Kirkcaldy High School

Chemistry

National 4

Unit 1 – Chemical Changes and Structure

NOTES

Course Overview

Contents

The National 4 Chemistry Course is split into three units. *Italic* shows the contents of this notes booklet.

Unit 1 – Chemical Changes in Structure

Unit 2 – Nature's Chemistry

Unit 3 – Chemistry in Society

Assessment

There is NO final exam for National 4 Chemistry. To pass the course you must…

- Complete and pass three Unit tests (50 % pass mark each)
- Complete an experimental write-up
- Complete an "Added Value" unit (poster or essay on a Chemistry topic)

Success Criteria

✓	**I am confident that I understand this and I can apply this to problems**
?	I have some understanding but I need to revise this some more
✖	I do not understand this and I need help with it

I will be successful if I can…		Self-Evaluation		
1	State the factors that affect the rate of a reaction	✓	?	x
2	Define the term catalyst	✓	?	x
3	Describe the relationship between different factors and the rate of a reaction	✓	?	x
4	Describe how the rate of a reaction varies as a reaction proceeds	✓	?	x
5	Identify the end point of a reaction on a reaction rate graph	✓	?	x
6	Define the term element	✓	?	x
7	Name the subatomic particles that are found in an atom	✓	?	x
8	Describe subatomic particles in terms of their location in an atom, mass and charge	✓	?	x
9	Use atomic number and mass number to determine the number of protons, neutrons and electrons in an atom	✓	?	x
10	Explain why an atom is electrically neutral	✓	?	x
11	Describe how elements are organised in the periodic table	✓	?	x
12	Discuss the names and properties of Group 1, 7 and 0 elements	✓	?	x
13	Indicate the position of metals and non-metals in the Periodic Table	✓	?	x
14	Define the term compound	✓	?	x
15	Name compounds given the elements present using appropriate name endings	✓	?	x
16	Write the chemical formula for a given compound	✓	?	x
17	Calculate the gram formula mass of a compound	✓	?	x
18	Write a word equation for a given reaction	✓	?	x

19	Write a chemical equation for a given reaction including state symbols	✓	?	x
20	Describe how a covalent bond is formed	✓	?	x
21	State the type of atoms that can form a covalent bond	✓	?	x
22	Draw diagrams showing the sharing of electrons between two atoms	✓	?	x
23	Describe how an ionic bond is formed	✓	?	x
24	State the type of atoms that can form an ionic bond	✓	?	x
25	Explain how ions are formed	✓	?	x
26	Describe the properties (melting point, boiling point, conductivity) associated with different types of bonding	✓	?	x
27	Describe the difference between an exothermic and endothermic reaction	✓	?	x
28	Discuss the pH scale	✓	?	x
29	Give examples of everyday acids and bases	✓	?	x
30	State whether a soluble non-metal oxide / metal oxide will form an acidic / alkaline solution when dissolved in water	✓	?	x
31	List sources of carbon dioxide in the atmosphere	✓	?	x
32	Describe the effects of non-metal oxides on the environment	✓	?	x
33	Describe the negative impact acids have on human health	✓	?	x
34	State the definition of a neutralisation reaction	✓	?	x
35	Name three types of bases	✓	?	x
36	Name the salt produced as a result of a neutralisation reaction	✓	?	x
37	Write a word equation for a neutralisation reaction	✓	?	x

(a) Reaction Rates

Factors Affecting Rate of Reaction

- The rate of a chemical reaction is a measure of how fast the reaction occurs
- The reaction rate is dependent on the reaction that is taking place

Variables Affecting Reaction Rate

- There are many variables that can affect the rate of a reaction
- The table below contains information about how changing concentration, temperature and particle size can affect the rate of reaction

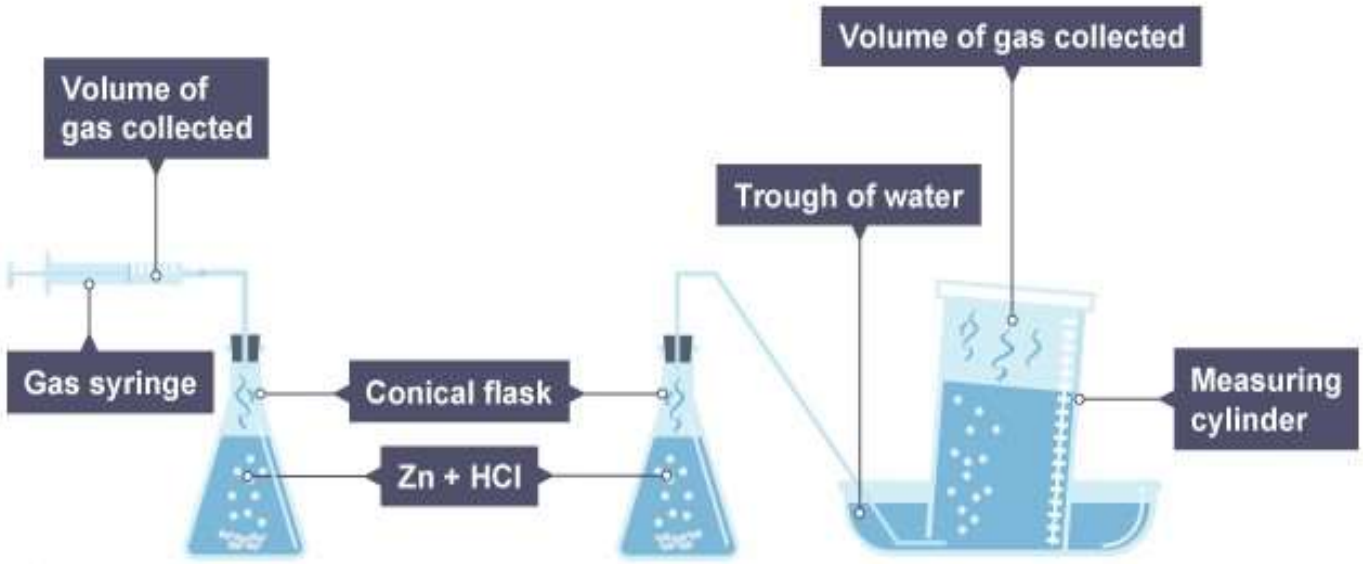
Variable	Change to Variable	Change to Reaction Rate
Concentration	Increase	Speeds up reaction
	Decrease	Slows down reaction
Temperature	Increase	Speeds up reaction
	Decrease	Slows down reaction
Particle Size	Increase	Slows down reaction
	Decrease	Speeds up reaction

Catalysts

- A catalyst is a substance which speeds up a reaction
    - A catalyst remains chemically unchanged at the end of a reaction and can be reused
    - The type of catalyst at the start of the reaction is the same at the end of the reaction.
    - The mass of the catalyst at the start of the reaction is the same at the end of the reaction.
    - For example, the addition of coper metal to the reaction of zinc and sulphuric acid

Monitoring Reaction Rates

- Reactions that produce a gas can be used to monitor the rate of a reaction
- The gas produced can be collected using a measuring cylinder or syringe
- The volume of gas produced at set time intervals would be recorded

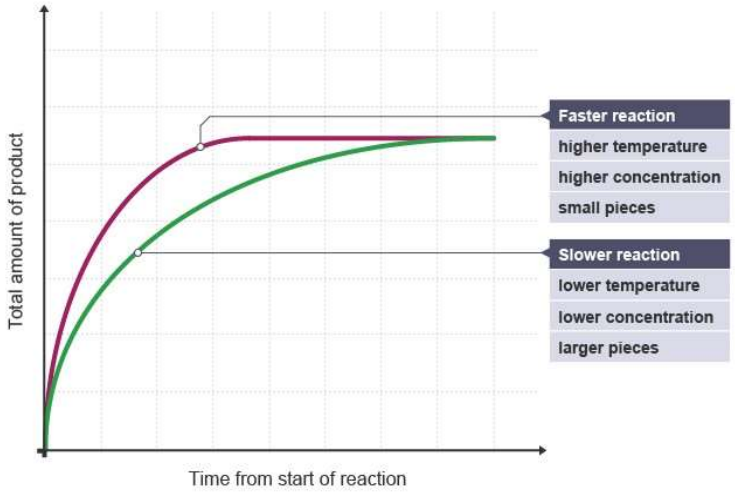


- The change in mass of the reactants can be monitored by carrying out the reaction on a balance
- The mass at set time intervals would be recorded

- We can use recorded data from an experiment to create a reaction rate graph
    - The reaction rate is related to the gradient (slope) of the line
- The reaction has stopped when the line is horizontal
- These graphs can be used to find out information about the reaction

- When was the reaction the fastest?
- What time did the reaction stop?
- What volume of gas was produced after a specified time?
- What was the total volume of gas produced in the reaction?

- To compare reactions, multiple experiments can be plotted on the same graph
  - The variable being measured in the experiments must be the same
  - The use of a catalyst, increased/decreased temperatures, increased/decreased concentrations, increased/decreased particle size can be seen by comparing reaction rate graphs



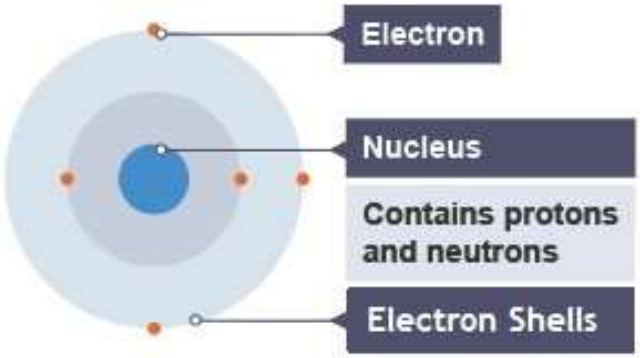
(b) Atomic Structure and Bonding

The Periodic Table

- 118 known elements are found in the Periodic Table
    - An element is a substance which contains only one type of atom
    - Each element has a different symbol and atomic number
- The Periodic Table is arranged in horizontal rows called periods and vertical columns called groups
    - The elements are arranged by atomic number and based on their chemical properties
- Elements in the same group of the Periodic Table have similar chemical properties
- The alkali metals are all soft and reactive metals that will react with water to produce an alkaline solution
    - The halogens are all reactive non-metal elements
    - The noble gases are all colourless and extremely unreactive elements

The Structure of the Atom

- Atoms are made up of three subatomic particles; protons, neutrons and electrons
- Protons and neutrons are found in the central nucleus
- Electrons are found in the electron shells outside the nucleus
- This is shown in the diagram below.



- Each of the subatomic particles has an associated charge and relative mass
  - These are summarised in the table below
  - The nucleus of an atom will have the highest mass
  - Protons are positively charged particles
  - Electrons are negatively charged particles
  - Neutrons are electrically neutral particles
  - Atoms are electrically neutral as the number of positive protons equals the number of negative electrons.

Particle	Position	Charge	Relative Mass (AMU)
Electron	Electron Shell	-1	Almost zero
Proton	Nucleus	+1	1
Neutron	Nucleus	0	1

Atomic Number and Mass number

- Each element in the periodic table has a different atomic number
  - The atomic number is equal to the number of protons in an atom
  - From the atomic number you can work out the number of electrons in an atom as there must be the same number of electrons and protons
- Each element in the periodic table has a mass number
  - The mass number is equal to the total number of protons and neutrons

Naming Compounds

- A compound is a substance that contains more than one type of atom
    - The chemical name of a compound can indicate the types of elements present
    - Name endings are used to indicate if there are two or three elements in a compound and these are shown below
    - Prefixes are used to indicate the number of atoms of a particular element present in a compound and these are shown below

Name Ending	Information provided
IDE	There are 2 elements present in the compound
ATE/ITE	There are 3 elements present in the compound, one of which is oxygen

Prefix	Number
mono	1
di	2
tri	3
tetra	4
penta	5
hexa	6

Formula of Compounds

- The chemical formula of a compound indicates the elements present and the number of atoms of that element in the compound
    - Elements are represented by their symbol
    - The number of atoms of that element present in the compound is represented by a small subscript number

CO_2

There is only one carbon atom **There are two oxygen atoms**

- The chemical formula of a compound can be constructed using three different methods
    - name of the compound if prefixes are present
    - full structural formula
    - valency of the atoms present
- The valency of an atom can be described as the number of bonds an atom can make and can be determined using the following methods
    - The group number of the element
    - The roman numerals present in the compound name

Group Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**0**
Valency	1	2	3	4	3	2	1	0

Roman Numeral	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
Valency	1	2	3	4	5	6	7

- The chemical formula of a compound is constructed using the steps detailed in the table below.

Symbols	Identify the elements present in the compound and note their symbols using the periodic table
Valency	Using group number of roman numerals, determine the valencies of the elements present
Swap	Swap the valencies
Divide	Divide by the lowest common denominator
Formula	Construct the chemical formula of the compound

- Writing the chemical formula for potassium oxide using this system is detailed below

SYMBOL	K		O
VALENCY	1		2
SWAP	2		1
DIVIDE	2		1

FORMULA

Gram Formula Mass

- The gram formula mass (GFM) of a compound is the sum of all the relative atomic masses of each of the elements in the chemical formula
    - The relative atomic mass of each element can be found in the databook.
    - The units of GFM is grams (g)

- For example, calculate the gram formula mass (GFM) of calcium bromide ($CaBr_2$).

1. Identify the number of atoms of each element

$$(1 \times Ca) + (2 \times Br)$$

2. Replace the symbols with the relative atomic masses (RAM)

$$(2 \times 40) + (2 \times 80)$$

3. Calculate

GFM = 200g

Bonding

- There are two main types of bonding, ionic and covalent
    - Covalent bonds are formed when two non-metal atoms share electrons
    - Ionic bonds are formed between a metal and a non-metal atom
- Compounds will have different chemical properties dependent on the type of bonding present
    - These properties are shown in the table below
    - The exceptions to the rule include silicon, carbon, boron, silicon carbide and silicon dioxide

	Covalent		**Ionic**
	Compounds	**Elements**	**Compounds**
Melting Point	Low	Low	High
Boiling Point	Low	Low	High
Conductivity	Do not conduct	Do not conduct	Conduct when in solution

(c) Energy Changes of Chemical Reactions

Energy Changes

- Chemical reactions can be exothermic or endothermic
    - Exothermic reactions release energy
    - Endothermic reactions take in energy

Chemical Equations

- Chemical equations are used to describe a reaction including the reactants and the products
    - The reactants are what you start with¶
    - The products are what you make
    - The reactants and products are separated by an arrow with the reactants on the left-hand side and the products on the right-hand side

Reactants ⟶ **Products**

- In a chemical equation the reactants and products are represented by their symbols/chemical formula
    - Elements are represented by their symbol
    - Compounds are represented by their chemical formula
- The state of the compound/element must be included in a chemical equation
    - Solids are represented by (s)
    - Liquids are represented by (l)
    - Gases are represented by (g)
    - Aqueous solutions are represented by (aq)

(d) Acids and Bases

The pH Scale

- The pH scale is a measure of how acidic a solution is
    - Acidic solutions have a pH less than 7
    - Alkaline solutions have a pH greater than 7
    - Neutral solutions have a pH of 7
- Universal indicator can be used to indicate if a solution is acidic or alkaline
    - Acidic solutions are red/orange/yellow in colour
    - Alkaline solutions are dark green/ blue/ purple in colour
    - Neutral solutions are green in colour
- Everyday and laboratory substances can be acidic, neutral or alkaline
    - Hydrochloric acid, battery acid, lemon juice, vinegar and tomatoes are examples of acidic substances
    - Egg shells, baking soda, bleach, sodium hydroxide, ammonia and hand soap are examples of alkaline substances
    - Water is an example of a neutral solution

Making Acids and Alkalis

- Acids and alkalis can be made from dissolving soluble metal and non-metal oxides in water
    - Dissolving soluble non-metal oxides will always produce acidic solutions
    - Dissolving soluble metal oxides will always produce alkaline solutions
    - Insoluble substances will not change the pH of a solution

Neutralisation

- When a base is added to an acid, neutralisation will take place
  - Neutralisation results in the pH of a solution moving towards pH 7 (neutral)
  - The pH of an acid will rise towards 7
  - The pH of a base will fall towards 7
- When a neutralisation takes place using a metal oxide/hydroxide a salt and water are formed
  - A neutralisation reaction can be represented by a general word equation

Acid + Base ⟶ **Salt + Water**

- There are two simple steps to follow when naming the salt formed as a result of a neutralisation
  - The name of the metal in the base becomes the first part of the salt name
  - The acid used creates the second part of the salt name

Name of Acid	Second part of salt name
Hydrochloric acid	Chloride
Nitric acid	Nitrate
Sulfuric acid	Sulfate

Impacts of Acids on the Environment and Health

- Carbon dioxide, sulfur dioxide and oxides of nitrogen are produced as a result of our continued use of fossil fuels
    - These compounds are non-metals and will dissolve in water to form acidic solutions
    - The increased volumes of these gases being released in the atmosphere has resulted in environmental issues including acid rain, global warming and ocean acidification
- Acids are commonly present in food and drink as preservatives
    - These acids can cause tooth decay and indigestion