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	
$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$	$CH_3COOH(aq)$ $CH_3COO^-(aq)$	$H_2O(l)$ $H_3O^+(aq)$
$CH_3NH_2(aq) + H_2O(aq) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$	$CH_3NH_2(aq)$ $CH_3NH_3^+(aq)$	$H_2O(aq)$ $OH^-(aq)$
$NH_4^+(aq) + OH^-(aq) \rightleftharpoons NH_3(aq) + H_2O(l)$	$NH_4^+(aq)$ $NH_3(aq)$	$OH^-(aq)$ $H_2O(l)$

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?

HCO_3^- NO_3^- H_2O $H_2PO_4^-$ NH_4^+ OCl^-

8 Complete the following equations:

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$

$NH_3 + HCl \rightarrow NH_4Cl$

$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

$2CH_3COOH + Ca \rightarrow (CH_3COO)_2Ca + H_2$

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

SMOSNOTES

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 *(for first dissociation)*	CH_3NH_2
Carbonic acid	Potassium hydroxide
Nitric acid	Barium hydroxide

14 Write equations for the dissociation of the following acids:

CH_3COOH, HCl, H_2SO_4

$CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$ ***or*** $CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$ ***or*** $HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$
$H_2SO_4(aq) \rightarrow H^+(aq) + HSO_4^-(aq)$ ***or*** $H_2SO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-(aq)$

HSO_4^- can then dissociate further:
$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$ ***or*** $HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$

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

CH_3COOH, HCl, H_2SO_4, H_2O

$H_2SO_4 > HCl > CH_3COOH > H_2O$

16 Write equations for the ionisation of the following bases:

NaOH, NH_3, $Ba(OH)_2$

$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$ $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$

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

NaOH, NH_3, $Ba(OH)_2$

$NH_3 < NaOH < Ba(OH)_2$

© SMO SMOsNotes.com

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

CH_3COOH or CH_3COONa
NH_3 or NH_4Cl

CH_3COONa conducts electricity better – fully ionised in solution as it is an ionic salt
CH_3COOH is a weak acid – only partially ionised
CH_3COONa – higher concentration of ions, therefore better conductor.

NH_4Cl conducts electricity better – fully ionised in solution as it is an ionic salt
NH_3 is a weak base – only partially ionised
NH_4Cl – 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 $Mg/CaCO_3$.

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.

$HA(aq) \rightleftharpoons A^-(aq) + H^+(aq)$

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.

SMOSNOTES

22 Define pH

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

23 Complete the following table without using a calculator:

pH	[H^+(aq)]/mol dm^{-3}	acidic/alkaline/neutral?
4	$1x10^{-4}$	acidic
6.0	$1.0x10^{-6}$	acidic
7	$1x10^{-7}$	neutral
11	$1.0x10^{-11}$	alkaline
13	$1.0x10^{-13}$	alkaline

24 Calculate the pH for each of the following solutions: 0.1 M HCl(aq) 0.020 M HNO_3(aq)

Both strong acids 0.1 M HCl(aq) pH=1 0.020 M HNO_3(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 [H^+(aq)] in a solution of pH=2 and one of pH=6?

6-2=4

Solution of pH=2 has 10^4 times the [H^+(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.

$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$ $K_w = [H^+(aq)][OH^-(aq)]$

29 State the value of K_w at 25 ^oC? $1.0x10^{-14}$

30 Complete the following table for aqueous solutions at 25 ^oC:

[H^+(aq)]/mol dm^{-3}	[OH^-(aq)]/mol dm^{-3}	acidic/alkaline/neutral?
$1.0x10^{-6}$	$1.0x10^{-8}$	acidic
$1.0x10^{-11}$	$1.0x10^{-3}$	alkaline
$2.5x10^{-5}$	$4.0x10^{-10}$	acidic
$8.3x10^{-4}$	$1.2x10^{-11}$	acidic
$3.6x10^{-12}$	$2.8x10^{-3}$	alkaline

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

0.1 M HCl, 0.01 M NaOH, 0.020 M $Ba(OH)_2$.

	[H^+(aq)] / mol dm^{-3}	**[$OH^-_{(aq)}$] / mol dm^{-3}**
0.1 M HCl	0.1	$1x10^{-13}$
0.01 M NaOH	$1x10^{-12}$	0.01
0.020 M $Ba(OH)_2$	$2.5x10^{-13}$	0.040

SMOsNOTES

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

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

H_2CO_3 is a weak acid: $H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$

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

$S(s) + O_2(g) \rightarrow SO_2(g)$
$N_2(g) + O_2(g) \rightarrow 2NO(g)$

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.

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

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

SMOSNOTES