GLEN TUTORIALS

Comprehensive Study Notes & Solutions Manual

Grade: 9th IGCSE **Subject:** Chemistry **Chapter:** Acids, Bases & Salts

KEY CHAPTER CONCEPTS & KEYWORDS:

Strong Acid | Weak Acid | Proton Donor (H^+) | Proton Acceptor | Dissociation | pH Scale | Neutralisation | Titration | Burette Reading | Effervescence

Exercise 11.1: Acids, Alkalis and pH

Question 1: Paragraph Completion (Fill in the Blanks)

> *Using the words provided, complete the paragraph. Note that not all words should be used, and one word should be used twice.*
> *Word Bank: acids | alkalis | greater | hydrochloric | hydrogen | hydroxide | insoluble | less | nitric | oxides | potassium | sodium | soluble | sulfuric | water*

Completed Text with Answers Highlighted:

Acids are substances that dissolve in **water** to give a solution with a pH **less** than 7. **hydrochloric** acid has the formula HCl and is a strong acid. **sulfuric** acid (formula = H_2SO_4) and **nitric** acid (formula = HNO_3) are also strong **acids**. In acidic solutions the concentration of the **hydrogen** ions is greater than the concentration of **hydroxide** ions.

Bases are the **oxides** and hydroxides of metals and ammonia. A base will neutralise an acid to form a salt and **water**.

Most bases are **insoluble** in water, but alkalis are bases that are **soluble** in water and their solutions have pH values **greater** than 7. KOH (**potassium** hydroxide) and NaOH (**sodium** hydroxide) are both strong **alkalis**. In alkaline solutions the concentration of **hydroxide** ions is greater than the concentration of **hydrogen** ions.

REMEMBER:

- **Acids:** pH < 7, excess **H^+ (hydrogen)** ions in aqueous solution.
- **Alkalis:** Soluble bases, pH > 7, excess **OH^- (hydroxide)** ions in aqueous solution.
- **Bases:** Metal oxides, metal hydroxides, and ammonia. Base + Acid → Salt + Water.

Exercise 11.2: Reactions of Acids

Question 4: Matching Reactions of Acids to Statements

> *Draw lines from the left-hand side statements (Type of reaction) to the true statements on the right-hand side. Note that more than one line can be drawn from each type of reaction.*

Correct Matching & Explanations:

Type of Reaction	Matching Statements (Products / Observations)
1. Acid + Metal Carbonate	• Gives a **salt + water + a gas** as the products • Gives **CO_2** as a product • Does give an **effervescence (fizzing)**
2. Acid + Reactive Metal	• Gives **H_2 gas** as a product • Gives a **salt and gas only** • Does give an **effervescence (fizzing)**
3. Acid + Insoluble Metal Oxide	• Gives a **salt and water as the only products**
4. Acid + Alkali (Metal Hydroxide Solution)	• Gives a **salt and water as the only products**

EXAM TIP:

Carbonates always produce **Carbon Dioxide (CO_2)** gas along with salt and water. Reactive metals produce **Hydrogen (H_2)** gas and a salt. Both gas-evolving reactions produce visible **effervescence (fizzing)**.

Question 5: Chemical Equations for Reactions of Acids

> *Write the word and balanced symbol equations for the reactions (a–f) based on the provided table of acids, bases, carbonates, and salts.*

a. Magnesium + Hydrochloric acid

- **Word Equation:** Magnesium + Hydrochloric acid → Magnesium chloride + Hydrogen
- **Symbol Equation:** $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

b. Calcium hydroxide + Hydrochloric acid

- **Word Equation:** Calcium hydroxide + Hydrochloric acid → Calcium chloride + Water
- **Symbol Equation:** $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

c. Calcium oxide + Nitric acid

- **Word Equation:** Calcium oxide + Nitric acid → Calcium nitrate + Water
- **Symbol Equation:** $CaO(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l)$

d. Sodium hydroxide + Sulfuric acid

- **Word Equation:** Sodium hydroxide + Sulfuric acid → Sodium sulfate + Water
- **Symbol Equation:** $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

e. Sodium carbonate + Nitric acid

- **Word Equation:** Sodium carbonate + Nitric acid → Sodium nitrate + Carbon dioxide + Water
- **Symbol Equation:** $Na_2CO_3(s) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$

f. Magnesium + Nitric acid

- **Word Equation:** Magnesium + Nitric acid → Magnesium nitrate + Hydrogen
- **Symbol Equation:** $Mg(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$

Question 6 (Challenge): Antacid Reactions

> *Antacids contain compounds like magnesium hydroxide and magnesium carbonate to neutralise excess stomach acid (HCl). Write balanced chemical equations for both reactions.*

a. For Magnesium hydroxide:

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

b. For Magnesium carbonate:

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

Exercise 11.3: Titrations & Neutralisation

Question 7: Titration Procedure Paragraph Completion

> *Delete the incorrect words to complete the procedure description for titration experiments.*

a. Experiment 1:

Using a **volumetric pipette**, 10 cm³ of the sodium hydroxide solution was placed in a **conical flask**. Thymolphthalein indicator was added to the flask turning the solution **blue** because of the **alkaline** conditions. A **burette** was filled to the **0.0 cm³** mark with hydrochloric acid (solution P). The acid was then run into the flask until the colour changed to **colourless** showing that the alkali in the flask had been **neutralised** by the acid.

The volume of **acid** added was noted. The flask was washed thoroughly with **distilled water**.

b. Experiment 2:

The experiment was repeated using the same volume of sodium hydroxide **alkali** in the flask but a different solution of acid (solution Q) in the **burette**.

c. White Tile Purpose:

Answer: The white tile is placed directly beneath the conical flask to provide a neutral background so that the **colour change of the indicator** at the end-point can be seen clearly and accurately.

Question 8: Reading Burette Scales & Results Table

Read the burette diagrams (Figure 11.2 and 11.3) and complete Table 11.3.

EXAM TIP — READING BURETTES:
Burette values increase downwards! Always read from the **bottom of the meniscus** at eye level. Record readings to **1 decimal place** (or 2 decimal places ending in .0 or .5 per IGCSE standards).

Burette Readings	Experiment 1 / cm^3 (Acid P)	Experiment 2 / cm^3 (Acid Q)
Final reading	**10.5 cm^3** (from Fig 11.2)	**21.5 cm^3** (from Fig 11.3 final)
Initial reading	0.0 cm^3	**0.2 cm^3** (from Fig 11.3 initial)
Difference (Volume added)	**10.5 cm^3**	**21.3 cm^3** (21.5 – 0.2)

Exercise 11.4: The Ionic Nature of Acids and Bases

Question 10: H^+ and OH^- Balance Diagrams (Figure 11.4)

Match the labels (pure water, acid solution, alkali solution) to the balance diagrams (a, b, c).

a. Seesaw balanced level ($H^+ = OH^-$):

→ Label: **pure water: $H^+ = OH^-$** (pH = 7)

b. Seesaw tilted left towards H^+ ($H^+ > OH^-$):

→ Label: **acid solution: $H^+ > OH^-$** (pH lower than 7, litmus turns red)

c. Seesaw tilted right towards OH^- ($OH^- > H^+$):

→ Label: **alkali solution: $OH^- > H^+$** (pH higher than 7, litmus turns blue)

Question 11: Statements on the Ionic Nature of Acids and Bases (Table 11.4)

Put ticks in the correct columns (Acid, Base, Alkali) for each statement.

Statement	Acid	Base	Alkali
A solution of the substance contains an excess of hydroxide (OH^-) ions.			✓
A solution of the substance contains an excess of hydrogen (H^+) ions.	✓		
The substance is a proton acceptor.		✓	✓
The substance is a proton donor.	✓		

Question 12: Strong vs Weak Acids (Multiple Choice Selection)

> *Complete the statements by selecting the correct term in bold.*

a. Hydrochloric Acid:

Hydrochloric acid is a **strong** acid. Hydrogen chloride gas consists of **covalent** molecules. When they dissolve in water these molecules **completely** dissociate into hydrogen and **chloride** ions, producing as many hydrogen ions in the solution as possible.

b. Ethanoic Acid:

Ethanoic acid is a **weak** acid. When it dissolves in water **some** of the molecules dissociate into ions. The majority of the molecules remain intact. This means that the concentration of hydrogen ions is **less** than it could be if all the molecules had dissociated into ions.

c. Comparing HCl and Ethanoic Acid Solutions of Same Concentration:

Two solutions of hydrochloric acid and ethanoic acid have the same concentration. The hydrochloric acid solution will have the **lower** pH value. It has the **higher** concentration of hydrogen ions and is the **more** acidic solution.

Question 13: Dissociation Equations and Proton Transfer

> *Complete the ionic dissociation equations and answer questions on electrical conductivity and proton transfer.*

a. Complete the dissociation equations:

- **i. Ethanoic acid (Weak acid):**
  $CH_3COOH(aq) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$
- **ii. Hydrochloric acid (Strong acid):**
  $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
- **iii. Sulfuric acid (Strong acid):**
  $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

b. Equilibrium Sign Meaning (in ethanoic acid equation):

The equilibrium symbol (⇌) means that the reaction is **reversible** and does not go to completion. It indicates partial ionization where both reactants (molecules) and products (ions) exist simultaneously at dynamic equilibrium.

c. Electrical Conductivity Comparison:

Hydrochloric acid has greater electrical conductivity than ethanoic acid of the same concentration.
Explanation: Hydrochloric acid is a strong acid that **completely dissociates** into ions in water, producing a significantly higher concentration of mobile hydrogen (H^+) and chloride (Cl^-) ions to carry electrical charge.

d. Brønsted-Lowry Proton Transfer:

Equation: $HCl + NH_3 \rightarrow NH_4^+ + Cl^-$
Explanation: **HCl** acts as an acid because it **donates a proton (H^+)** to NH_3. **NH_3** acts as a base because it **accepts a proton (H^+)** to form NH_4^+.

Question 14: Rate of Reaction Graphs (HCl vs Ethanoic Acid with $CaCO_3$)

> *Comparing rate of reaction and carbon dioxide volume produced over time when equal amounts of hydrochloric acid and ethanoic acid react with calcium carbonate.*

a. Sketch Graph Description & Key Features:

Graph Characteristics (Volume of CO_2 / cm^3 vs Time / minutes):
1. **Vertical Axis Scale:** 0 to 80 cm^3 (maximum volume).
2. **Hydrochloric Acid (Strong Acid):** Curve starts with a **steeper initial gradient** (faster reaction rate due to higher H^+ ion concentration) and levels off first at 80 cm^3.
3. **Ethanoic Acid (Weak Acid):** Curve starts with a **gentler/shallower initial gradient** (slower reaction rate due to lower H^+ ion concentration) and levels off later at the same 80 cm^3 height.

b. Explanation of Differences Between the Two Graphs:

- **Gradient / Steepness:** Hydrochloric acid is a strong acid and fully ionises, producing a higher concentration of H^+ ions. This leads to a higher frequency of successful collisions per unit time and a faster initial rate of reaction (steeper curve). Ethanoic acid is a weak acid and only partially ionises, resulting in a lower initial H^+ concentration and a slower reaction rate.
- **Final Volume Level:** Both curves level off at exactly the **same total volume (80 cm^3)** because both experiments used equal moles of acid (limiting reactant), yielding the exact same amount of carbon dioxide gas.

Peer Assessment Checklist & Model Comments

Aspect of Graph and Answer	Model Assessor Comment
Each graph goes up steeply at first and then levels off.	**Correct:** Shows that the reaction rate is fastest at the start and drops to zero when reactants are exhausted.
They have given a scale for the vertical axis.	**Correct:** Y-axis clearly calibrated from 0 up to 80 cm^3 in equal linear intervals.
Both graphs level off at 80 cm^3.	**Correct:** Since both acids have the same number of moles, the same total volume of CO_2 gas is evolved.
The graph for HCl goes up more steeply than the graph for ethanoic acid.	**Correct:** HCl is a strong acid with higher $[H^+]$, resulting in a faster rate of reaction.
Explanation covers: • Strength of acids • Concentration of H^+ ions • Reaction rate & curve steepness	**Excellent:** Correctly links full vs partial dissociation to $[H^+]$ concentration, collision frequency, and initial curve gradient.