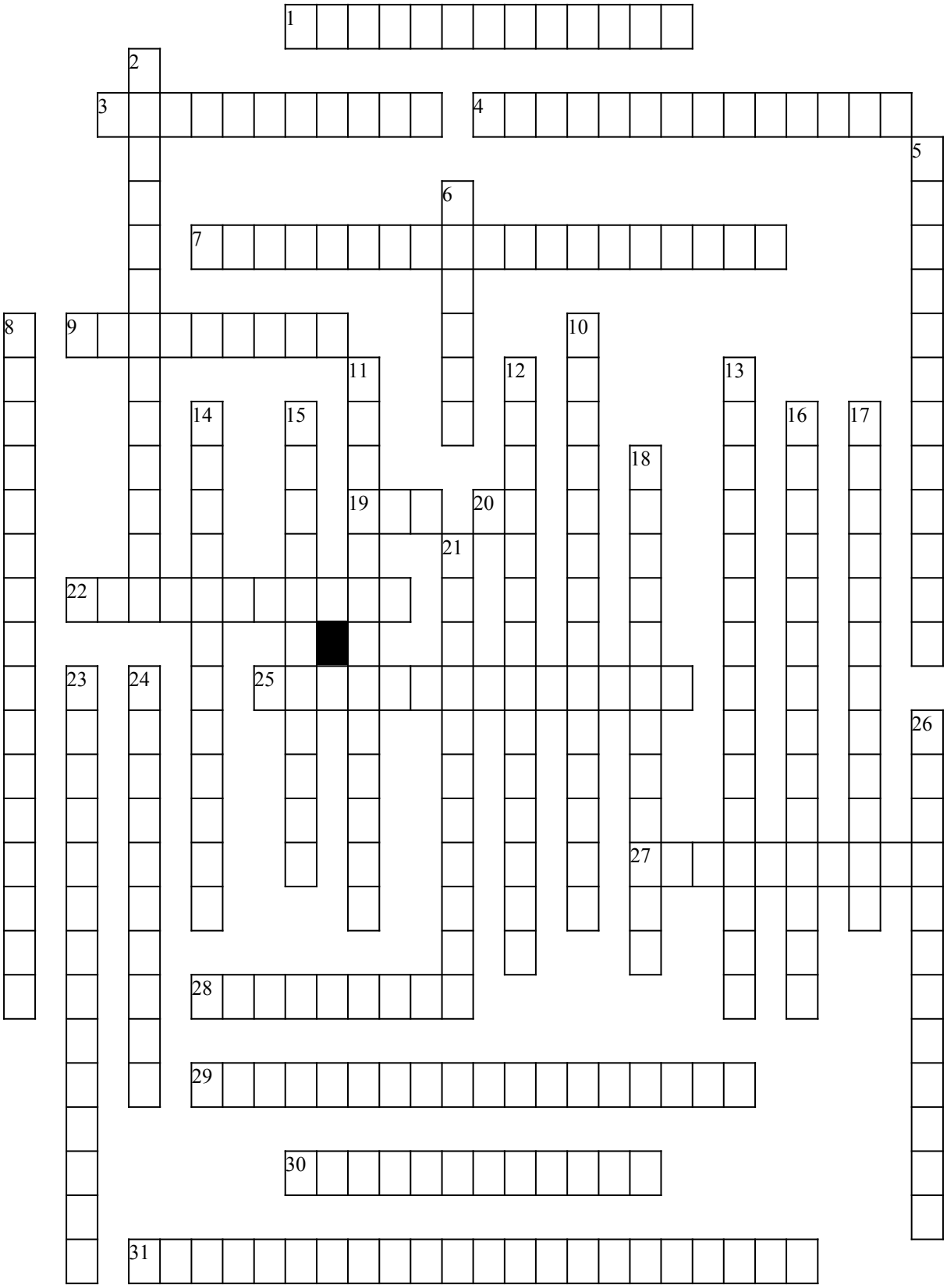
ACTIVITY 3

Complete and balance the following equations representing neutralization reactions:

HF	+	$Mg(OH)_2$	→		+	
	+		→	H_2O	+	KCl
HNO_3	+	$Al(OH)_3$	→		+	$Al(NO_3)_3$
	+		→	H_2O	+	$LiBrO_3$
CsOH	+	H_2CO_3	→		+	

Activity 4

Instructions: Using the hints provided fill in the correct words in the crossword puzzle.



Across

1. The species produced when an acid donates a hydrogen ion to form a base.
3. pOH = -log[OH^-]
4. Low pOH and high pH
7. A substance which can behave as either a B/L acid or a B/L base, depending on the circumstances.
9. Bases that ionize only partially in dilute aqueous solution to form the conjugate acid and hydroxide ions.
19. A measure of the strength of an acid or base solution which is based on the amount of OH- ion.
20. A measure of the strength of an acid or base solution which is based on the amount of H^+ ion
22. H^+
25. Have pH > 7
27. Chemicals that change color in the presence of acids or bases.
28. Acids that only ionize partially in solution.
29. An acid is defined as a hydrogen-ion donor and a base is a hydrogen-ion acceptor.
30. LiOH NaOH KOH $Ca(OH)_2$ $Sr(OH)_2$ $Ba(OH)_2$
31. Two substances related to each other by the donating and accepting of a single H^+ ion.

Down

2. The species produced when a base accepts a hydrogen ion to form an acid.
5. A polyprotic acid that has two acidic H+ ions. An example is H_2SO_4.
6. An indicator that is used to determine if a solution is acidic or basic. Red litmus turns blue for bases, while blue litmus turns red for acids.
8. Have pH = 7
10. An acid that has two or more acidic H^+ ions.
11. A polyprotic acid that has three acidic H^+ ions. An example is H_3PO_4.
12. Acid contains H and dissociates to produce H^+ ions in aqueous solution, while a base contains OH and dissociates to produce OH- ions in aqueous solution.
13. Low pH and high pOH
14. H_3O^+ (can be used interchangeably with H^+)
15. Acids that ionize completely in solution.
16. An acid that has only one acidic H^+ ion
17. OH^-
18. HCl HBr HI H_2SO_4 $HClO_4$ HNO_3
21. Bases that dissociate entirely into metal ions and hydroxide (OH-) ions in aqueous solution (Arrhenius base).
23. Have pH < 7
24. pH = -log[H^+]
26. When acids and bases ionize - fall apart - in solution to form electrolyte solutions

ACTIVITY 5

1. The following is a neutralization reaction:

$ACID + KOH \rightarrow KBr + H_2O$

In this reaction, which acid is neutralizing KOH?

a) HNO_3
b) HBr
c) H_3PO_4
d) H_2SO_4
e) HCl

2. Consider the following reaction

$$Ba(OH)_2+H_2CO_3 \rightarrow ?$$

What product or products are formed during the neutralization reaction?

a) $BaCO_3+O_2+2H_2$
b) $BaCO_3+2H_2$
c) $BaCO_3$
d) $Ba(OH)_2+H_2O+CO_2$
e) $CO_3(OH)_2+H_2Ba$

3. What salt is produced when phosphoric acid (H_3PO_4) is neutralized by lithium hydroxide?
   a) $PO_4(OH_2)_3$
   b) POH_2
   c) H_2O
   d) LiH_3
   e) Li_3PO_4

4. A neutralization reaction is shown below:

$$HNO_{3(aq)}+KOH_{(aq)} \rightarrow KNO_{3(aq)}+H_2O_{(l)}$$

What is the acid in this equation?

a) KOH
b) KNO_3
c) HNO_3
d) H_2O

What is the base in this equation?

a) KNO_3
b) HNO_3
c) H_2O
d) KOH

What is the salt in this equation?

a) KOH
b) KNO_3
c) H_2O
d) HNO_3

5. What does the term *neutralization* mean when applied to a chemical reaction?
   a) The reaction between an acid and a base
   b) The reaction between water and ionic compounds
   c) The reaction between a base and a gas

d) The reaction between an acid and a metal
e) The dissociation of a substance to form H^+ ions

6. A neutralization reaction is complete when all the acid and base have reacted. The equation below shows the reaction between HCl and NaOH:

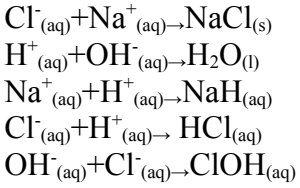
$$HCl+NaOH \rightarrow NaCl+H_2O$$

If 100 mL of 0.1 M HCl is added to 100 mL of 0.2 M NaOH, why does **not** a complete neutralization occur?

a) The reaction is reversible.
b) There is not an equal volume of acid and base.
c) NaOH is more concentrated than HCl.
d) There is not an equal number of moles of acid and base.
e) HCl is a weak acid and so does not fully ionize.

7. Which of the following is the correct balanced equation for the reaction between hydrochloric acid and calcium hydroxide?
   a) $H_2Cl_{(aq)} + Ca(OH)_{2(aq)} \rightarrow CaCl_{(aq)} + 2H_2O_{(l)}$
   b) $HCl_{(aq)} + Ca(OH)_{2(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)}$
   c) $2HCl_{(aq)} + 2CaOH_{(aq)} \rightarrow 2CaCl_{2(aq)} + 2H_2O_{(l)}$
   d) $2HCl_{(aq)} + Ca(OH)_{2(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$
   e) $HCl_{(aq)} + CaOH_{(aq)} \rightarrow CaCl_{(aq)} + H_2O_{(l)}$,

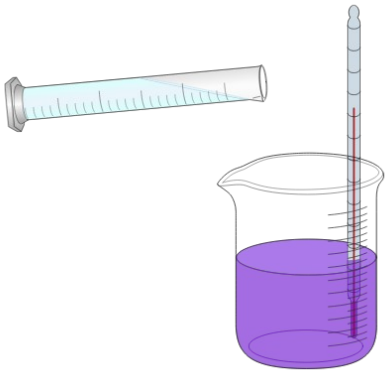
8. In aqueous solution, HCl reacts with NaOH to form NaCl and HO2.How can this neutralization reaction be written as a net ionic equation?



$Cl^-_{(aq)} + Na^+_{(aq)} \rightarrow NaCl_{(s)}$
$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
$Na^+_{(aq)} + H^+_{(aq)} \rightarrow NaH_{(aq)}$
$Cl^-_{(aq)} + H^+_{(aq)} \rightarrow HCl_{(aq)}$
$OH^-_{(aq)} + Cl^-_{(aq)} \rightarrow ClOH_{(aq)}$

9. In general, which products are produced by acid–base neutralization reactions in aqueous solution?
   a) Water only
   b) Salt and water
   c) Salt only
   d) Hydrogen and carbon dioxide
   e) Water and carbon dioxide

10. The diagram below shows an experiment to investigate a neutralization reaction. 50 mL of 1 M LiOH was placed into a beaker. A thermometer was also placed into the beaker. Upon the addition of a few drops of universal indicator, the solution turned dark purple. A 50mL solution of 0.5M H_2SO_4 was then added to the beaker. What observations would you expect to see upon the addition of H_2SO_4?



a) The temperature would stay the same and the solution would turn green.
b) The temperature would decrease, and the solution would turn dark red.
c) The temperature would increase, and the solution would turn green.
d) The temperature would increase, but the solution would remain dark purple.
e) The temperature would stay the same and the solution would remain dark purple.

ACTIVITY 6

Instructions: Calculate the pH and pOH of the solutions in the questions given.

Example 1

Calculate the pH of a 0.1 mol dm^{-3} HCl solution.

$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

1mole→1 mole H^+

0.1mole →0.1 mole H^+

Hence $pH = -\log_{10}(H^+)$

$= -\log_{10}(0.1)$

$=1$

Example 2

Calculate the pH of a 0.23 mol dm^{-3} $Ca(OH)_2$ solution.

$Ca(OH)_{2(aq)} \rightarrow Ca^{2+} + 2OH^-_{(aq)}$

1 mole→ 2 moles OH^-

0.23 mole→0.46 mole OH^-

Then calculate pOH

$pOH = -\log_{10}(OH^-)$

$= -\log_{10}(0.46)$

$=0.34$

Then determine the pH using

$pH = 14 - pOH$

$=14-0.34$

$=13.66$

1) What is the pH of a 0.0235 M HCl solution?
2) What is the pOH of a 0.0235 M HCl solution?

3) What is the pH of a 6.50 x 10^{-3} M KOH solution? (Hint: this is a basic solution – concentration is of OH^-)
4) A solution is created by measuring 3.60 x 10^{-3} moles of NaOH and 5.95 x 10^{-4} moles of HCl into a container and then water is added until the final volume is 1.00 L. What is the pH of this solution?
5) What is the pH of a 6.2 x 10^{-5} M NaOH solution? (Hint: this is a basic solution concentration is of OH^-
6) A solution with a H^+ concentration of 1.00 x 10-7 M is said to be neutral. Why?

ACTIVITY 7

Fill in the missing information in the table.

H^+	**pH**	**OH^-**	**pOH**	**Acid or Base**
2.5×10^{-8}				
		4×10^{-6}		
	5.8			
			9.2	
		3.00×10^{-4}		
8.00×10^{-11}				
	9			
			4.1	
		3.16×10^{-12}		
			0.5	
1×10^{-6}				
	3.3			
		6.67×10^{-10}		
			2.6	
5.0×10^{-2}				