10th Class Chemistry Notes

Federal Board (FBISE)

Full Book Notes • Chapter-wise Key Concepts, Definitions, Formulas,
Multiple Choice Questions, Short Questions and Long Questions

Based on the National Book Foundation Grade 10 Chemistry book
(National Curriculum of Pakistan 2022-23)

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A Note on the Examination Paper

Please read this before you start. The Federal Board (FBISE) has restructured its examination pattern under Notification No.1-10/FBISE/RES/242 (7 August 2026) and the Inclusive Scheme of Studies 2024, with 50% multiple choice questions and 50% descriptive questions for the science subjects, including Chemistry. The new pattern is being introduced in stages: it reaches SSC Part-II students only if they sat the Second Annual 2026 examination under the new pattern, and all SSC Part-II students from the First Annual 2028 examination. Most SSC Part-II students in 2027 will still sit the existing pattern.

Because the change is being introduced in stages, and because different third-party sources give different figures for the marks of each section, this book does **not** print any marks figures as fact. For the exact paper pattern that applies to you, check the model papers on the official FBISE website, fbise.edu.pk, and ask your teacher. What does not change is the syllabus: learn

every chapter of this book, practise the questions, and you will be ready for either pattern.

How to Use This Book

- Read the key concepts of a chapter first, then the definitions and formulas.
- Try the multiple choice questions without looking at the answers, then check them with the answer key at the end.
- Write the short and long questions in your own words. Writing is the best way to remember.
- Revise one chapter a day, and in the last week revise the whole book again.

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Chapter 1: History of Chemistry

Chemistry is the study of matter: what it is made of, how it changes and why it changes. This chapter follows chemistry from ancient alchemy to modern science, the work of the early Muslim chemists, and the branches of chemistry we study today.

Key Concepts

- Chemistry is the branch of science that studies matter: its composition, structure, properties and the changes it undergoes. It explains the materials of daily life, from food and medicines to fuels and plastics.
- Alchemy was the early, practical study of matter. Alchemists tried to change cheap metals into gold and to find a medicine for all diseases. They did not succeed in those aims, but they invented useful apparatus and methods, such as distillation and crystallisation.
- Jabir ibn Hayyan, known in Europe as Geber, is called the father of chemistry. He described many chemical processes and apparatus, and he prepared important substances such as strong acids. His work was written down and used for hundreds of years.

- Al-Razi (Rhazes) divided substances into animal, vegetable and mineral kinds, and he described the preparation of alcohol by distillation. Muslim chemists also improved the making of soaps, perfumes, glass and paper.
- Antoine Lavoisier, in the 1700s, showed that mass is conserved in a chemical reaction and gave chemistry its modern basis: careful measurement. He is called the father of modern chemistry.
- John Dalton's atomic theory (1800s) said that matter is made of tiny particles called atoms, that all atoms of an element are alike, and that atoms combine in simple whole-number ratios to form compounds.
- The main branches of chemistry are: organic chemistry (compounds of carbon), inorganic chemistry (other compounds), physical chemistry (energy and rates of change), analytical chemistry (finding what is in a sample) and biochemistry (the chemistry of living things).
- Chemistry helps society in many ways: medicines that cure disease, fertilisers that grow more food, materials such as plastics and steel, clean water and safe food. It also brings duties: chemicals must be used safely and waste must not harm people or the environment.

Important Definitions

Term	Definition
Chemistry	The branch of science that studies matter: its composition, structure, properties and the changes it undergoes.
Alchemy	The early, practical study of matter, from which chemistry grew; its workers invented methods such as distillation.
Distillation	A method of separating a liquid from a mixture by heating it to vapour and then cooling the vapour back to liquid.
Crystallisation	A method of getting pure solid crystals from a solution by cooling or by evaporating the solvent.
Law of conservation of mass	In a chemical reaction, mass is neither created nor destroyed; the total mass stays the same.
Atomic theory	The idea that matter is made of tiny particles called atoms, and that atoms combine in simple ratios to form compounds.
Organic chemistry	The branch of chemistry that studies the compounds of carbon.
Inorganic chemistry	The branch of chemistry that studies compounds other than the compounds of carbon.
Analytical chemistry	The branch of chemistry that finds out what substances are in a sample and how much of each there is.
Biochemistry	The branch of chemistry that studies the chemical processes of living things.

Important Formulas

> Law of conservation of mass: total mass of reactants = total mass of products.

> Example: 2 g of hydrogen + 16 g of oxygen -> 18 g of water (mass is conserved).

> Dalton's idea: atoms of the same element are alike; compounds form when atoms combine in simple whole-number ratios.

> Water: H_2O (2 hydrogen atoms and 1 oxygen atom); carbon dioxide: CO_2 (1 carbon atom and 2 oxygen atoms).

> Jabir ibn Hayyan is called the father of chemistry; Lavoisier is called the father of modern chemistry.

Key Terms to Remember

chemistry, **alchemy**, **Jabir ibn Hayyan**, **al-Razi**, **Lavoisier**, **Dalton**, **atomic theory**, **distillation**, **crystallisation**, **organic chemistry**, **inorganic chemistry**, **physical chemistry**, **analytical chemistry**, **biochemistry**, **conservation of mass**

Multiple Choice Questions

1. Chemistry is the study of:

(a) Living things only (b) Matter and its changes (c) The stars only (d) Numbers only

2. Alchemy is best described as:

(a) Modern chemistry (b) The early practical study of matter (c) The study of the stars (d) The study of living things

3. Who is called the father of chemistry?

(a) Lavoisier (b) Dalton (c) Jabir ibn Hayyan (d) Newton

4. Al-Razi described the preparation of alcohol by:

(a) Filtration (b) Distillation (c) Freezing (d) Burning

5. The law of conservation of mass was shown by:

(a) Dalton (b) Lavoisier (c) Jabir ibn Hayyan (d) Al-Razi

6. According to the law of conservation of mass, in a reaction mass is:

(a) Created (b) Destroyed (c) Neither created nor destroyed (d) Doubled

7. Dalton's atomic theory says that matter is made of:

(a) Cells (b) Atoms (c) Molecules only (d) Ions only

8. The branch of chemistry that studies the compounds of carbon is:

(a) Inorganic chemistry (b) Organic chemistry (c) Physical chemistry (d) Analytical chemistry

9. The chemistry of living things is called:

(a) Analytical chemistry (b) Biochemistry (c) Physical chemistry (d) Alchemy

10. Which of the following is a benefit of chemistry?

(a) Medicines and fertilisers (b) Pollution (c) Waste (d) Poison

Short Questions

1. Define chemistry.
2. What is alchemy? Name two methods invented by alchemists that are still used today.
3. Who was Jabir ibn Hayyan, and why is he called the father of chemistry?
4. What did al-Razi contribute to chemistry?
5. State the law of conservation of mass and give one example.

6. What did Dalton's atomic theory say about atoms?
7. Name the five main branches of chemistry.
8. What does organic chemistry study? What does inorganic chemistry study?
9. Give two benefits of chemistry to society and one duty that comes with using chemicals.
10. How did Lavoisier change chemistry into a modern science?

Long Questions

1. Describe the history of chemistry from alchemy to modern chemistry. Explain the contributions of Jabir ibn Hayyan, al-Razi and Lavoisier.
2. Explain Dalton's atomic theory and the law of conservation of mass. Show with the example of hydrogen and oxygen forming water how mass is conserved in a reaction.
3. Describe the five main branches of chemistry and give one example of what each one studies. Explain how chemistry helps society and what duties come with the use of chemicals.

Chapter 2: Matter

Matter is anything that has mass and takes up space. This chapter explains the states of matter, the properties of matter, elements, compounds and mixtures, and the difference between physical and chemical changes.

Key Concepts

- Matter is anything that has mass and occupies space. All the things around us, air, water, wood, iron and our own bodies, are matter.
- Matter exists in three common states: solid, liquid and gas. A solid has a fixed shape and a fixed volume; a liquid has a fixed volume but takes the shape of its container; a gas has neither a fixed shape nor a fixed volume.
- The particles of a solid are closely packed and vibrate about fixed positions. The particles of a liquid are close but can slide past each other. The particles of a gas are far apart and move freely and fast.
- Matter can change state: melting (solid to liquid), freezing (liquid to solid), evaporation and boiling (liquid to gas), condensation (gas to liquid) and sublimation (solid directly to gas, as with dry ice or camphor).
- Physical properties can be seen or measured without changing the substance: colour, smell, density, melting point, boiling point and hardness. Chemical properties describe how a substance reacts with other substances, such as burning or rusting.
- An element is a pure substance made of only one kind of atom, such as oxygen, iron or gold. A compound is a pure substance made of two or more elements joined chemically in a fixed ratio, such as water (H2O) or common salt (NaCl).
- A mixture is made of two or more substances mixed together without a chemical reaction, such as air, sea water or sand and salt. The parts of a mixture keep their own properties and can be separated by physical methods.
- Physical changes, such as melting or dissolving, do not make a new substance and are often easy to reverse. Chemical changes, such as burning or rusting, make new substances and are usually hard to reverse.
- Mixtures are separated by physical methods: filtration (solid from liquid), evaporation (a dissolved

solid from a solution), distillation (liquids of different boiling points) and magnetic separation (iron from other solids).

Important Definitions

Term	Definition
Matter	Anything that has mass and occupies space.
Solid	A state of matter with a fixed shape and a fixed volume.
Liquid	A state of matter with a fixed volume but no fixed shape; it takes the shape of its container.
Gas	A state of matter with neither a fixed shape nor a fixed volume.
Element	A pure substance made of only one kind of atom.
Compound	A pure substance made of two or more elements joined chemically in a fixed ratio.
Mixture	Two or more substances mixed together without a chemical reaction.
Physical change	A change that does not make a new substance, such as melting or dissolving.
Chemical change	A change that makes one or more new substances, such as burning or rusting.
Sublimation	The change of a solid directly into a gas without passing through the liquid state.

Important Formulas

> Density = mass / volume; SI unit kg/m^3; density of water = 1000 kg/m^3.

> Water: H2O; common salt: NaCl; carbon dioxide: CO2; sulphuric acid: H2SO4.

> Melting point of ice = 0 degrees C; boiling point of water = 100 degrees C (at standard pressure).

> Physical change: no new substance is made (melting, freezing, dissolving). Chemical change: a new substance is made (burning, rusting).

> Separation: filtration separates a solid from a liquid; evaporation separates a dissolved solid from a solution; distillation separates liquids of different boiling points.

Key Terms to Remember

matter, **solid**, **liquid**, **gas**, **melting**, **freezing**, **evaporation**, **boiling**, **condensation**, **sublimation**, **element**, **compound**, **mixture**, **physical change**, **chemical change**, **density**, **filtration**, **distillation**

Multiple Choice Questions

1. Matter is anything that has:

(a) Mass and volume (b) Colour only (c) Smell only (d) Energy only

2. Which state of matter has a fixed shape and a fixed volume?

(a) Solid (b) Liquid (c) Gas (d) Plasma

3. The particles of a gas are:

(a) Closely packed (b) Far apart and moving fast (c) Fixed in position (d) In layers

4. Sublimation is the change of:

(a) Solid to liquid (b) Liquid to gas (c) Solid directly to gas (d) Gas to liquid

5. Which of the following is an element?

(a) Water (b) Common salt (c) Iron (d) Air

6. Which of the following is a compound?

(a) Oxygen (b) Gold (c) Water (d) Nitrogen

7. Air is an example of a:

(a) Element (b) Compound (c) Mixture (d) Pure substance

8. Melting of ice is a:

(a) Chemical change (b) Physical change (c) Nuclear change (d) No change

9. Rusting of iron is a:

(a) Physical change (b) Chemical change (c) Change of state (d) Reversible change

10. A solid can be separated from a liquid by:

(a) Distillation (b) Filtration (c) Sublimation (d) Condensation

Short Questions

1. Define matter and give three examples.
2. Describe the three states of matter and how their particles are arranged.
3. Define melting, freezing, evaporation and condensation.
4. What is sublimation? Give one example.
5. Distinguish between physical and chemical properties with one example of each.
6. Distinguish between an element and a compound with one example of each.
7. What is a mixture? Give two examples.
8. Distinguish between a physical change and a chemical change with one example of each.
9. How would you separate sand from water? How would you get salt from sea water?
10. State the formula and the density of water.

Long Questions

1. Describe the three states of matter and the arrangement and motion of their particles. Explain melting, freezing, evaporation, boiling, condensation and sublimation with examples.
2. Distinguish between elements, compounds and mixtures with examples. Explain how mixtures are separated by filtration, evaporation, distillation and magnetic separation.
3. Distinguish between physical and chemical changes with examples. Explain physical and chemical properties, and describe the changes that happen when iron rusts and when ice melts.

Chapter 3: Stoichiometry

Stoichiometry is the study of the amounts of substances in a chemical reaction. This chapter explains the mole, molar mass, Avogadro's number, chemical equations, empirical and molecular formulas, limiting reactants and percentage yield.

Key Concepts

- A mole is the amount of a substance that contains as many particles as there are atoms in 12 g of carbon-12. One mole of any substance contains 6.02 x 10^23 particles (Avogadro's number).
- Molar mass is the mass of one mole of a substance, in grams per mole. It is found by adding the atomic masses of all the atoms in the formula. The molar mass of water (H2O) is 18 g/mol.
- The number of moles is found from n = mass / molar mass, or from n = number of particles / Avogadro's number. For a gas at standard temperature and pressure, one mole occupies 22.4 dm^3.
- A chemical equation shows the reactants and the products of a reaction. It must be balanced, so that the number of atoms of each element is the same on both sides, following the law of conservation of mass.
- The empirical formula is the simplest whole-number ratio of the atoms in a compound. The molecular formula shows the actual number of atoms in one molecule. For glucose, the empirical formula is CH2O and the molecular formula is C6H12O6.
- The limiting reactant is the reactant that is used up first in a reaction; it decides how much product can form. The other reactants are in excess and some of them is left over.
- The theoretical yield is the amount of product that should form if the reaction goes perfectly. The actual yield is what is really obtained. Percentage yield = (actual yield / theoretical yield) x 100.
- Stoichiometry is used to find how much of each reactant is needed and how much product will form. For example, 2 g of hydrogen reacts with 16 g of oxygen to make 18 g of water, in the ratio of their molar masses.

Important Definitions

Term	Definition
Mole	The amount of a substance that contains 6.02 x 10^23 particles (Avogadro's number).
Avogadro's number	6.02 x 10^23; the number of particles in one mole of a substance.
Molar mass	The mass of one mole of a substance, in grams per mole (g/mol).
Chemical equation	A short way of writing a chemical reaction with symbols and formulas.
Balanced equation	A chemical equation in which the number of atoms of each element is the same on both sides.
Empirical formula	The simplest whole-number ratio of the atoms in a compound.
Molecular formula	The formula that shows the actual number of atoms of each element in one molecule.
Limiting reactant	The reactant that is used up first in a reaction and decides how much product can form.
Theoretical yield	The amount of product that should form if a reaction goes perfectly.
Percentage yield	The actual yield as a percentage of the theoretical yield.

Important Formulas

- Number of moles n = mass / molar mass.
- Number of particles = number of moles x Avogadro's number (6.02 x 10^23).
- Molar mass of H2O = (2 x 1) + 16 = 18 g/mol; molar mass of H2SO4 = (2 x 1) + 32 + (4 x 16) = 98 g/mol.
- Percentage yield = (actual yield / theoretical yield) x 100.
- Balanced equation: 2H2 + O2 -> 2H2O; N2 + 3H2 -> 2NH3.
- One mole of a gas occupies 22.4 dm^3 at standard temperature and pressure.

Key Terms to Remember

mole, **Avogadro's number**, **molar mass**, **chemical equation**, **balanced equation**, **empirical formula**, **molecular formula**, **limiting reactant**, **excess reactant**, **theoretical yield**, **actual yield**, **percentage yield**, **reactant**, **product**

Multiple Choice Questions

1. One mole of any substance contains:

(a) 6.02 x 10^23 particles (b) 6.02 x 10^22 particles (c) 12 particles (d) 100 particles

2. The molar mass of water (H2O) is:

(a) 16 g/mol (b) 18 g/mol (c) 20 g/mol (d) 10 g/mol

3. The molar mass of sulphuric acid (H2SO4) is:

(a) 49 g/mol (b) 98 g/mol (c) 96 g/mol (d) 100 g/mol

4. How many moles are there in 49 g of H2SO4?

(a) 0.5 mol (b) 1 mol (c) 2 mol (d) 49 mol

5. A balanced chemical equation has:

(a) More atoms on the left (b) More atoms on the right (c) The same number of atoms of each element on both sides (d) No atoms

6. The empirical formula of glucose (C6H12O6) is:

(a) C6H12O6 (b) CH2O (c) C2H4O2 (d) CHO

7. The limiting reactant is the reactant that:

(a) Is left over (b) Is used up first (c) Is a gas (d) Is a liquid

8. Percentage yield is equal to:

(a) Actual yield x theoretical yield (b) Actual yield / theoretical yield x 100 (c) Theoretical yield / actual yield (d) Actual yield + theoretical yield

9. 2H2 + O2 -> 2H2O shows that 2 g of hydrogen reacts with:

(a) 8 g of oxygen (b) 16 g of oxygen (c) 32 g of oxygen (d) 2 g of oxygen

10. One mole of a gas at standard temperature and pressure occupies:

(a) 22.4 dm^3 (b) 2.24 dm^3 (c) 224 dm^3 (d) 1 dm^3

Short Questions

1. Define a mole and state Avogadro's number.
2. Define molar mass. Find the molar mass of carbon dioxide (CO2).
3. How many moles are there in 36 g of water?
4. How many molecules are there in 2 moles of water?
5. What is a balanced chemical equation? Why must equations be balanced?
6. Balance the equation: H2 + O2 -> H2O.
7. Distinguish between empirical and molecular formulas with the example of glucose.
8. What is a limiting reactant? Why does it decide how much product forms?
9. Define theoretical yield and percentage yield.
10. A reaction should give 50 g of product but gives 40 g. Find the percentage yield.

Long Questions

1. Explain the mole, Avogadro's number and molar mass. Find the molar mass of H2SO4 and the number of moles in 49 g of it, and the number of molecules in 2 moles of water.
2. Explain empirical and molecular formulas with the example of glucose. Describe how to find the empirical formula of a compound from its percentage composition.
3. Explain the limiting reactant and percentage yield. Describe how a balanced chemical equation is used to find the masses of reactants needed and products formed, using the reaction of hydrogen and oxygen to make water.

Chapter 4: Electrochemistry

Electrochemistry is the study of the link between chemical reactions and electricity. This chapter explains oxidation and reduction, electrochemical cells, electrolysis, batteries and electroplating.

Key Concepts

- Oxidation is the loss of electrons (or the gain of oxygen, or the loss of hydrogen). Reduction is the gain of electrons (or the loss of oxygen, or the gain of hydrogen). Oxidation and reduction always happen together; one substance is oxidised while another is reduced.
- An oxidising agent is a substance that oxidises another substance and is itself reduced. A reducing agent is a substance that reduces another substance and is itself oxidised.
- An electrochemical cell changes chemical energy into electrical energy. It has two electrodes (an anode and a cathode) dipped in an electrolyte. Electrons flow from the anode (where oxidation happens) to the cathode (where reduction happens) through the outer wire.
- A Daniell cell is made of a zinc electrode in zinc sulphate solution and a copper electrode in copper sulphate solution, joined by a salt bridge. Zinc is oxidised at the anode and copper ions are reduced at the cathode; the cell gives about 1.1 V.
- Electrolysis is the breaking down of a compound by passing an electric current through it. It happens in an electrolytic cell: the positive electrode is the anode and the negative electrode is the cathode. The electrolyte must be molten or in solution so that its ions can move.
- In the electrolysis of water, hydrogen gas is given off at the cathode and oxygen gas at the anode, in the ratio of 2:1 by volume. In the electrolysis of molten sodium chloride, sodium forms at the cathode and chlorine gas at the anode.

- Electroplating is coating one metal with a thin layer of another metal by electrolysis. The object to be plated is the cathode, the plating metal is the anode, and the electrolyte contains ions of the plating metal. It is used to protect iron from rusting and to make objects look good.
- Batteries store chemical energy and give it as electricity. A dry cell gives 1.5 V; a car battery is made of six lead-acid cells giving 12 V. Rechargeable batteries can be charged again by passing a current through them in the opposite direction.
- Electrochemistry is used in daily life: in batteries and fuel cells, in the extraction of reactive metals such as aluminium, in electroplating, and in protecting ships and pipelines from rusting (sacrificial protection).

Important Definitions

Term	Definition
Oxidation	The loss of electrons (or the gain of oxygen, or the loss of hydrogen) by a substance.
Reduction	The gain of electrons (or the loss of oxygen, or the gain of hydrogen) by a substance.
Oxidising agent	A substance that oxidises another substance and is itself reduced.
Reducing agent	A substance that reduces another substance and is itself oxidised.
Electrochemical cell	A device that changes chemical energy into electrical energy.
Electrolyte	A substance that conducts electricity when molten or in solution because it has free ions.
Electrolysis	The breaking down of a compound by passing an electric current through it.
Anode	The electrode at which oxidation happens; in an electrolytic cell it is the positive electrode.
Cathode	The electrode at which reduction happens; in an electrolytic cell it is the negative electrode.
Electroplating	Coating one metal with a thin layer of another metal by electrolysis.

Important Formulas

> Oxidation is loss of electrons; reduction is gain of electrons (remember: OIL RIG - Oxidation Is Loss, Reduction Is Gain).

> At the anode, oxidation happens; at the cathode, reduction happens.

> Daniell cell: Zn -> Zn2+ + 2e- (anode, oxidation); Cu2+ + 2e- -> Cu (cathode, reduction); cell voltage about 1.1 V.

> Electrolysis of water: 2H2O -> 2H2 + O2; hydrogen at the cathode and oxygen at the anode, in the ratio 2:1 by volume.

> Electrolysis of molten NaCl: Na+ + e- -> Na (cathode); 2Cl- -> Cl2 + 2e- (anode).

> Electroplating: the object to be plated is the cathode; the plating metal is the anode.

Key Terms to Remember

oxidation, **reduction**, **oxidising agent**, **reducing agent**, **electrochemical cell**, **electrolyte**, **electrolysis**, **anode**, **cathode**, **electroplating**, **Daniell cell**, **salt bridge**, **battery**, **fuel cell**

Multiple Choice Questions

1. Oxidation is the:

(a) Gain of electrons (b) Loss of electrons (c) Gain of protons (d) Loss of neutrons

2. Reduction is the:

(a) Loss of electrons (b) Gain of electrons (c) Gain of oxygen (d) Loss of hydrogen

3. An oxidising agent is itself:

(a) Oxidised (b) Reduced (c) Unchanged (d) Melted

4. In an electrochemical cell, oxidation happens at the:

(a) Cathode (b) Anode (c) Salt bridge (d) Wire

5. In an electrolytic cell, the anode is the:

(a) Negative electrode (b) Positive electrode (c) Neutral electrode (d) Salt bridge

6. In the electrolysis of water, hydrogen is given off at the:

(a) Anode (b) Cathode (c) Salt bridge (d) Battery

7. The ratio of hydrogen to oxygen by volume in the electrolysis of water is:

(a) 1:1 (b) 1:2 (c) 2:1 (d) 1:8

8. In electroplating, the object to be plated is the:

(a) Anode (b) Cathode (c) Electrolyte (d) Battery

9. A Daniell cell gives a voltage of about:

(a) 1.5 V (b) 1.1 V (c) 12 V (d) 220 V

10. A car battery is made of six lead-acid cells giving:

(a) 1.5 V (b) 6 V (c) 12 V (d) 24 V

Short Questions

1. Define oxidation and reduction in terms of electrons.
2. Distinguish between an oxidising agent and a reducing agent.
3. What is an electrochemical cell? Name its two electrodes and state what happens at each.
4. Describe the Daniell cell and state the voltage it gives.
5. Define electrolysis and electrolyte.
6. What are the products of the electrolysis of water, and in what ratio are they given off?
7. What are the products of the electrolysis of molten sodium chloride?
8. What is electroplating? Which electrode is the object to be plated?
9. Name two uses of electrolysis.
10. What is a battery? Give the voltage of a dry cell and of a car battery.

Long Questions

1. Explain oxidation and reduction in terms of electrons, oxygen and hydrogen. Describe oxidising and reducing agents, giving one example of each, and explain why oxidation and reduction always happen together.
2. Describe the construction and working of the Daniell cell, including the reactions at each electrode. Explain electrolysis with the examples of water and molten sodium chloride.
3. Explain electroplating: the apparatus, the reactions, and its uses in protecting metals and in decoration. Describe how batteries work and give two uses of electrochemistry in daily life.

Chapter 5: Reaction Kinetics

Reaction kinetics is the study of how fast chemical reactions go and what changes their speed. This chapter explains the rate of a reaction, collision theory, activation energy and the factors that affect the rate: concentration, temperature, surface area and catalysts.

Key Concepts

- The rate of a reaction is how fast the reactants change into products. It is measured by how quickly a reactant is used up or a product is formed, for example the volume of gas given off in a set time.
- Collision theory says that particles must collide to react, and only collisions with enough energy and the right orientation cause a reaction. Most collisions do not cause a reaction.
- Activation energy is the smallest amount of energy that colliding particles must have to react. Particles with less energy than this bounce off each other without reacting.
- Increasing the concentration of a reactant increases the rate, because there are more particles in the same volume, so collisions happen more often.
- Increasing the temperature increases the rate, because the particles move faster, collide more often, and more of them have energy above the activation energy. As a rough guide, the rate doubles for a rise of 10 degrees C.
- Increasing the surface area of a solid reactant increases the rate, because more particles are exposed and can collide. A powder reacts faster than a lump of the same mass.
- A catalyst is a substance that speeds up a reaction without being used up in it. It works by giving the reaction a new path with a lower activation energy, so more collisions can succeed.
- Enzymes are biological catalysts. They speed up reactions in living things, work best at body temperature and a particular pH, and are destroyed by high temperatures.
- A reaction can be followed by measuring the change in mass, the volume of gas given off, a colour change or a change in pH over time. A graph of the amount against time is steep at first and flattens when the reaction ends.

Important Definitions

Term	Definition
Rate of reaction	How fast the reactants change into products; measured by the change in amount per unit time.
Collision theory	The idea that particles must collide with enough energy and the right orientation

	to react.
Activation energy	The smallest amount of energy that colliding particles must have for a reaction to happen.
Catalyst	A substance that speeds up a reaction without being used up in it.
Enzyme	A biological catalyst that speeds up reactions in living things.
Surface area	The total area of the surface of a solid that is exposed to a reactant.
Concentration	The amount of a substance in a given volume of solution, usually in mol/dm^3.
Exothermic reaction	A reaction that gives out heat to the surroundings.
Endothermic reaction	A reaction that takes in heat from the surroundings.
Rate curve	A graph of the amount of reactant or product against time, which shows how fast a reaction goes.

Important Formulas

> Rate of reaction = change in amount of reactant or product / time taken.

> Collision theory: for a reaction, particles must collide with energy at least equal to the activation energy and in the right orientation.

> A catalyst gives a new reaction path with a lower activation energy, so more collisions succeed.

> As a rough guide, the rate of a reaction doubles for a rise of 10 degrees C in temperature.

> Rate increases with concentration, temperature, surface area and the use of a catalyst.

> Example: zinc powder reacts with dilute acid faster than a zinc lump of the same mass, because its surface area is larger.

Key Terms to Remember

rate of reaction, **collision theory**, **activation energy**, **catalyst**, **enzyme**, **concentration**, **surface area**, **temperature**, **exothermic**, **endothermic**, **rate curve**

Multiple Choice Questions

1. The rate of a reaction is measured by:

(a) The colour of the product only (b) How quickly a reactant is used up or a product is formed (c) The mass of the catalyst (d) The volume of the container

2. According to collision theory, particles must collide with:

(a) Any energy (b) Enough energy and the right orientation (c) No energy (d) A catalyst only

3. Activation energy is the:

(a) Energy given out by a reaction (b) Smallest energy colliding particles must have to react (c) Energy of the products (d) Energy of the catalyst

4. Increasing the concentration of a reactant:

(a) Decreases the rate (b) Increases the rate (c) Does not change the rate (d) Stops the reaction

5. Increasing the temperature increases the rate because:

(a) Particles move slower (b) Particles move faster and more have energy above the activation energy (c) The catalyst is used up (d) The volume increases

6. A powder reacts faster than a lump of the same mass because it has:

(a) Less mass (b) A larger surface area (c) A smaller surface area (d) More catalyst

7. A catalyst speeds up a reaction by:

(a) Being used up (b) Giving a new path with a lower activation energy (c) Cooling the mixture (d) Adding more reactant

8. Enzymes are:

(a) Inorganic catalysts (b) Biological catalysts (c) Acids (d) Salts

9. As a rough guide, the rate of a reaction doubles for a rise of:

(a) 1 degree C (b) 10 degrees C (c) 100 degrees C (d) 1000 degrees C

10. A graph of the amount of product against time is steep at first and then flattens because:

(a) The reaction speeds up (b) The reactants are used up and the reaction ends (c) The catalyst is added (d) The temperature falls

Short Questions

1. Define the rate of a reaction and state how it can be measured.
2. State collision theory.
3. Define activation energy.
4. How does increasing the concentration change the rate of a reaction? Explain with collision theory.
5. How does increasing the temperature change the rate? Explain.
6. Why does a powder react faster than a lump of the same solid?
7. What is a catalyst? How does it speed up a reaction?
8. What is an enzyme? State two properties of enzymes.
9. How can the rate of a reaction that gives off a gas be followed?
10. Describe the shape of a graph of the amount of product against time for a reaction, and explain it.

Long Questions

1. Explain collision theory and activation energy. Describe why most collisions between particles do not cause a reaction.
2. Explain how concentration, temperature and surface area affect the rate of a reaction, using collision theory. Give one example for each factor.
3. Explain what a catalyst is and how it works. Describe enzymes as biological catalysts, and explain how the rate of a reaction can be followed by measuring the volume of gas given off.

Chapter 6: Salts

Salts are the ionic compounds formed when an acid reacts with a base. This chapter explains how salts

are made, their types, their properties and their uses in daily life, farming and industry.

Key Concepts

- A salt is an ionic compound formed when the hydrogen ions of an acid are replaced by a metal ion or an ammonium ion. Common salt, sodium chloride, is formed from hydrochloric acid and sodium hydroxide.
- Salts are made by neutralisation: an acid plus a base gives a salt plus water. For example, hydrochloric acid plus sodium hydroxide gives sodium chloride plus water.
- Salts are also made by an acid reacting with a metal (giving a salt plus hydrogen), with a metal oxide (giving a salt plus water) or with a metal carbonate (giving a salt plus water plus carbon dioxide).
- A normal salt is formed when all the replaceable hydrogen ions of an acid are replaced, such as sodium chloride from hydrochloric acid. An acidic salt is formed when only some are replaced, such as sodium hydrogen sulphate. A basic salt is formed when a base is only partly neutralised.
- Most salts are solids with high melting points. They are usually soluble in water and their solutions conduct electricity, because they contain free ions. Solid salts do not conduct electricity, because their ions cannot move.
- Some salts contain water in their crystals, called water of crystallisation. Blue copper sulphate crystals (CuSO4.5H2O) lose their water on heating and become white; they turn blue again when water is added.
- Salts have many uses: common salt flavours and preserves food; washing soda (sodium carbonate) is used for cleaning; baking soda (sodium hydrogen carbonate) is used in cooking and in fire extinguishers; plaster of Paris is used for casts and moulds.
- Salt solutions can be acidic, basic or neutral. A salt of a strong acid and a strong base (such as sodium chloride) gives a neutral solution. A salt of a strong acid and a weak base gives an acidic solution, and a salt of a weak acid and a strong base gives a basic solution.
- Fertilisers are salts that give plants the nutrients they need: ammonium sulphate and urea give nitrogen, and potassium salts give potassium. Too much fertiliser can pollute rivers and lakes.

Important Definitions

Term	Definition
Salt	An ionic compound formed when the hydrogen ions of an acid are replaced by a metal ion or an ammonium ion.
Neutralisation	The reaction of an acid with a base to give a salt and water.
Normal salt	A salt formed when all the replaceable hydrogen ions of an acid are replaced.
Acidic salt	A salt formed when only some of the replaceable hydrogen ions of an acid are replaced.
Basic salt	A salt formed when a base is only partly neutralised by an acid.
Water of crystallisation	Water molecules held inside the crystals of a salt, in a fixed ratio.
Hydrated salt	A salt that contains water of crystallisation in its crystals.

Anhydrous salt	A salt that contains no water of crystallisation.
Salt hydrolysis	The reaction of a salt with water, which can make the solution acidic or basic.
Fertiliser	A salt that gives plants the nutrients they need, such as nitrogen or potassium.

Important Formulas

> Acid + base -> salt + water: HCl + NaOH -> NaCl + H2O.

> Acid + metal -> salt + hydrogen: 2HCl + Zn -> ZnCl2 + H2.

> Acid + metal carbonate -> salt + water + carbon dioxide: 2HCl + CaCO3 -> CaCl2 + H2O + CO2.

> Acid + metal oxide -> salt + water: 2HCl + CuO -> CuCl2 + H2O.

> Blue copper sulphate: CuSO4.5H2O (hydrated); on heating it becomes white anhydrous CuSO4.

> Baking soda: NaHCO3; washing soda: Na2CO3.10H2O; plaster of Paris: CaSO4.1/2H2O.

Key Terms to Remember

salt, **neutralisation**, **normal salt**, **acidic salt**, **basic salt**, **water of crystallisation**, **hydrated salt**, **anhydrous salt**, **hydrolysis**, **fertiliser**, **washing soda**, **baking soda**, **plaster of Paris**

Multiple Choice Questions

1. A salt is formed when an acid reacts with a:

(a) Metal only (b) Base (c) Salt (d) Gas

2. Hydrochloric acid plus sodium hydroxide gives:

(a) Sodium chloride and water (b) Sodium chloride and hydrogen (c) Sodium oxide (d) Chlorine gas

3. An acid plus a metal gives a salt and:

(a) Oxygen (b) Hydrogen (c) Water (d) Carbon dioxide

4. An acid plus a metal carbonate gives a salt, water and:

(a) Hydrogen (b) Oxygen (c) Carbon dioxide (d) Nitrogen

5. Sodium hydrogen sulphate is an example of a:

(a) Normal salt (b) Acidic salt (c) Basic salt (d) Neutral salt

6. Solid salts do not conduct electricity because:

(a) They have no ions (b) Their ions cannot move (c) They are gases (d) They are wet

7. Blue copper sulphate crystals contain:

(a) No water (b) Water of crystallisation (c) Acid (d) Alcohol

8. On heating, blue copper sulphate becomes:

(a) Green (b) White (c) Black (d) Red

9. Baking soda is:

(a) Sodium chloride (b) Sodium hydrogen carbonate (c) Sodium carbonate (d) Calcium sulphate

10. A salt of a strong acid and a strong base gives a:

(a) Acidic solution (b) Basic solution (c) Neutral solution (d) Coloured solution

Short Questions

1. Define a salt and give two examples.
2. Write the word equation for neutralisation and give one example with a chemical equation.
3. How is a salt made from an acid and a metal? Give one example.
4. How is a salt made from an acid and a metal carbonate? Give one example.
5. Distinguish between a normal salt, an acidic salt and a basic salt with one example of each.
6. Why do salt solutions conduct electricity while solid salts do not?
7. What is water of crystallisation? Give one example of a hydrated salt.
8. What happens when blue copper sulphate crystals are heated? What happens when water is added again?
9. Give three uses of salts in daily life.
10. Why are fertilisers used, and what harm can too much fertiliser do?

Long Questions

1. Explain how salts are made by neutralisation and by the reactions of acids with metals, metal oxides and metal carbonates, giving one balanced equation for each method.
2. Explain normal, acidic and basic salts with examples. Describe the properties of salts, including their melting points and their conduction of electricity in the solid state and in solution.
3. Explain water of crystallisation with the example of copper sulphate. Describe the uses of common salt, washing soda, baking soda and plaster of Paris, and the use of salts as fertilisers.

Chapter 7: Nitrogen, Sulphur and Metals

Nitrogen and sulphur are non-metals whose compounds are used in farming and industry, and metals are the materials of tools, machines and buildings. This chapter explains the nitrogen cycle, ammonia and nitric acid, sulphur and sulphuric acid, oxides, and the properties and reactivity of metals.

Key Concepts

- Nitrogen makes up about 78% of the air. It is unreactive because its molecules have a strong triple bond. Nitrogen is needed by plants to make proteins, but plants cannot use nitrogen gas directly.
- The nitrogen cycle moves nitrogen between the air, the soil and living things: lightning and bacteria fix nitrogen into nitrates in the soil, plants take up the nitrates, animals eat the plants, and bacteria return nitrogen to the air when organisms decay.
- Ammonia is made by the Haber process: nitrogen and hydrogen react at high temperature and high pressure with an iron catalyst: N2 + 3H2 -> 2NH3. Ammonia is used to make fertilisers and nitric acid.
- Nitric acid is made by the Ostwald process, from ammonia. It is a strong acid used to make fertilisers, explosives and dyes.
- Sulphur is a yellow non-metal found near volcanoes. It burns in air to give sulphur dioxide, which is used to make sulphuric acid. Sulphur is used in vulcanising rubber, in fungicides and in making matches.
- Sulphuric acid is made by the Contact process: sulphur dioxide is oxidised to sulphur trioxide with

a vanadium(V) oxide catalyst, and the trioxide is dissolved in concentrated acid to give oleum, which is then diluted. Sulphuric acid is used in car batteries, fertilisers and detergents, and is called the king of chemicals.

- Oxides are compounds of an element with oxygen. Acidic oxides (such as sulphur dioxide and carbon dioxide) form acids with water. Basic oxides (such as calcium oxide) form bases with water. Amphoteric oxides (such as aluminium oxide and zinc oxide) react with both acids and bases.
- Metals are shiny, malleable, ductile and good conductors of heat and electricity. They lose electrons to form positive ions. Most metals react with oxygen to form basic oxides, and with dilute acids to give a salt and hydrogen.
- The reactivity series lists metals from most reactive to least reactive: potassium, sodium, calcium, magnesium, aluminium, zinc, iron, lead, copper, silver, gold. A more reactive metal displaces a less reactive metal from its salt solution.
- Highly reactive metals are extracted by electrolysis (such as aluminium); less reactive metals are extracted by heating their ores with carbon (such as iron in a blast furnace). Gold is found uncombined because it is so unreactive.
- Photochemical smog is formed when sunlight acts on nitrogen oxides and unburned hydrocarbons from vehicles, making secondary pollutants. Acid rain is caused by sulphur dioxide and nitrogen dioxide dissolving in rainwater to form acids.

Important Definitions

Term	Definition
Nitrogen fixation	The changing of nitrogen gas into nitrates in the soil, by lightning or by bacteria, so that plants can use it.
Haber process	The industrial making of ammonia from nitrogen and hydrogen with an iron catalyst at high temperature and pressure.
Contact process	The industrial making of sulphuric acid from sulphur dioxide, using a vanadium(V) oxide catalyst.
Oleum	A solution of sulphur trioxide in concentrated sulphuric acid ($H_2S_2O_7$), used in making sulphuric acid.
Acidic oxide	An oxide that forms an acid when it reacts with water, such as sulphur dioxide.
Basic oxide	An oxide that forms a base when it reacts with water, such as calcium oxide.
Amphoteric oxide	An oxide that reacts with both acids and bases, such as aluminium oxide or zinc oxide.
Reactivity series	A list of metals in order of how reactive they are, from most reactive to least reactive.
Displacement reaction	A reaction in which a more reactive metal takes the place of a less reactive metal in its salt.
Acid rain	Rain made acidic by sulphur dioxide and nitrogen dioxide from burning fuels.
Photochemical	A haze formed when sunlight acts on nitrogen oxides and hydrocarbons from

smog vehicles.

Important Formulas

- Haber process: N2 + 3H2 -> 2NH3 (iron catalyst, high temperature and pressure).
- Contact process: 2SO2 + O2 -> 2SO3 (vanadium(V) oxide catalyst); SO3 + H2SO4 -> H2S2O7 (oleum); H2S2O7 + H2O -> 2H2SO4.
- Sulphur dioxide with water: SO2 + H2O -> H2SO3 (sulphurous acid).
- Acidic oxide example: CO2 + H2O -> H2CO3 (carbonic acid). Basic oxide example: CaO + H2O -> Ca(OH)2.
- Metal with dilute acid: Zn + 2HCl -> ZnCl2 + H2.
- Reactivity order (most to least): K, Na, Ca, Mg, Al, Zn, Fe, Pb, Cu, Ag, Au.

Key Terms to Remember

nitrogen, **nitrogen cycle**, **ammonia**, **Haber process**, **nitric acid**, **sulphur**, **sulphuric acid**, **Contact process**, **oleum**, **acidic oxide**, **basic oxide**, **amphoteric oxide**, **reactivity series**, **displacement**, **acid rain**, **photochemical smog**

Multiple Choice Questions

1. Nitrogen makes up about how much of the air?

(a) 21% (b) 78% (c) 1% (d) 50%

2. Plants take up nitrogen from the soil as:

(a) Nitrogen gas (b) Nitrates (c) Ammonia gas (d) Nitric acid

3. Ammonia is made by the:

(a) Contact process (b) Haber process (c) Ostwald process (d) Blast furnace

4. The catalyst used in the Haber process is:

(a) Vanadium(V) oxide (b) Iron (c) Platinum (d) Nickel

5. Sulphuric acid is made by the:

(a) Haber process (b) Contact process (c) Ostwald process (d) Electrolysis

6. The catalyst used in the Contact process is:

(a) Iron (b) Vanadium(V) oxide (c) Platinum (d) Zinc

7. Sulphur dioxide with water gives:

(a) Sulphuric acid (b) Sulphurous acid (c) Nitric acid (d) Carbonic acid

8. Calcium oxide is an example of a:

(a) Acidic oxide (b) Basic oxide (c) Amphoteric oxide (d) Neutral oxide

9. Aluminium oxide is an example of a:

(a) Acidic oxide (b) Basic oxide (c) Amphoteric oxide (d) Neutral oxide

10. Which metal is most reactive?

(a) Copper (b) Iron (c) Zinc (d) Potassium

Short Questions

1. Why is nitrogen gas unreactive? How do plants get the nitrogen they need?
2. Describe the nitrogen cycle in your own words.
3. Write the equation for the Haber process and state its conditions and its catalyst.
4. What is ammonia used for?
5. Write the equations for the Contact process and state its catalyst.
6. What is oleum? How is sulphuric acid made from it?
7. Distinguish between acidic, basic and amphoteric oxides with one example of each.
8. List the reactivity series from potassium to gold.
9. What is a displacement reaction? Give one example.
10. What is acid rain, and what causes it? What is photochemical smog?

Long Questions

1. Describe the nitrogen cycle. Explain the Haber process for making ammonia, including its equation, conditions and catalyst, and the uses of ammonia and nitric acid.
2. Describe the Contact process for making sulphuric acid, including its equations and catalyst. Explain why sulphuric acid is called the king of chemicals, giving three of its uses.
3. Explain acidic, basic and amphoteric oxides with examples. Describe the properties of metals and the reactivity series, and explain how metals are extracted and how displacement reactions work.

Chapter 8: Organic Chemistry

Organic chemistry is the chemistry of the compounds of carbon, the element of life. This chapter explains why carbon forms so many compounds, functional groups, homologous series, naming and isomerism.

Key Concepts

- Organic chemistry is the study of the compounds of carbon, except for simple ones such as carbon dioxide and carbonates. There are millions of organic compounds because carbon atoms can join to each other in long chains, branches and rings.
- Carbon forms four covalent bonds. This property, called catenation, lets carbon atoms link together in chains of any length. Carbon also forms single, double and triple bonds with other carbon atoms.
- A functional group is a group of atoms that gives an organic compound its properties. For example, the hydroxyl group (-OH) makes an alcohol, and the carboxyl group (-COOH) makes a carboxylic acid.
- A homologous series is a family of organic compounds with the same functional group, where each member differs from the next by one -CH2- group. Members of a series have similar chemical properties and their physical properties change gradually.
- Alkanes are the simplest homologous series: they have only single bonds and the general formula CnH2n+2. Alkenes have one double bond and the formula CnH2n; alkynes have one triple bond and the formula CnH2n-2.
- Organic compounds are named by the IUPAC system: the root shows the number of carbon

atoms (meth-, eth-, prop-, but-), and the suffix shows the family (-ane for alkanes, -ene for alkenes, -yne for alkynes, -ol for alcohols, -oic acid for carboxylic acids).

- Isomers are compounds with the same molecular formula but different structures. Butane and methylpropane are isomers of C4H10; they have different properties because their structures are different.
- Structural formulas show how the atoms are joined together. A condensed formula writes the groups together, such as CH3CH2OH for ethanol, instead of drawing every bond.
- Organic compounds are found everywhere: fuels (petrol, natural gas), plastics, medicines, dyes, soaps and the food we eat. Their study is the basis of the chemical industry and of biochemistry.

Important Definitions

Term	Definition
Organic chemistry	The study of the compounds of carbon, except for simple ones such as carbon dioxide and carbonates.
Catenation	The ability of carbon atoms to join to each other in long chains, branches and rings.
Functional group	A group of atoms that gives an organic compound its characteristic properties.
Homologous series	A family of organic compounds with the same functional group, where each member differs from the next by one -CH2- group.
Alkane	A hydrocarbon with only single bonds between carbon atoms; general formula CnH2n+2.
Alkene	A hydrocarbon with one double bond between carbon atoms; general formula CnH2n.
Alkyne	A hydrocarbon with one triple bond between carbon atoms; general formula CnH2n-2.
Isomers	Compounds with the same molecular formula but different structures.
Structural formula	A formula that shows how the atoms in a molecule are joined together.
IUPAC naming	The international system for naming organic compounds by their structure.

Important Formulas

> Alkanes: CnH2n+2 (methane CH4, ethane C2H6, propane C3H8, butane C4H10).

> Alkenes: CnH2n (ethene C2H4, propene C3H6). Alkynes: CnH2n-2 (ethyne C2H2).

> Alcohol functional group: -OH (ethanol CH3CH2OH). Carboxylic acid functional group: -COOH (ethanoic acid CH3COOH).

> Members of a homologous series differ by one -CH2- group.

> Butane (C4H10) and methylpropane (C4H10) are isomers: same formula, different structures.

> Roots: meth- (1 carbon), eth- (2), prop- (3), but- (4), pent- (5).

Key Terms to Remember

organic chemistry, **catenation**, **functional group**, **homologous series**, **alkane**, **alkene**, **alkyne**, **isomer**, **structural formula**, **IUPAC**, **hydroxyl group**, **carboxyl group**, **covalent bond**

Multiple Choice Questions

1. Organic chemistry is the study of the compounds of:

(a) Iron (b) Carbon (c) Sodium (d) Calcium

2. Carbon forms how many covalent bonds?

(a) Two (b) Three (c) Four (d) Five

3. Catenation is the ability of carbon atoms to:

(a) Join to each other in chains (b) Lose electrons (c) Form ions (d) Melt

4. The functional group of an alcohol is:

(a) -COOH (b) -OH (c) -CHO (d) -NH2

5. The functional group of a carboxylic acid is:

(a) -OH (b) -COOH (c) -Cl (d) -NH2

6. Members of a homologous series differ by:

(a) -CH2- (b) -OH (c) -COOH (d) -CH3

7. The general formula of alkanes is:

(a) CnH2n (b) CnH2n+2 (c) CnH2n-2 (d) CnH2n+1

8. The general formula of alkenes is:

(a) CnH2n+2 (b) CnH2n (c) CnH2n-2 (d) CnH2n+4

9. Butane and methylpropane are:

(a) The same compound (b) Isomers (c) Elements (d) Salts

10. Ethyne (C2H2) is an example of a:

(a) Alkane (b) Alkene (c) Alkyne (d) Alcohol

Short Questions

1. Define organic chemistry.
2. Why does carbon form millions of compounds?
3. What is catenation?
4. Define a functional group and give two examples with their formulas.
5. What is a homologous series? Give one example.
6. Write the general formulas of alkanes, alkenes and alkynes, with one example of each.
7. How are organic compounds named? What do the roots meth-, eth-, prop- and but- mean?
8. What are isomers? Give one example.
9. Write the structural formula of ethanol and of ethanoic acid.
10. Give four examples of organic compounds used in daily life.

Long Questions

1. Explain why carbon forms so many compounds: catenation and single, double and triple bonds. Describe functional groups with the examples of alcohols and carboxylic acids.
2. Explain homologous series with the example of alkanes. Describe the IUPAC naming of organic compounds and name the first five alkanes.
3. Explain isomerism with the example of butane and methylpropane. Describe the structural formulas of ethane, ethene, ethyne, ethanol and ethanoic acid.

Chapter 9: Hydrocarbons

Hydrocarbons are organic compounds made only of carbon and hydrogen. This chapter explains alkanes, alkenes, alkynes and aromatic hydrocarbons, how they are made, their properties and their reactions, and why they matter as fuels.

Key Concepts

- Hydrocarbons are organic compounds made only of carbon and hydrogen. They are the main part of natural gas, petrol, diesel and other fuels.
- Alkanes are saturated hydrocarbons: they have only single bonds between carbon atoms. They are unreactive, except that they burn in air. Methane, the main part of natural gas, is the simplest alkane.
- Alkanes burn in plenty of air to give carbon dioxide and water (complete combustion). In a limited supply of air they burn to give carbon monoxide and water, and carbon monoxide is a poisonous gas.
- Alkenes are unsaturated hydrocarbons with one double bond. They are more reactive than alkanes and take part in addition reactions, in which the double bond opens and atoms add across it.
- Alkenes react with bromine water: the brown colour of bromine disappears, which is a test for a double bond. They also react with hydrogen (hydrogenation) to give alkanes, and with water (hydration) to give alcohols.
- Alkynes are unsaturated hydrocarbons with one triple bond. Ethyne (acetylene) burns with a very hot flame and is used in oxy-acetylene welding and cutting.
- Aromatic hydrocarbons contain a benzene ring of six carbon atoms. Benzene (C6H6) is the simplest aromatic hydrocarbon; it is used to make plastics, dyes and medicines, but it is poisonous and must be handled with care.
- Hydrocarbons are obtained from crude oil by fractional distillation: the oil is heated and its parts (fractions) are separated by their boiling points, from gases and petrol at the top to bitumen at the bottom.
- Cracking breaks large hydrocarbon molecules into smaller, more useful ones (such as petrol) by heating with a catalyst. It also makes alkenes, which are used to make plastics.
- Burning fossil fuels gives energy but also gives carbon dioxide, which adds to global warming, and other pollutants. Using fuels wisely and using cleaner energy reduces this harm.

Important Definitions

Term	Definition

Hydrocarbon	An organic compound made only of carbon and hydrogen.
Saturated hydrocarbon	A hydrocarbon with only single bonds between carbon atoms, such as an alkane.
Unsaturated hydrocarbon	A hydrocarbon with a double or triple bond between carbon atoms, such as an alkene or alkyne.
Complete combustion	Burning in plenty of air to give carbon dioxide and water.
Incomplete combustion	Burning in a limited supply of air, giving carbon monoxide and water.
Addition reaction	A reaction in which atoms add across a double or triple bond, opening it.
Hydrogenation	An addition reaction in which hydrogen adds across a double bond, changing an alkene into an alkane.
Aromatic hydrocarbon	A hydrocarbon that contains a benzene ring of six carbon atoms.
Fractional distillation	The separation of crude oil into fractions by heating and condensing at different temperatures.
Cracking	Breaking large hydrocarbon molecules into smaller ones by heating with a catalyst.

Important Formulas

- Complete combustion of methane: CH4 + 2O2 -> CO2 + 2H2O.
- Incomplete combustion of methane: 2CH4 + 3O2 -> 2CO + 4H2O.
- Alkane general formula: CnH2n+2; alkene: CnH2n; alkyne: CnH2n-2.
- Test for a double bond: bromine water loses its brown colour when shaken with an alkene.
- Hydrogenation: C2H4 + H2 -> C2H6 (ethene to ethane, with a nickel catalyst).
- Hydration: C2H4 + H2O -> C2H5OH (ethene to ethanol).
- Ethyne: C2H2; benzene: C6H6.

Key Terms to Remember

hydrocarbon, **saturated**, **unsaturated**, **alkane**, **alkene**, **alkyne**, **aromatic**, **benzene**, **combustion**, **addition reaction**, **hydrogenation**, **hydration**, **fractional distillation**, **cracking**, **crude oil**

Multiple Choice Questions

1. Hydrocarbons are made only of:

(a) Carbon and oxygen (b) Carbon and hydrogen (c) Carbon and nitrogen (d) Hydrogen and oxygen

2. Alkanes have only:

(a) Double bonds (b) Triple bonds (c) Single bonds (d) Ionic bonds

3. Complete combustion of methane gives:

(a) Carbon monoxide and water (b) Carbon dioxide and water (c) Carbon and hydrogen (d) Carbon dioxide only

4. Incomplete combustion of a fuel gives the poisonous gas:

(a) Carbon dioxide (b) Carbon monoxide (c) Oxygen (d) Nitrogen

5. Alkenes are more reactive than alkanes because they have a:

(a) Single bond (b) Double bond (c) Triple bond (d) Ring

6. Bromine water loses its brown colour with:

(a) An alkane (b) An alkene (c) Water (d) Salt

7. Hydrogenation of ethene gives:

(a) Ethane (b) Ethyne (c) Ethanol (d) Methane

8. Ethyne is used in:

(a) Cooking (b) Oxy-acetylene welding (c) Making soap (d) Making salt

9. Benzene has the formula:

(a) C6H6 (b) C6H12 (c) C6H14 (d) C2H2

10. Cracking is used to:

(a) Make large molecules (b) Break large hydrocarbon molecules into smaller ones (c) Join atoms (d) Cool oil

Short Questions

1. Define a hydrocarbon and give two examples.
2. Distinguish between saturated and unsaturated hydrocarbons.
3. Write the equation for the complete combustion of methane.
4. What is incomplete combustion? Why is carbon monoxide dangerous?
5. How can you test for a double bond in a hydrocarbon?
6. What is hydrogenation? Write the equation for the hydrogenation of ethene.
7. What is hydration? Write the equation for the hydration of ethene.
8. What is benzene? Give one use and one danger of it.
9. How is crude oil separated into fractions? Name three fractions.
10. What is cracking? Why is it useful?

Long Questions

1. Describe alkanes, alkenes and alkynes: their general formulas, their bonding and one example of each. Explain complete and incomplete combustion with equations.
2. Explain addition reactions of alkenes: with bromine water, with hydrogen and with water. Describe the test for a double bond and the uses of ethyne.
3. Explain how crude oil is separated by fractional distillation and what cracking is. Describe the uses of hydrocarbons as fuels and the harm caused by burning fossil fuels.

Chapter 10: Hydroxy Compounds

Hydroxy compounds are organic compounds that contain the hydroxyl group (-OH). This chapter explains alcohols, phenols and ethers: how they are made, their properties and their uses.

Key Concepts

- Alcohols are organic compounds with one or more hydroxyl (-OH) groups joined to a carbon atom. Their general formula is CnH2n+1OH. Methanol (CH3OH) and ethanol (C2H5OH) are the simplest alcohols.
- Ethanol is made by the fermentation of sugars by yeast, and by the hydration of ethene with steam and a catalyst. It is used in alcoholic drinks, as a fuel, as a solvent and in hand sanitisers.
- Alcohols burn in air to give carbon dioxide and water. They react with sodium to give hydrogen and a sodium alkoxide, and with carboxylic acids to give esters and water.
- Methanol is poisonous: even a small amount can cause blindness or death. It is used as a fuel and as a solvent, and to make formaldehyde.
- Phenol is an aromatic hydroxy compound: a hydroxyl group joined directly to a benzene ring (C6H5OH). It is a weak acid, unlike alcohols. Phenol is used as a disinfectant and to make plastics and medicines.
- Ethers are organic compounds with an oxygen atom joined to two carbon groups (R-O-R). Diethyl ether was once used as an anaesthetic; ethers are now used mainly as solvents.
- Alcohols are soluble in water because their hydroxyl group can form hydrogen bonds with water molecules. Their boiling points are higher than those of alkanes of similar size, for the same reason.
- Alcohols can be oxidised to carboxylic acids. Ethanol is oxidised to ethanoic acid by acidified potassium dichromate, which changes colour from orange to green; this is the basis of the breath test for drink-driving.
- Glycerol (propane-1,2,3-triol) is an alcohol with three hydroxyl groups. It is used in medicines, cosmetics and explosives, and it is a part of fats and oils.

Important Definitions

Term	Definition
Alcohol	An organic compound with one or more hydroxyl (-OH) groups joined to a carbon atom.
Hydroxyl group	The group -OH, which gives alcohols and phenols their properties.
Fermentation	The changing of sugars into ethanol and carbon dioxide by yeast.
Hydration	An addition reaction in which water adds across a double bond, such as ethene to ethanol.
Phenol	An aromatic hydroxy compound: a hydroxyl group joined directly to a benzene ring (C6H5OH).
Ether	An organic compound with an oxygen atom joined to two carbon groups (R-O-R).
Oxidation of	The changing of an alcohol into a carboxylic acid by an oxidising agent.

alcohols

Glycerol	An alcohol with three hydroxyl groups (propane-1,2,3-triol), found in fats and oils.
Esterification	The reaction of an alcohol with a carboxylic acid to give an ester and water.
Solvent	A liquid that dissolves other substances.

Important Formulas

- General formula of alcohols: CnH2n+1OH; methanol CH3OH, ethanol C2H5OH, propanol C3H7OH.
- Fermentation: C6H12O6 -> 2C2H5OH + 2CO2 (yeast).
- Hydration of ethene: C2H4 + H2O -> C2H5OH (steam, phosphoric acid catalyst).
- Combustion of ethanol: C2H5OH + 3O2 -> 2CO2 + 3H2O.
- Alcohol with sodium: 2C2H5OH + 2Na -> 2C2H5ONa + H2.
- Oxidation of ethanol: C2H5OH -> CH3COOH (acidified potassium dichromate; orange to green).
- Phenol: C6H5OH; diethyl ether: C2H5OC2H5.

Key Terms to Remember

alcohol, **hydroxyl group**, **methanol**, **ethanol**, **fermentation**, **hydration**, **phenol**, **ether**, **glycerol**, **esterification**, **oxidation**, **solvent**

Multiple Choice Questions

1. The functional group of an alcohol is:

(a) -COOH (b) -OH (c) -CHO (d) -NH2

2. The general formula of alcohols is:

(a) CnH2n (b) CnH2n+1OH (c) CnH2n+2 (d) CnH2n-2

3. Ethanol is made by fermentation of sugars by:

(a) Bacteria (b) Yeast (c) Mould (d) Algae

4. Fermentation of glucose gives ethanol and:

(a) Oxygen (b) Carbon dioxide (c) Hydrogen (d) Nitrogen

5. Methanol is:

(a) Safe to drink (b) Poisonous (c) A salt (d) A metal

6. Phenol is:

(a) An alkane (b) An aromatic hydroxy compound (c) An ether (d) A salt

7. An ether has the general structure:

(a) R-OH (b) R-O-R (c) R-COOH (d) R-NH2

8. Ethanol reacts with sodium to give:

(a) Oxygen (b) Hydrogen (c) Carbon dioxide (d) Nitrogen

9. Acidified potassium dichromate changes from orange to green when it oxidises:

(a) An alkane (b) Ethanol (c) Water (d) Salt

10. Glycerol has how many hydroxyl groups?

(a) One (b) Two (c) Three (d) Four

Short Questions

1. Define an alcohol and state its general formula.
2. Write the formulas of methanol, ethanol and propanol.
3. How is ethanol made by fermentation? Write the equation.
4. How is ethanol made from ethene? Write the equation.
5. Write the equation for the combustion of ethanol.
6. What happens when ethanol reacts with sodium?
7. What is phenol? How is it different from an alcohol?
8. What is an ether? Give one example and one use.
9. Why do alcohols have higher boiling points than alkanes of similar size?
10. What is glycerol? Give two of its uses.

Long Questions

1. Describe alcohols: their functional group, general formula and naming. Explain how ethanol is made by fermentation and by the hydration of ethene, with equations.
2. Describe the chemical properties of alcohols: combustion, reaction with sodium, oxidation to carboxylic acids and esterification. Explain the breath test for drink-driving.
3. Describe phenol and ethers: their structures, properties and uses. Compare alcohols, phenols and ethers, and explain the uses of methanol, ethanol and glycerol.

Chapter 11: Carboxylic Compounds

Carboxylic compounds are organic compounds that contain the carboxyl group (-COOH). This chapter explains carboxylic acids and esters: how they are made, their properties and their uses.

Key Concepts

- Carboxylic acids are organic compounds with the carboxyl group (-COOH). Their general formula is CnH2n+1COOH. Ethanoic acid (CH3COOH), the acid in vinegar, is the best-known example.
- Carboxylic acids are weak acids: they partly ionise in water to give hydrogen ions and carboxylate ions. Ethanoic acid ionises as CH3COOH -> CH3COO- + H+.
- Carboxylic acids react like other acids: with metals to give a salt and hydrogen, with bases to give a salt and water, and with carbonates to give a salt, water and carbon dioxide.
- Ethanoic acid is made by oxidising ethanol with acidified potassium dichromate. It is used to make vinegar, plastics, dyes and medicines.
- Esters are made by the reaction of a carboxylic acid with an alcohol, with a few drops of concentrated sulphuric acid as catalyst. The reaction is called esterification: acid + alcohol -> ester + water.
- Esters have sweet, fruity smells and are used in perfumes, flavourings and solvents. Ethyl ethanoate (CH3COOC2H5) is made from ethanoic acid and ethanol.

- Esters can be broken down by water (hydrolysis) to give back the acid and the alcohol. Hydrolysis with an alkali gives the salt of the acid and the alcohol; this is how soap is made from fats.
- Fats and oils are esters of glycerol with long-chain carboxylic acids (fatty acids). They are an important part of our food and are used to make soap.
- Carboxylic acids have higher boiling points than alcohols of similar size, because their molecules form strong hydrogen bonds in pairs.

Important Definitions

Term	Definition
Carboxylic acid	An organic compound with the carboxyl group (-COOH); general formula CnH2n+1COOH.
Carboxyl group	The group -COOH, which gives carboxylic acids their properties.
Weak acid	An acid that only partly ionises in water.
Ester	An organic compound made from a carboxylic acid and an alcohol; it has the group -COO-.
Esterification	The reaction of a carboxylic acid with an alcohol to give an ester and water.
Hydrolysis	The breaking down of a compound by reaction with water.
Ethanoic acid	CH3COOH, the acid in vinegar.
Fatty acid	A long-chain carboxylic acid found in fats and oils.
Vinegar	A dilute solution of ethanoic acid in water, about 5% acid.
Soap	The sodium salt of a long-chain carboxylic acid, made by hydrolysing fats with an alkali.

Important Formulas

> General formula of carboxylic acids: CnH2n+1COOH; methanoic acid HCOOH, ethanoic acid CH3COOH.

> Ionisation of ethanoic acid: CH3COOH -> CH3COO- + H+.

> Ethanoic acid with sodium carbonate: 2CH3COOH + Na2CO3 -> 2CH3COONa + H2O + CO2.

> Esterification: CH3COOH + C2H5OH -> CH3COOC2H5 + H2O (concentrated H2SO4 catalyst).

> Hydrolysis of ethyl ethanoate: CH3COOC2H5 + H2O -> CH3COOH + C2H5OH.

> Making soap: fat + sodium hydroxide -> soap + glycerol.

Key Terms to Remember

carboxylic acid, **carboxyl group**, **weak acid**, **ester**, **esterification**, **hydrolysis**, **ethanoic acid**, **vinegar**, **fatty acid**, **soap**, **saponification**

Multiple Choice Questions

1. The functional group of a carboxylic acid is:

(a) -OH (b) -COOH (c) -CHO (d) -NH2

2. The general formula of carboxylic acids is:

(a) CnH2n+1OH (b) CnH2n+1COOH (c) CnH2n (d) CnH2n+2

3. Ethanoic acid is the acid found in:

(a) Lemon juice (b) Vinegar (c) Milk (d) Battery acid

4. Carboxylic acids are:

(a) Strong acids (b) Weak acids (c) Bases (d) Salts

5. Ethanoic acid with sodium carbonate gives:

(a) Hydrogen (b) Carbon dioxide (c) Oxygen (d) Nitrogen

6. Esters are made from a carboxylic acid and an:

(a) Alkane (b) Alcohol (c) Alkene (d) Salt

7. The catalyst used in esterification is:

(a) Dilute acid (b) Concentrated sulphuric acid (c) Iron (d) Nickel

8. Esters have a:

(a) Sharp smell (b) Sweet, fruity smell (c) No smell (d) Rotten smell

9. Hydrolysis of an ester gives back the:

(a) Acid and alcohol (b) Salt and water (c) Alkane and water (d) Acid only

10. Soap is made by hydrolysing fats with:

(a) An acid (b) An alkali (c) Water only (d) A salt

Short Questions

1. Define a carboxylic acid and state its general formula.
2. Write the formulas of methanoic acid and ethanoic acid.
3. Why are carboxylic acids called weak acids? Write the ionisation equation of ethanoic acid.
4. How is ethanoic acid made from ethanol?
5. Write the equation for ethanoic acid reacting with sodium carbonate.
6. What is esterification? Write the equation for making ethyl ethanoate.
7. Give three uses of esters.
8. What is hydrolysis of an ester? What are its products?
9. What are fats and oils, chemically?
10. How is soap made from fats?

Long Questions

1. Describe carboxylic acids: their functional group, general formula and naming. Explain why they are weak acids and describe their reactions with metals, bases and carbonates, with equations.
2. Explain esterification: how esters are made, their properties and their uses. Describe the hydrolysis of esters and how soap is made from fats.
3. Describe ethanoic acid: how it is made, its properties and its uses. Explain why carboxylic acids have higher boiling points than alcohols of similar size, and the role of fats and oils in food.

Chapter 12: Polymers

Polymers are very large molecules made by joining many small molecules together. This chapter explains addition and condensation polymerisation, natural and synthetic polymers, plastics, and the problem of plastic waste.

Key Concepts

- A polymer is a very large molecule made by joining many small molecules, called monomers, together. The repeating unit is the group of atoms that repeats along the polymer chain.
- Addition polymerisation joins monomers with double bonds together without losing any atoms. Poly(ethene), made from ethene, is an addition polymer: n(C2H4) -> -(CH2-CH2)n-.
- Poly(ethene) is used for plastic bags and bottles. Poly(propene) is used for ropes and containers. Poly(chloroethene), known as PVC, is used for pipes and window frames.
- Condensation polymerisation joins monomers together with the loss of a small molecule, usually water. Nylon and polyesters are condensation polymers.
- Nylon is made from a diamine and a dicarboxylic acid. It is strong and is used for ropes, clothes and fishing lines. Polyester (such as Terylene) is used for clothes and bottles.
- Natural polymers are found in nature: starch and cellulose in plants, proteins in animals, and natural rubber from trees. Synthetic polymers are made in factories: plastics, nylon and polyester.
- Plastics can be thermoplastics, which soften on heating and can be reshaped (such as poly(ethene) and PVC), or thermosetting plastics, which do not soften on heating (such as Bakelite and Melamine).
- Plastics are light, strong, cheap and do not rust, so they are used everywhere. But most plastics do not break down in nature, so plastic waste pollutes land and seas and harms animals.
- Plastic waste can be reduced by using less plastic, reusing plastic items, recycling them into new products, and using biodegradable plastics that break down naturally.
- Polymers are also used in medicines (slow-release capsules), in paints and glues, and in fibres for clothes and carpets.

Important Definitions

Term	Definition
Polymer	A very large molecule made by joining many small molecules (monomers) together.
Monomer	A small molecule that joins with others to form a polymer.
Repeating unit	The group of atoms that repeats along a polymer chain.
Addition polymerisation	Joining monomers with double bonds together without losing any atoms.
Condensation polymerisation	Joining monomers together with the loss of a small molecule, usually water.
Thermoplastic	A plastic that softens on heating and can be reshaped.
Thermosetting plastic	A plastic that does not soften on heating and cannot be reshaped.
Natural polymer	A polymer found in nature, such as starch, cellulose or protein.

Synthetic polymer	A polymer made in a factory, such as poly(ethene), nylon or polyester.
Biodegradable	Able to be broken down naturally by living things.

Important Formulas

> Addition polymerisation of ethene: n(C2H4) -> -(CH2-CH2)n- (poly(ethene)).

> Poly(propene) is made from propene; PVC is made from chloroethene (vinyl chloride).

> Condensation polymerisation: monomers join with the loss of water (or another small molecule).

> Nylon is made from a diamine and a dicarboxylic acid; polyester is made from a diol and a dicarboxylic acid.

> Thermoplastics soften on heating and can be reshaped; thermosetting plastics do not soften on heating.

> Natural polymers: starch, cellulose, proteins, natural rubber. Synthetic polymers: poly(ethene), PVC, nylon, polyester.

Key Terms to Remember

polymer, **monomer**, **repeating unit**, **addition polymerisation**, **condensation polymerisation**, **poly(ethene)**, **PVC**, **nylon**, **polyester**, **thermoplastic**, **thermosetting plastic**, **natural polymer**, **synthetic polymer**, **biodegradable**, **recycling**

Multiple Choice Questions

1. A polymer is made by joining many small molecules called:

(a) Atoms (b) Monomers (c) Ions (d) Salts

2. Addition polymerisation joins monomers:

(a) With the loss of water (b) Without losing any atoms (c) With the loss of hydrogen (d) With the loss of oxygen

3. Poly(ethene) is made from:

(a) Propene (b) Ethene (c) Chloroethene (d) Styrene

4. PVC is made from:

(a) Ethene (b) Propene (c) Chloroethene (d) Benzene

5. Condensation polymerisation joins monomers with the loss of:

(a) A small molecule, usually water (b) A metal (c) An electron (d) A proton

6. Nylon is an example of a:

(a) Addition polymer (b) Condensation polymer (c) Natural polymer only (d) Monomer

7. Starch and cellulose are:

(a) Synthetic polymers (b) Natural polymers (c) Monomers (d) Salts

8. A thermoplastic:

(a) Does not soften on heating (b) Softens on heating and can be reshaped (c) Burns easily (d) Dissolves in water

9. Bakelite is an example of a:

(a) Thermoplastic (b) Thermosetting plastic (c) Natural polymer (d) Monomer

10. Plastic waste is a problem because most plastics:

(a) Dissolve in water (b) Do not break down in nature (c) Are heavy (d) Are expensive

Short Questions

1. Define a polymer, a monomer and a repeating unit.
2. What is addition polymerisation? Give one example with an equation.
3. Name three addition polymers and one use of each.
4. What is condensation polymerisation? Give one example.
5. What is nylon made from? Give two uses of nylon.
6. Give two examples of natural polymers and two of synthetic polymers.
7. Distinguish between thermoplastics and thermosetting plastics with one example of each.
8. Give three advantages of plastics.
9. Why is plastic waste a problem? Give three ways to reduce it.
10. Give two uses of polymers in medicines and in daily life.

Long Questions

1. Explain addition polymerisation with the example of poly(ethene). Describe three addition polymers and their uses.
2. Explain condensation polymerisation with the examples of nylon and polyester. Compare natural and synthetic polymers with examples.
3. Distinguish between thermoplastics and thermosetting plastics with examples. Describe the advantages of plastics, the problem of plastic waste and how it can be reduced.

Chapter 13: Biochemistry

Biochemistry is the chemistry of living things. This chapter explains the main molecules of life: carbohydrates, proteins, lipids and nucleic acids, and the roles of enzymes and vitamins.

Key Concepts

- Biochemistry is the study of the chemical processes of living things. The main molecules of life are carbohydrates, proteins, lipids (fats and oils) and nucleic acids.
- Carbohydrates are made of carbon, hydrogen and oxygen. Glucose ($C_6H_{12}O_6$) is a simple sugar (monosaccharide). Sucrose (table sugar) is a disaccharide made of glucose and fructose. Starch and cellulose are polysaccharides made of many glucose units.
- Starch is the way plants store energy, and glycogen is the way animals store energy. Cellulose makes the cell walls of plants; humans cannot digest it, but it is useful as fibre in food.
- Proteins are made of amino acids joined by peptide bonds. There are 20 different amino acids, and the order in which they are joined decides the shape and the job of each protein.
- Proteins have many jobs: enzymes speed up reactions, haemoglobin carries oxygen in the blood, antibodies fight disease, and muscles are made of proteins.

- Lipids include fats and oils. They are esters of glycerol with fatty acids. They store energy, keep the body warm and protect organs. Too much fat in food can cause heart disease.
- Nucleic acids are DNA and RNA. DNA carries the instructions for making proteins and passes them from parents to children. RNA helps to make proteins from those instructions.
- Enzymes are biological catalysts made of protein. Each enzyme works on one substance (its substrate) and works best at body temperature and a particular pH. High temperature destroys enzymes.
- Vitamins are substances the body needs in small amounts to stay healthy. Vitamin C prevents scurvy, vitamin D helps bones to grow, and vitamin A is needed for good eyesight.
- Minerals are also needed in small amounts: iron is needed to make haemoglobin, calcium is needed for bones and teeth, and iodine is needed for the thyroid gland.

Important Definitions

Term	Definition
Biochemistry	The study of the chemical processes of living things.
Carbohydrate	A compound of carbon, hydrogen and oxygen that gives the body energy, such as glucose or starch.
Monosaccharide	A simple sugar, such as glucose or fructose.
Polysaccharide	A carbohydrate made of many sugar units joined together, such as starch or cellulose.
Protein	A large molecule made of amino acids joined by peptide bonds.
Amino acid	One of the 20 small molecules that join together to make proteins.
Peptide bond	The bond that joins two amino acids together in a protein.
Lipid	A fat or oil; an ester of glycerol with fatty acids.
Nucleic acid	DNA or RNA, the molecules that carry the instructions for making proteins.
Enzyme	A biological catalyst made of protein, which speeds up a reaction in a living thing.
Vitamin	A substance the body needs in small amounts to stay healthy.

Important Formulas

> Glucose: $C_6H_{12}O_6$; sucrose: $C_{12}H_{22}O_{11}$; starch and cellulose are made of many glucose units $(C_6H_{10}O_5)_n$.

> Photosynthesis: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ (sunlight, chlorophyll).

> Respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy.

> Proteins are made of amino acids joined by peptide bonds; there are 20 different amino acids.

> Fats and oils are esters of glycerol with fatty acids.

> Vitamin C prevents scurvy; vitamin D helps bones to grow; vitamin A is needed for good eyesight; iron is needed for haemoglobin; calcium is needed for bones and teeth.

Key Terms to Remember

biochemistry, **carbohydrate**, **glucose**, **starch**, **cellulose**, **protein**, **amino acid**, **peptide bond**, **lipid**, **fat**, **nucleic acid**, **DNA**, **RNA**, **enzyme**, **vitamin**, **mineral**

Multiple Choice Questions

1. Biochemistry is the study of the chemical processes of:

(a) Rocks (b) Living things (c) Metals (d) Gases

2. Glucose has the formula:

(a) $C_6H_{12}O_6$ (b) $C_{12}H_{22}O_{11}$ (c) $C_6H_{10}O_5$ (d) CH_3COOH

3. Sucrose is made of:

(a) Glucose only (b) Glucose and fructose (c) Starch only (d) Cellulose only

4. Starch is the way plants store:

(a) Water (b) Energy (c) Minerals (d) Protein

5. Proteins are made of:

(a) Sugars (b) Amino acids (c) Fatty acids (d) Nucleotides only

6. How many different amino acids make up proteins?

(a) 10 (b) 20 (c) 30 (d) 4

7. Haemoglobin carries in the blood:

(a) Carbon dioxide only (b) Oxygen (c) Glucose (d) Fat

8. Lipids are esters of glycerol with:

(a) Sugars (b) Fatty acids (c) Amino acids (d) Water

9. DNA carries:

(a) Energy (b) Instructions for making proteins (c) Oxygen (d) Vitamins

10. Vitamin C prevents:

(a) Rickets (b) Scurvy (c) Night blindness (d) Anaemia

Short Questions

1. Define biochemistry and name the four main molecules of life.
2. Write the formula of glucose and of sucrose.
3. Distinguish between a monosaccharide, a disaccharide and a polysaccharide with one example of each.
4. What are starch, glycogen and cellulose? What is each one used for?
5. What are amino acids? How many are there, and what joins them together?
6. Give three jobs of proteins in the body.
7. What are lipids? Give two of their jobs in the body.
8. What are nucleic acids? What is the job of DNA and of RNA?
9. What is an enzyme? Why does high temperature destroy enzymes?
10. Name three vitamins and state what each one is needed for. Name two minerals and state what

each is needed for.

Long Questions

1. Describe carbohydrates: glucose, sucrose, starch, glycogen and cellulose. Explain how plants make glucose by photosynthesis and how living things release its energy by respiration.
2. Describe proteins: amino acids, peptide bonds and the jobs of proteins. Explain enzymes as biological catalysts and how temperature and pH affect them.
3. Describe lipids and nucleic acids. Explain the roles of vitamins and minerals in health, giving examples of the diseases caused when they are missing.

Answer Key — Multiple Choice Questions

Use this key to check your answers. If an answer is wrong, read the key concepts of that chapter again and try to find why.

Chapter 1: History of Chemistry

Question	Answer
1	(B) Matter and its changes
2	(B) The early practical study of matter
3	(C) Jabir ibn Hayyan
4	(B) Distillation
5	(B) Lavoisier
6	(C) Neither created nor destroyed
7	(B) Atoms
8	(B) Organic chemistry
9	(B) Biochemistry
10	(A) Medicines and fertilisers

Chapter 2: Matter

Question	Answer
1	(A) Mass and volume
2	(A) Solid
3	(B) Far apart and moving fast
4	(C) Solid directly to gas
5	(C) Iron
6	(C) Water

7	(C) Mixture
8	(B) Physical change
9	(B) Chemical change
10	(B) Filtration

Chapter 3: Stoichiometry

Question	Answer
1	(A) 6.02 x 10^23 particles
2	(B) 18 g/mol
3	(B) 98 g/mol
4	(A) 0.5 mol
5	(C) The same number of atoms of each element on both sides
6	(B) CH2O
7	(B) Is used up first
8	(B) Actual yield / theoretical yield x 100
9	(B) 16 g of oxygen
10	(A) 22.4 dm^3

Chapter 4: Electrochemistry

Question	Answer
1	(B) Loss of electrons
2	(B) Gain of electrons
3	(B) Reduced
4	(B) Anode
5	(B) Positive electrode
6	(B) Cathode
7	(C) 2:1
8	(B) Cathode
9	(B) 1.1 V
10	(C) 12 V

Chapter 5: Reaction Kinetics

Question	Answer

1	(B) How quickly a reactant is used up or a product is formed
2	(B) Enough energy and the right orientation
3	(B) Smallest energy colliding particles must have to react
4	(B) Increases the rate
5	(B) Particles move faster and more have energy above the activation energy
6	(B) A larger surface area
7	(B) Giving a new path with a lower activation energy
8	(B) Biological catalysts
9	(B) 10 degrees C
10	(B) The reactants are used up and the reaction ends

Chapter 6: Salts

Question	Answer
1	(B) Base
2	(A) Sodium chloride and water
3	(B) Hydrogen
4	(C) Carbon dioxide
5	(B) Acidic salt
6	(B) Their ions cannot move
7	(B) Water of crystallisation
8	(B) White
9	(B) Sodium hydrogen carbonate
10	(C) Neutral solution

Chapter 7: Nitrogen, Sulphur and Metals

Question	Answer
1	(B) 78%
2	(B) Nitrates
3	(B) Haber process
4	(B) Iron
5	(B) Contact process
6	(B) Vanadium(V) oxide

7	(B) Sulphurous acid
8	(B) Basic oxide
9	(C) Amphoteric oxide
10	(D) Potassium

Chapter 8: Organic Chemistry

Question	Answer
1	(B) Carbon
2	(C) Four
3	(A) Join to each other in chains
4	(B) -OH
5	(B) -COOH
6	(A) -CH2-
7	(B) CnH2n+2
8	(B) CnH2n
9	(B) Isomers
10	(C) Alkyne

Chapter 9: Hydrocarbons

Question	Answer
1	(B) Carbon and hydrogen
2	(C) Single bonds
3	(B) Carbon dioxide and water
4	(B) Carbon monoxide
5	(B) Double bond
6	(B) An alkene
7	(A) Ethane
8	(B) Oxy-acetylene welding
9	(A) C6H6
10	(B) Break large hydrocarbon molecules into smaller ones

Chapter 10: Hydroxy Compounds

Question	Answer

1	(B) -OH
2	(B) CnH2n+1OH
3	(B) Yeast
4	(B) Carbon dioxide
5	(B) Poisonous
6	(B) An aromatic hydroxy compound
7	(B) R-O-R
8	(B) Hydrogen
9	(B) Ethanol
10	(C) Three

Chapter 11: Carboxylic Compounds

Question	Answer
1	(B) -COOH
2	(B) CnH2n+1COOH
3	(B) Vinegar
4	(B) Weak acids
5	(B) Carbon dioxide
6	(B) Alcohol
7	(B) Concentrated sulphuric acid
8	(B) Sweet, fruity smell
9	(A) Acid and alcohol
10	(B) An alkali

Chapter 12: Polymers

Question	Answer
1	(B) Monomers
2	(B) Without losing any atoms
3	(B) Ethene
4	(C) Chloroethene
5	(A) A small molecule, usually water
6	(B) Condensation polymer

7	(B) Natural polymers
8	(B) Softens on heating and can be reshaped
9	(B) Thermosetting plastic
10	(B) Do not break down in nature

Chapter 13: Biochemistry

Question	Answer
1	(B) Living things
2	(A) C6H12O6
3	(B) Glucose and fructose
4	(B) Energy
5	(B) Amino acids
6	(B) 20
7	(B) Oxygen
8	(B) Fatty acids
9	(B) Instructions for making proteins
10	(B) Scurvy