Year 3 Chemistry Supplementary Exercise

- Acids and Bases

There are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in the brackets provided.

1 The pH of an aqueous solution of hydrochloric acid is 2.

What will be the pH of the acid after the addition of 10 g of sodium chloride?

A 1

B 2

C 7

D 9

(**B**)

Assume that there is no change in volume of the aqueous solution after the addition of (solid) NaCl. The 10 g of NaCl will dissolve in the aqueous solution, but it does **not** change the number of moles of HCl in the solution and hence does **not** alter [H^+(aq)]. Thus, the pH of the acid remains at 2.

2 A 25 cm^3 sample of dilute sulfuric acid contains 0.025 moles of the acid.

What is the hydrogen ion concentration in the solution?

A 0.25 mol / dm^3

B 0.50 mol / dm^3

C 1.00 mol / dm^3

D 2.00 mol / dm^3

(**D**)

$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
$H_2SO_4 : H^+ = 1 : 2 = 0.025 : 0.050$
$[H^+] = 0.050 \text{ mol} \div 0.025 \text{ dm}^3 = 2.00 \text{ mol dm}^{-3}$

3 The following equations represent reactions of dilute sulfuric acid.

Which reaction is not 'typical' of a dilute acid?

A $2KOH(aq) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + 2H_2O(l)$

B $CuO(s) + H_2SO_4(aq) \longrightarrow CuSO_4(aq) + H_2O(l)$

C $Pb(NO_3)_2(aq) + H_2SO_4(aq) \longrightarrow PbSO_4(s) + 2HNO_3(aq)$

D $ZnCO_3(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + CO_2(g) + H_2O(l)$

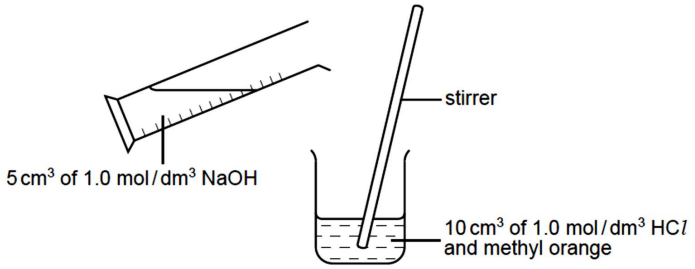
(**C**)

Arrhenius definition: An acid is a substance that ionises in water to give H^+ ions.
Bronsted-Lowry definition: An acid is an H^+ donor.

	ionic equation	**type of reaction**
A	$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$	neutralisation
B	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$	acid-base reaction
C	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$	precipitation
D	$ZnCO_3(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + CO_2(g) + H_2O(l)$	"acid + carbonate" reaction (acid-base reaction)

For options **A**, **B** and **D**, H^+ ions took part in the reaction, while SO_4^{2-} ions were spectator ions.
For option **C**, H^+ ions did not take part in the reaction, which is not 'typical' of a dilute acid.

4 In an experiment 5 cm^3 of 1.0 mol / dm^3 sodium hydroxide are gradually added to 10 cm^3 of 1.0 mol / dm^3 hydrochloric acid containing methyl orange.



Which change occurs in the mixture?

A The concentration of the H^+ ions increases.

B The methyl orange changes colour.

C More water molecules are formed.

D A precipitate is formed.

(**C**)

Total amount of HCl (in excess) = 10/1000 x 1.0 = 0.0100 mol
Amount of NaOH = 5/1000 x 1.0 = 0.00500 mol
$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$ (water molecules are formed, but no ppt is formed)
Amount of HCl unreacted = 0.0100 – 0.00500 = 0.00500 mol

$[H^+]$ after mixing = 0.00500 mol ÷ [(5 + 10)/1000] dm^3 = 0.33333 mol dm^{-3}
The concentration of H^+ ions decreases because some of the acid is neutralised by NaOH(aq).

New pH = −lg 0.33333 = 0.477 (3 sf)
Methyl orange is red when pH is below 3 and yellow when pH is above 5. The initial pH of the acid is – lg (1.0) = 0, while the pH of the resulting solution is 0.477. Methyl orange is red in both cases, i.e. no change in colour.

5 All ammonium salts on heating with sodium hydroxide produce ammonia gas.

From which ammonium salt can the greatest mass of ammonia be obtained?

A 0.5 mol $(NH_4)_3PO_4$

B 0.5 mol $(NH_4)_2SO_4$

C 1.0 mol NH_4Cl

D 1.0 mol NH_4NO_3

(**A**)

The ionic equation is $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$.
$NH_4^+ : NH_3 = 1 : 1$

	amount of salt / mol	amount of NH_4^+ / mol	amount of NH_3 / mol
$(NH_4)_3PO_4 \rightarrow 3NH_4^+ + PO_4^{3-}$	0.5	3 x 0.5 = 1.5	1.5
$(NH_4)_2SO_4 \rightarrow 2NH_4^+ + SO_4^{2-}$	0.5	2 x 0.5 = 1.0	1.0
$NH_4Cl \rightarrow NH_4^+ + Cl^-$	1.0	1.0	1.0
$NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$	1.0	1.0	1.0

6 When aqueous sodium hydroxide was added to aqueous lead(II) nitrate, a white precipitate formed. The precipitate dissolved when excess aqueous sodium hydroxide was added.

Which statement is **not** correct?

A Aqueous lead(II) nitrate contains Pb^{2+} and NO^{3-} ions.
B Aqueous sodium hydroxide has a pH above 7.
C The ionic equation for the formation of the precipitate is $Pb^{2+}(aq) + 2OH^{-}(aq) \rightarrow Pb(OH)_2(s)$.
D The precipitate dissolved because an acid-base reaction occurred. (**A**)

Aqueous lead(II) nitrate contains Pb^{2+} and NO_3^{-} ions.
B and **C** are correct statements.
Lead(II) hydroxide is amphoteric. It acts as an acid when it reacts with sodium hydroxide. Thus, **D** is also a correct statement.

7 A toilet cleaner contains the acid salt, sodium dihydrogen phosphate, NaH_2PO_4.

(a) Explain why sodium dihydrogen phosphate is both an 'acid' and a 'salt'. [2]

(b) Sodium dihydrogen phosphate can be made by reacting sodium hydroxide with phosphoric acid, H_3PO_4.

(i) Write an equation for the formation of sodium dihydrogen phosphate.

(ii) Suggest the formula of **two** other salts formed from sodium hydroxide and phosphoric acid. [3]

(c) The table shows information about other acidic compounds.

name	pH of a 0.5 mol / dm^3 solution	
sodium dihydrogen phosphate	4.5	increasing acid strength ↓
ethanoic acid	3.8	
sulfuric acid	1.0	

(i) Explain why sulfuric acid behaves as a *strong acid* but ethanoic acid behaves as a *weak acid*.

(ii) Describe an experiment, other than measuring pH, that you could carry out to show that sulfuric acid is a strong acid but ethanoic acid is a weak acid.

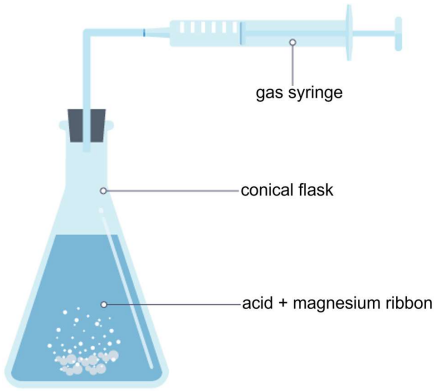
State what measurements you would make and what results you would expect. [5]

(a) NaH_2PO_4 is an 'acid' because the $H_2PO_4^{-}$ ions can ionise in aqueous solution to give H^+ ions according to the equation: $H_2PO_4^{-} \rightarrow H^+ + HPO_4^{2-}$.
NaH_2PO_4 is a 'salt' because it is formed, together with water, by the neutralisation reaction between an acid (H_3PO_4) and a base/alkali (NaOH).

(b) **(i)** $H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$
(ii) Na_2HPO_4 and Na_3PO_4

(c) **(i)** Sulfuric acid is a strong acid as it ionises completely in aqueous solution to give H^+ ions. $H_2SO_4(aq) \rightarrow H^+(aq) + HSO_4^{-}(aq)$ or $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
Ethanoic acid is a weak acid as it ionises partially in aqueous solution to give H^+ ions. $CH_3COOH(aq) \rightleftharpoons CH_3COO^{-}(aq) + H^+(aq)$

(ii) Procedure
1. Using a measuring cylinder, transfer 50 cm^3 of 1.00 mol dm^{-3} sulfuric acid into a clean 250 cm^3 conical flask that is clamped to a retort stand.
2. Add a 3 cm magnesium ribbon to the acid, quickly stopper the flask and start a stopwatch at the same time. The hydrogen produced by the reaction is collected in a gas syringe that is connected to the flask by a rubber stopper and a delivery tube.
3. Record the volume of gas produced every 5 s, until no more gas is evolved.
4. Repeat steps 1 to 3 using 1.00 mol dm^{-3} ethanoic acid.



$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$
Sulfuric acid is a strong acid, while ethanoic acid is a weak acid. In 50 cm^3 of aqueous solution, there is a higher concentration of H^+ ions in 1.00 mol dm^{-3} sulfuric acid than in 1.00 mol dm^{-3} ethanoic acid. Hydrogen gas is evolved at a higher rate when $[H^+(aq)]$ ions is higher. The time taken to collect the same volume of hydrogen gas is shorter when sulfuric acid is used.

(If the magnesium ribbon is replaced with solid calcium carbonate, the gas collected will be carbon dioxide.)

8 **(b)** Potassium reacts with water as shown in the equation.

$$2K(s) + 2H_2O(l) \longrightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$$

Describe what you would see when potassium reacts with water.

.....

.....

.....[2]

(c) A sample of 0.195 g of potassium was added to 500 cm^3 of cold water. When the reaction was finished, 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added to form solution **X**.

(i) Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

(ii) Calculate the number of moles of hydrogen ions in 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

(iii) Give an ionic equation to represent the neutralisation reaction.

.....

(iv) Suggest a pH value for solution **X**.
Explain your answer.

.....

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[4]

(b) Potassium (floats and moves rapidly across the water surface, and) dissolves in water to form a colourless solution of potassium hydroxide. The hydrogen gas evolved (is ignited by the large amount of heat given out by the reaction and it) extinguishes a lighted splint with a 'pop'.

NOTE: Refer to Exercise – Observations of Reactions Involving Acids and Bases. Observations in brackets are not required yet; these observations will be taught in Year 4. Click on https://www.youtube.com/watch?v=oqMN3y8k9So to see a video of the reaction.

(c) **(i)** $K : OH^- = 2 : 2 = 1 : 1$
Amount of K used = Amount of OH^- formed = 0.195 ÷ 39
= 0.00500 mol

(ii) Amount of H^+ in 100 cm^3 = 100/1000 x 0.100 = 0.0100 mol

(iii) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(iv) Amount of H^+ unreacted = 0.0100 – 0.00500 = 0.00500 mol
$[H^+]$ in X(aq) = 0.00500 ÷ [(500 + 100)/1000] = 0.0083333 mol dm^{-3}
pH of X(aq) = −lg (0.0083333) = 2.08 (3 sf)

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What is the hydrogen ion concentration in the solution?

A 0.25 mol / dm^3

B 0.50 mol / dm^3

C 1.00 mol / dm^3

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(**D**)

$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
$H_2SO_4 : H^+ = 1 : 2 = 0.025 : 0.050$
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Which reaction is not 'typical' of a dilute acid?

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Arrhenius definition: An acid is a substance that ionises in water to give H^+ ions.
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For options **A**, **B** and **D**, H^+ ions took part in the reaction, while SO_4^{2-} ions were spectator ions.
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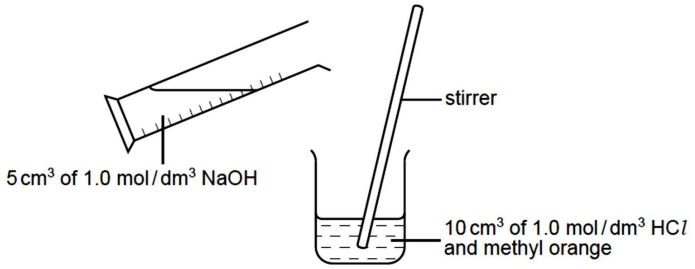
4 In an experiment 5 cm^3 of 1.0 mol / dm^3 sodium hydroxide are gradually added to 10 cm^3 of 1.0 mol / dm^3 hydrochloric acid containing methyl orange.



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From which ammonium salt can the greatest mass of ammonia be obtained?

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(**A**)

The ionic equation is $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$.
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	amount of salt / mol	amount of NH_4^+ / mol	amount of NH_3 / mol
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$NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$	1.0	1.0	1.0

6 When aqueous sodium hydroxide was added to aqueous lead(II) nitrate, a white precipitate formed. The precipitate dissolved when excess aqueous sodium hydroxide was added.

Which statement is **not** correct?

A Aqueous lead(II) nitrate contains Pb^{2+} and NO^{3-} ions.
B Aqueous sodium hydroxide has a pH above 7.
C The ionic equation for the formation of the precipitate is $Pb^{2+}(aq) + 2OH^{-}(aq) \rightarrow Pb(OH)_2(s)$.
D The precipitate dissolved because an acid-base reaction occurred. (**A**)

Aqueous lead(II) nitrate contains Pb^{2+} and NO_3^{-} ions.
B and **C** are correct statements.
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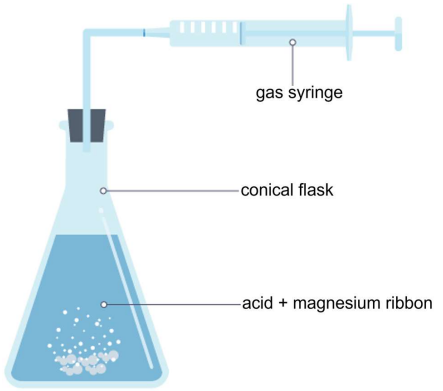

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(If the magnesium ribbon is replaced with solid calcium carbonate, the gas collected will be carbon dioxide.)

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Describe what you would see when potassium reacts with water.

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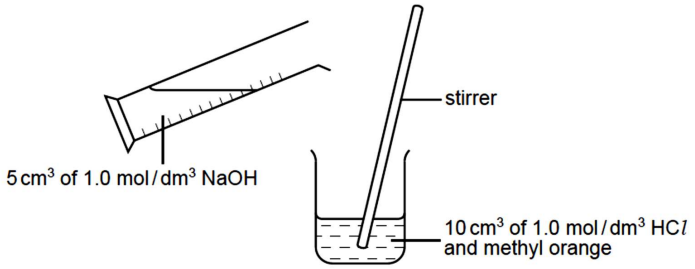

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5 All ammonium salts on heating with sodium hydroxide produce ammonia gas.

From which ammonium salt can the greatest mass of ammonia be obtained?

A 0.5 mol $(NH_4)_3PO_4$

B 0.5 mol $(NH_4)_2SO_4$

C 1.0 mol NH_4Cl

D 1.0 mol NH_4NO_3

(**A**)

The ionic equation is $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$.
$NH_4^+ : NH_3 = 1 : 1$

	amount of salt / mol	amount of NH_4^+ / mol	amount of NH_3 / mol
$(NH_4)_3PO_4 \rightarrow 3NH_4^+ + PO_4^{3-}$	0.5	3 x 0.5 = 1.5	1.5
$(NH_4)_2SO_4 \rightarrow 2NH_4^+ + SO_4^{2-}$	0.5	2 x 0.5 = 1.0	1.0
$NH_4Cl \rightarrow NH_4^+ + Cl^-$	1.0	1.0	1.0
$NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$	1.0	1.0	1.0

6 When aqueous sodium hydroxide was added to aqueous lead(II) nitrate, a white precipitate formed. The precipitate dissolved when excess aqueous sodium hydroxide was added.

Which statement is **not** correct?

A Aqueous lead(II) nitrate contains Pb^{2+} and NO^{3-} ions.
B Aqueous sodium hydroxide has a pH above 7.
C The ionic equation for the formation of the precipitate is $Pb^{2+}(aq) + 2OH^{-}(aq) \rightarrow Pb(OH)_2(s)$.
D The precipitate dissolved because an acid-base reaction occurred. (**A**)

Aqueous lead(II) nitrate contains Pb^{2+} and NO_3^{-} ions.
B and **C** are correct statements.
Lead(II) hydroxide is amphoteric. It acts as an acid when it reacts with sodium hydroxide. Thus, **D** is also a correct statement.

7 A toilet cleaner contains the acid salt, sodium dihydrogen phosphate, NaH_2PO_4.

(a) Explain why sodium dihydrogen phosphate is both an 'acid' and a 'salt'. [2]

(b) Sodium dihydrogen phosphate can be made by reacting sodium hydroxide with phosphoric acid, H_3PO_4.

(i) Write an equation for the formation of sodium dihydrogen phosphate.

(ii) Suggest the formula of **two** other salts formed from sodium hydroxide and phosphoric acid. [3]

(c) The table shows information about other acidic compounds.

name	pH of a 0.5 mol / dm^3 solution	
sodium dihydrogen phosphate	4.5	increasing acid strength ↓
ethanoic acid	3.8	
sulfuric acid	1.0	

(i) Explain why sulfuric acid behaves as a *strong acid* but ethanoic acid behaves as a *weak acid*.

(ii) Describe an experiment, other than measuring pH, that you could carry out to show that sulfuric acid is a strong acid but ethanoic acid is a weak acid.

State what measurements you would make and what results you would expect. [5]

(a) NaH_2PO_4 is an 'acid' because the $H_2PO_4^{-}$ ions can ionise in aqueous solution to give H^+ ions according to the equation: $H_2PO_4^{-} \rightarrow H^+ + HPO_4^{2-}$.
NaH_2PO_4 is a 'salt' because it is formed, together with water, by the neutralisation reaction between an acid (H_3PO_4) and a base/alkali (NaOH).

(b) **(i)** $H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$
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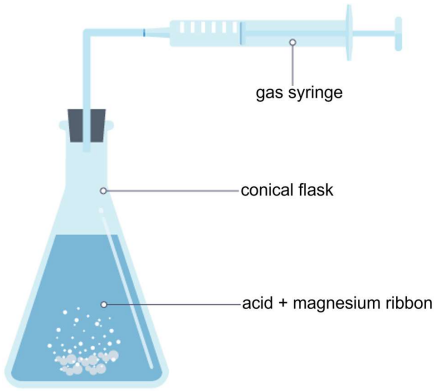
(c) **(i)** Sulfuric acid is a strong acid as it ionises completely in aqueous solution to give H^+ ions. $H_2SO_4(aq) \rightarrow H^+(aq) + HSO_4^{-}(aq)$ or $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
Ethanoic acid is a weak acid as it ionises partially in aqueous solution to give H^+ ions. $CH_3COOH(aq) \rightleftharpoons CH_3COO^{-}(aq) + H^+(aq)$

(ii) Procedure
1. Using a measuring cylinder, transfer 50 cm^3 of 1.00 mol dm^{-3} sulfuric acid into a clean 250 cm^3 conical flask that is clamped to a retort stand.
2. Add a 3 cm magnesium ribbon to the acid, quickly stopper the flask and start a stopwatch at the same time. The hydrogen produced by the reaction is collected in a gas syringe that is connected to the flask by a rubber stopper and a delivery tube.
3. Record the volume of gas produced every 5 s, until no more gas is evolved.
4. Repeat steps 1 to 3 using 1.00 mol dm^{-3} ethanoic acid.



$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$
Sulfuric acid is a strong acid, while ethanoic acid is a weak acid. In 50 cm^3 of aqueous solution, there is a higher concentration of H^+ ions in 1.00 mol dm^{-3} sulfuric acid than in 1.00 mol dm^{-3} ethanoic acid. Hydrogen gas is evolved at a higher rate when $[H^+(aq)]$ ions is higher. The time taken to collect the same volume of hydrogen gas is shorter when sulfuric acid is used.

(If the magnesium ribbon is replaced with solid calcium carbonate, the gas collected will be carbon dioxide.)

8 **(b)** Potassium reacts with water as shown in the equation.

$$2K(s) + 2H_2O(l) \longrightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$$

Describe what you would see when potassium reacts with water.

.....

.....

.....[2]

(c) A sample of 0.195 g of potassium was added to 500 cm^3 of cold water. When the reaction was finished, 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added to form solution **X**.

(i) Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

(ii) Calculate the number of moles of hydrogen ions in 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

(iii) Give an ionic equation to represent the neutralisation reaction.

.....

(iv) Suggest a pH value for solution **X**.
Explain your answer.

.....

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[4]

(b) Potassium (floats and moves rapidly across the water surface, and) dissolves in water to form a colourless solution of potassium hydroxide. The hydrogen gas evolved (is ignited by the large amount of heat given out by the reaction and it) extinguishes a lighted splint with a 'pop'.

NOTE: Refer to Exercise – Observations of Reactions Involving Acids and Bases. Observations in brackets are not required yet; these observations will be taught in Year 4. Click on https://www.youtube.com/watch?v=oqMN3y8k9So to see a video of the reaction.

(c) **(i)** $K : OH^- = 2 : 2 = 1 : 1$
Amount of K used = Amount of OH^- formed = 0.195 ÷ 39
= 0.00500 mol

(ii) Amount of H^+ in 100 cm^3 = 100/1000 x 0.100 = 0.0100 mol

(iii) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(iv) Amount of H^+ unreacted = 0.0100 – 0.00500 = 0.00500 mol
$[H^+]$ in X(aq) = 0.00500 ÷ [(500 + 100)/1000] = 0.0083333 mol dm^{-3}
pH of X(aq) = −lg (0.0083333) = 2.08 (3 sf)

Year 3 Chemistry Supplementary Exercise

- Acids and Bases

There are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in the brackets provided.

1 The pH of an aqueous solution of hydrochloric acid is 2.

What will be the pH of the acid after the addition of 10 g of sodium chloride?

A 1

B 2

C 7

D 9

(**B**)

Assume that there is no change in volume of the aqueous solution after the addition of (solid) NaCl. The 10 g of NaCl will dissolve in the aqueous solution, but it does **not** change the number of moles of HCl in the solution and hence does **not** alter [H^+(aq)]. Thus, the pH of the acid remains at 2.

2 A 25 cm^3 sample of dilute sulfuric acid contains 0.025 moles of the acid.

What is the hydrogen ion concentration in the solution?

A 0.25 mol / dm^3

B 0.50 mol / dm^3

C 1.00 mol / dm^3

D 2.00 mol / dm^3

(**D**)

$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
$H_2SO_4 : H^+ = 1 : 2 = 0.025 : 0.050$
$[H^+] = 0.050 \text{ mol} \div 0.025 \text{ dm}^3 = 2.00 \text{ mol dm}^{-3}$

3 The following equations represent reactions of dilute sulfuric acid.

Which reaction is not 'typical' of a dilute acid?

A $2KOH(aq) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + 2H_2O(l)$

B $CuO(s) + H_2SO_4(aq) \longrightarrow CuSO_4(aq) + H_2O(l)$

C $Pb(NO_3)_2(aq) + H_2SO_4(aq) \longrightarrow PbSO_4(s) + 2HNO_3(aq)$

D $ZnCO_3(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + CO_2(g) + H_2O(l)$

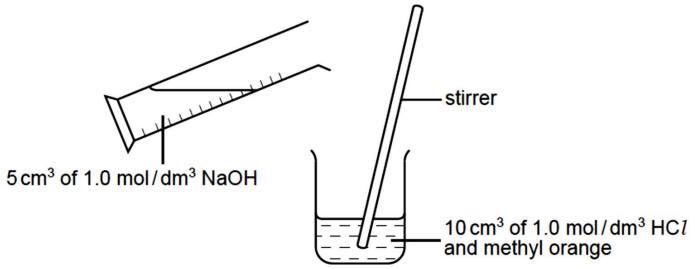
(**C**)

Arrhenius definition: An acid is a substance that ionises in water to give H^+ ions.
Bronsted-Lowry definition: An acid is an H^+ donor.

	ionic equation	**type of reaction**
A	$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$	neutralisation
B	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$	acid-base reaction
C	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$	precipitation
D	$ZnCO_3(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + CO_2(g) + H_2O(l)$	"acid + carbonate" reaction (acid-base reaction)

For options **A**, **B** and **D**, H^+ ions took part in the reaction, while SO_4^{2-} ions were spectator ions.
For option **C**, H^+ ions did not take part in the reaction, which is not 'typical' of a dilute acid.

4 In an experiment 5 cm^3 of 1.0 mol / dm^3 sodium hydroxide are gradually added to 10 cm^3 of 1.0 mol / dm^3 hydrochloric acid containing methyl orange.



Which change occurs in the mixture?

A The concentration of the H^+ ions increases.

B The methyl orange changes colour.

C More water molecules are formed.

D A precipitate is formed.

(**C**)

Total amount of HCl (in excess) = 10/1000 x 1.0 = 0.0100 mol
Amount of NaOH = 5/1000 x 1.0 = 0.00500 mol
$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$ (water molecules are formed, but no ppt is formed)
Amount of HCl unreacted = 0.0100 – 0.00500 = 0.00500 mol

$[H^+]$ after mixing = 0.00500 mol ÷ [(5 + 10)/1000] dm^3 = 0.33333 mol dm^{-3}
The concentration of H^+ ions decreases because some of the acid is neutralised by NaOH(aq).

New pH = −lg 0.33333 = 0.477 (3 sf)
Methyl orange is red when pH is below 3 and yellow when pH is above 5. The initial pH of the acid is – lg (1.0) = 0, while the pH of the resulting solution is 0.477. Methyl orange is red in both cases, i.e. no change in colour.

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From which ammonium salt can the greatest mass of ammonia be obtained?

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D 1.0 mol NH_4NO_3

(**A**)

The ionic equation is $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(g) + H_2O(l)$.
$NH_4^+ : NH_3 = 1 : 1$

	amount of salt / mol	amount of NH_4^+ / mol	amount of NH_3 / mol
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$NH_4Cl \rightarrow NH_4^+ + Cl^-$	1.0	1.0	1.0
$NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$	1.0	1.0	1.0

6 When aqueous sodium hydroxide was added to aqueous lead(II) nitrate, a white precipitate formed. The precipitate dissolved when excess aqueous sodium hydroxide was added.

Which statement is **not** correct?

A Aqueous lead(II) nitrate contains Pb^{2+} and NO^{3-} ions.
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Aqueous lead(II) nitrate contains Pb^{2+} and NO_3^{-} ions.
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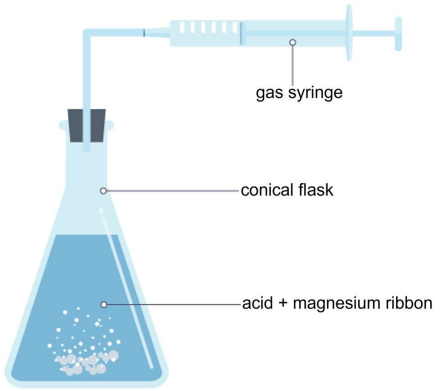

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Describe what you would see when potassium reacts with water.

.....

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(c) A sample of 0.195 g of potassium was added to 500 cm^3 of cold water. When the reaction was finished, 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added to form solution **X**.

(i) Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

(ii) Calculate the number of moles of hydrogen ions in 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

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Explain your answer.

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(c) **(i)** $K : OH^- = 2 : 2 = 1 : 1$
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= 0.00500 mol

(ii) Amount of H^+ in 100 cm^3 = 100/1000 x 0.100 = 0.0100 mol

(iii) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(iv) Amount of H^+ unreacted = 0.0100 – 0.00500 = 0.00500 mol
$[H^+]$ in X(aq) = 0.00500 ÷ [(500 + 100)/1000] = 0.0083333 mol dm^{-3}
pH of X(aq) = −lg (0.0083333) = 2.08 (3 sf)

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What will be the pH of the acid after the addition of 10 g of sodium chloride?

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(**B**)

Assume that there is no change in volume of the aqueous solution after the addition of (solid) NaCl. The 10 g of NaCl will dissolve in the aqueous solution, but it does **not** change the number of moles of HCl in the solution and hence does **not** alter [H^+(aq)]. Thus, the pH of the acid remains at 2.

2 A 25 cm^3 sample of dilute sulfuric acid contains 0.025 moles of the acid.

What is the hydrogen ion concentration in the solution?

A 0.25 mol / dm^3

B 0.50 mol / dm^3

C 1.00 mol / dm^3

D 2.00 mol / dm^3

(**D**)

$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
$H_2SO_4 : H^+ = 1 : 2 = 0.025 : 0.050$
$[H^+] = 0.050 \text{ mol} \div 0.025 \text{ dm}^3 = 2.00 \text{ mol dm}^{-3}$

3 The following equations represent reactions of dilute sulfuric acid.

Which reaction is not 'typical' of a dilute acid?

A $2KOH(aq) + H_2SO_4(aq) \longrightarrow K_2SO_4(aq) + 2H_2O(l)$

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D $ZnCO_3(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + CO_2(g) + H_2O(l)$

(**C**)

Arrhenius definition: An acid is a substance that ionises in water to give H^+ ions.
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A	$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$	neutralisation
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C	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$	precipitation
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For options **A**, **B** and **D**, H^+ ions took part in the reaction, while SO_4^{2-} ions were spectator ions.
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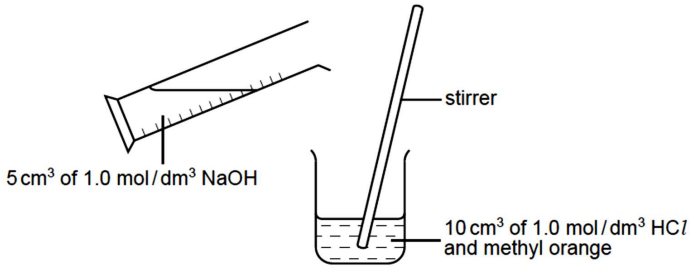

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C More water molecules are formed.

D A precipitate is formed.

(**C**)

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$NH_4Cl \rightarrow NH_4^+ + Cl^-$	1.0	1.0	1.0
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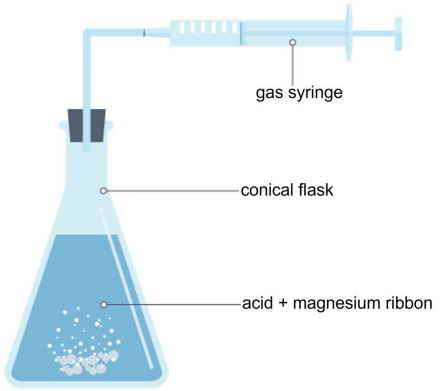
2. Add a 3 cm magnesium ribbon to the acid, quickly stopper the flask and start a stopwatch at the same time. The hydrogen produced by the reaction is collected in a gas syringe that is connected to the flask by a rubber stopper and a delivery tube.
3. Record the volume of gas produced every 5 s, until no more gas is evolved.
4. Repeat steps 1 to 3 using 1.00 mol dm^{-3} ethanoic acid.



$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$
Sulfuric acid is a strong acid, while ethanoic acid is a weak acid. In 50 cm^3 of aqueous solution, there is a higher concentration of H^+ ions in 1.00 mol dm^{-3} sulfuric acid than in 1.00 mol dm^{-3} ethanoic acid. Hydrogen gas is evolved at a higher rate when $[H^+(aq)]$ ions is higher. The time taken to collect the same volume of hydrogen gas is shorter when sulfuric acid is used.

(If the magnesium ribbon is replaced with solid calcium carbonate, the gas collected will be carbon dioxide.)

8 **(b)** Potassium reacts with water as shown in the equation.

$$2K(s) + 2H_2O(l) \longrightarrow 2K^+(aq) + 2OH^-(aq) + H_2(g)$$

Describe what you would see when potassium reacts with water.

.....

.....

.....[2]

(c) A sample of 0.195 g of potassium was added to 500 cm^3 of cold water. When the reaction was finished, 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid was added to form solution **X**.

(i) Calculate the number of moles of hydroxide ions formed when the potassium was added to water.

(ii) Calculate the number of moles of hydrogen ions in 100 cm^3 of 0.100 mol/dm^3 hydrochloric acid.

(iii) Give an ionic equation to represent the neutralisation reaction.

.....

(iv) Suggest a pH value for solution **X**.
Explain your answer.

.....

.....
[4]

(b) Potassium (floats and moves rapidly across the water surface, and) dissolves in water to form a colourless solution of potassium hydroxide. The hydrogen gas evolved (is ignited by the large amount of heat given out by the reaction and it) extinguishes a lighted splint with a 'pop'.

NOTE: Refer to Exercise – Observations of Reactions Involving Acids and Bases. Observations in brackets are not required yet; these observations will be taught in Year 4. Click on https://www.youtube.com/watch?v=oqMN3y8k9So to see a video of the reaction.

(c) **(i)** $K : OH^- = 2 : 2 = 1 : 1$
Amount of K used = Amount of OH^- formed = 0.195 ÷ 39
= 0.00500 mol

(ii) Amount of H^+ in 100 cm^3 = 100/1000 x 0.100 = 0.0100 mol

(iii) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

(iv) Amount of H^+ unreacted = 0.0100 – 0.00500 = 0.00500 mol
$[H^+]$ in X(aq) = 0.00500 ÷ [(500 + 100)/1000] = 0.0083333 mol dm^{-3}
pH of X(aq) = −lg (0.0083333) = 2.08 (3 sf)