

I am able to

- 1 Define a Brønsted-Lowry acid A proton (H⁺) donor
- 2 Define a Brønsted-Lowry base A proton (H⁺) acceptor
- 3 Classify each of the species in the following reactions as Brønsted-Lowry acids and bases and identify conjugate acid-base pairs:

acids	bases	conjugate pairs	
$\text{CH}_3\text{COOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq})$		$\text{CH}_3\text{COOH}(\text{aq})$ / $\text{CH}_3\text{COO}^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$ / $\text{H}_3\text{O}^+(\text{aq})$
$\text{CH}_3\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{aq}) \rightleftharpoons \text{CH}_3\text{NH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$		$\text{CH}_3\text{NH}_2(\text{aq})$ / $\text{CH}_3\text{NH}_3^+(\text{aq})$	$\text{H}_2\text{O}(\text{aq})$ / $\text{OH}^-(\text{aq})$
$\text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$		$\text{NH}_4^+(\text{aq})$ / $\text{NH}_3(\text{aq})$	$\text{OH}^-(\text{aq})$ / $\text{H}_2\text{O}(\text{l})$

- 4 Identify the conjugate base of each of the following:

H_2SO_4	HCO_3^-	HPO_4^{2-}
HSO_4^-	CO_3^{2-}	PO_4^{3-}
- 5 Identify the conjugate acid of each of the following:

HCOO^-	H_2PO_4^-	SO_4^{2-}
HCOOH	H_3PO_4	HSO_4^-
- 6 Explain the difference between the terms *amphoteric* and *amphiprotic*

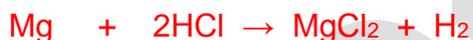
Amphoteric refers to any species that can act as an acid and a base

Amphiprotic refers specifically to a species that can donate and receive a proton (H⁺) [Brønsted-Lowry definition]

- 7 Identify which of the following is/are **amphiprotic**?



- 8 Complete the following equations:



- 9 State whether the neutralisation reaction between an acid and an alkali is exothermic or endothermic.

EXOTHERMIC

- 10 State the names of the acid and alkali needed to make each of the following salts using titration:

Potassium chloride Sodium bromide ammonium nitrate potassium sulfate

Potassium chloride	hydrochloric acid + potassium hydroxide
Sodium bromide	hydrobromic acid + sodium hydroxide
ammonium nitrate	nitric acid + ammonia
potassium sulfate	sulfuric acid + potassium hydroxide

- 11 State the names of an acid and another substance that could be reacted to make each of the following salts:

Copper(II) nitrate calcium chloride barium chloride magnesium sulfate

	acid	other substance
Copper(II) nitrate	nitric acid	copper(II) oxide/hydroxide/carbonate
calcium chloride	hydrochloric acid	Calcium Calcium oxide/hydroxide/carbonate/hydrogencarbonate
barium chloride	hydrochloric acid	Barium Barium oxide/hydroxide/carbonate/hydrogencarbonate
magnesium sulfate	sulfuric acid	Magnesium Magnesium oxide/hydroxide/carbonate/hydrogencarbonate

- 12 Explain the difference between a strong acid and a weak acid.

Strong acid: dissociates completely in aqueous solution

Weak acid: dissociates partially in aqueous solution

- 13 Classify the following acids and bases as **strong** or **weak**:

ACIDS	BASES
Hydrochloric acid	Sodium hydroxide
Ethanoic acid	Ammonia
Sulfuric acid <small>(for first dissociation)</small>	CH ₃ NH ₂
Carbonic acid	Potassium hydroxide
Nitric acid	Barium hydroxide

- 14 Write equations for the dissociation of the following acids:

CH₃COOH, HCl, H₂SO₄



HSO₄⁻ can then dissociate further:



- 15 Arrange the following in order of decreasing conductivity of solutions of equal concentration:

CH₃COOH, HCl, H₂SO₄, H₂O

H₂SO₄ > HCl > CH₃COOH > H₂O

- 16 Write equations for the ionisation of the following bases:

NaOH, NH₃, Ba(OH)₂



- 17 Arrange the following in order of increasing conductivity of solutions of equal concentration:

NaOH, NH₃, Ba(OH)₂

NH₃ < NaOH < Ba(OH)₂

18 Explain which of the following solutions of equal concentration conducts electricity better:

CH₃COOH or CH₃COONa

NH₃ or NH₄Cl

CH₃COONa conducts electricity better – fully ionised in solution as it is an ionic salt

CH₃COOH is a weak acid – only partially ionised

CH₃COONa – higher concentration of ions, therefore better conductor.

NH₄Cl conducts electricity better – fully ionised in solution as it is an ionic salt

NH₃ is a weak base – only partially ionised

NH₄Cl – higher concentration of ions, therefore better conductor.

19 Explain two experimental procedures to distinguish between strong and weak acids and bases

Test solutions of equal concentrations

Measure electrical conductivity (use a conductivity meter) – strong acids/bases fully ionised (strong electrolytes) but weak acids/bases only partially ionised (weak electrolytes). Strong acids/bases have higher concentration of ions, therefore conduct electricity better.

Measure pH (use a pH meter) – strong acids fully ionised but weak acids only partially ionised. Strong acids have higher concentration of H⁺ ions, therefore lower pH.

Strong bases fully ionised but weak bases only partially ionised. Strong bases have higher concentration of OH⁻ ions (lower concentration of H⁺ ions), therefore higher pH.

React acids with magnesium/calcium carbonate – strong acids fully ionised but weak acids only partially ionised. Strong acids have higher concentration of H⁺ ions, therefore react more vigorously with Mg/CaCO₃.

20 Complete the following sentences:

A strong acid has a **WEAK** conjugate **BASE**

A strong base has a **WEAK** conjugate **ACID**

21 If methanoic acid is a stronger acid than ethanoic acid, explain whether the methanoate ion or the ethanoate ion is the stronger base.

Ethanoate ion is the stronger base – the weaker the acid the stronger the conjugate base.



A weaker acid has less tendency to dissociate (position of above equilibrium lies more to left) therefore the conjugate base has greater tendency to pick up proton, i.e. it is stronger.

22 Define pH

$$\text{pH} = -\log_{10}[\text{H}^+(\text{aq})]$$

23 Complete the following table without using a calculator:

pH	$[\text{H}^+(\text{aq})]/\text{mol dm}^{-3}$	acidic/alkaline/neutral?
4	1×10^{-4}	acidic
6.0	1.0×10^{-6}	acidic
7	1×10^{-7}	neutral
11	1.0×10^{-11}	alkaline
13	1.0×10^{-13}	alkaline

24 Calculate the pH for each of the following solutions: 0.1 M HCl(aq) 0.020 M HNO₃(aq)

Both strong acids 0.1 M HCl(aq) pH=1 0.020 M HNO₃(aq) pH=1.7

25 Deduce by how much does the pH changes when a solution of a strong acid with pH=3 is diluted by a factor of 10.

Increases by 1

26 Calculate the relationship between the $[\text{H}^+(\text{aq})]$ in a solution of pH=2 and one of pH=6?

$$6-2=4$$

Solution of pH=2 has 10^4 times the $[\text{H}^+(\text{aq})]$ as the pH=6 solution

27 State two methods for measuring the pH of a solution.

Using a pH meter

Using universal indicator and comparing colour to a colour chart.

28 Write an expression for the equilibrium that exists in any aqueous solution and for the ionic product constant of water.



29 State the value of K_w at 25 °C? 1.0×10^{-14}

30 Complete the following table for aqueous solutions at 25 °C:

$[\text{H}^+(\text{aq})]/\text{mol dm}^{-3}$	$[\text{OH}^-(\text{aq})]/\text{mol dm}^{-3}$	acidic/alkaline/neutral?
1.0×10^{-6}	1.0×10^{-8}	acidic
1.0×10^{-11}	1.0×10^{-3}	alkaline
2.5×10^{-5}	4.0×10^{-10}	acidic
8.3×10^{-4}	1.2×10^{-11}	acidic
3.6×10^{-12}	2.8×10^{-3}	alkaline

31 Calculate $[\text{H}^+(\text{aq})]$ and $[\text{OH}^-(\text{aq})]$ for each of the following solutions:

0.1 M HCl, 0.01 M NaOH, 0.020 M Ba(OH)₂.

	$[\text{H}^+(\text{aq})] / \text{mol dm}^{-3}$	$[\text{OH}^-(\text{aq})] / \text{mol dm}^{-3}$
0.1 M HCl	0.1	1×10^{-13}
0.01 M NaOH	1×10^{-12}	0.01
0.020 M Ba(OH) ₂	2.5×10^{-13}	0.040

32 Explain why rain is naturally acidic and state its approximate pH.

Acidic due to dissolved carbon dioxide, which is in equilibrium with carbonic acid



H_2CO_3 is a weak acid: $\text{H}_2\text{CO}_3(\text{aq}) \rightleftharpoons \text{HCO}_3^-(\text{aq}) + \text{H}^+(\text{aq})$

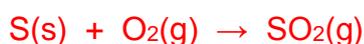
Unpolluted rain will have a pH of about 5.6

33 Explain what is meant by *acid deposition*

Any process by which acidic substances leave the atmosphere and are deposited on the surface of the Earth. E.g. acid rain

34 Identify 2 gases that can result in acid deposition and write an equation for the formation of each

SO_2 and NO



35 State one source of each of the gases in 34

SO_2 can come from burning fuels, such as coal, that contain sulfur / also formed in volcanic eruptions

NO is formed in internal combustion engines – at the very high temperatures in the engine, nitrogen and oxygen from the air react together / NO is also formed by lightning.

36 Write equations to show how HNO_2 , HNO_3 , H_2SO_3 and H_2SO_4 can be formed in the atmosphere.



37 Explain the difference between pre- and post-combustion methods for reducing SO_2 emissions. State which method would be used

(a) for producing fuels for cars
(b) in a power station

Pre-combustion method – the sulfur is removed before the fuel is burnt – this is used in producing fuels for cars.

Post-combustion method – the fuel containing sulfur is burnt, which produces SO_2 . The SO_2 is then removed from the exhaust gases. This is usually used in power stations.

38 Describe some of the problems associated with acid deposition.

- damage/death of trees
- acidification of lakes/rivers which can cause death of fish
- erosion of buildings/statues made of limestone/marble