9th Class Chemistry Notes Balochistan Board Full Book Notes

Complete chapter-wise notes with original practice questions

Based on the Chemistry book for Class 9 of the Balochistan Textbook Board, Quetta

Board of Intermediate and Secondary Education (BISE), Quetta

16 chapters • Key concepts, definitions, equations and key terms

160 original MCQs • 80 short questions • 32 long questions

with an MCQ answer key at the end

Zahid Notes — www.zahidenotes.com

About These Notes

These notes follow the chapters of the Chemistry book for Class 9 prescribed by the Balochistan Textbook Board, Quetta, for students of the Board of Intermediate and Secondary Education (BISE), Quetta. Each chapter contains concise study notes with key concepts, definitions and key terms, followed by original practice questions: 10 multiple-choice questions, 5 short questions and 2 long questions. An MCQ answer key is given at the end of the book.

All questions in these notes are original practice questions written for revision. They are not past-paper questions and no question is copied from the textbook or from any other notes.

Paper Pattern (Balochistan Board, Class 9 Chemistry)

Under the Board's revised scheme of studies, Chemistry in Class 9 carries **75 marks in total: 60 marks theory and 15 marks practical**. This distribution is reproduced from a published copy of the Board's scheme-of-studies notification; it has not been read directly off an official Board document, so it should be checked against the latest Board notice. The theory paper tests the chapters of the book, and the practical component tests laboratory work such as physical and chemical changes, indicators and separation techniques.

> **Note for students:** the Board announced a one-time reduction for one annual examination, excluding Chapters 15 and 16 from that examination. Chapters 15 and 16 are still included in full in these notes, because they are part of the book and of practical work. Check the latest Board notice to confirm which chapters are included in your own examination.

Contents

- Chapter 1: Nature of Science in Chemistry
- Chapter 2: Matter
- Chapter 3: Atomic Structure
- Chapter 4: Chemical Bonding
- Chapter 5: Stoichiometry
- Chapter 6: Electrochemistry
- Chapter 7: Chemical Energetics
- Chapter 8: Chemical Equilibrium
- Chapter 9: Acids and Bases
- Chapter 10: Periodic Table and Group Properties
- Chapter 11: Environmental Chemistry
- Chapter 12: Organic Chemistry
- Chapter 13: Biochemistry
- Chapter 14: Empirical Data Collection and Analysis
- Chapter 15: Separation Techniques
- Chapter 16: Qualitative Analysis

How to use these notes: read the study notes of a chapter first, then answer the short and long questions without looking, then attempt the MCQs and check your answers against the key at the end. Revise any chapter where you score below 7 out of 10 in the MCQs.

Chapter 1: Nature of Science in Chemistry

Study Notes

- **Chemistry** is the branch of science that studies matter, its composition, properties and the changes it undergoes.
- **Science** is organised knowledge gained by observation and experiment; **technology** applies scientific knowledge to make useful products, and **engineering** designs and builds things using science and technology together.
- **Main subfields:** physical chemistry (energy and change), organic chemistry (carbon compounds), inorganic chemistry (other elements and their compounds), biochemistry (chemistry of living things), analytical chemistry (identifying and measuring substances), environmental chemistry, industrial chemistry and nuclear chemistry.
- **Interdisciplinary fields** combine chemistry with other sciences, for example geochemistry (chemistry of the Earth), astrochemistry (chemistry of space), medicinal chemistry (designing medicines) and materials chemistry.
- **The scientific method:** observe a problem, ask a question, form a hypothesis, test it by experiment, record results, draw a conclusion and share the findings. A hypothesis tested many times and never disproved may become a theory; a theory that describes a regular pattern in nature is a law.
- **Why chemistry matters:** medicines, fertilisers, clean water, fuels, food preservation, soaps, plastics and the study of air and water pollution all depend on chemistry.

Short Questions (with answers)

Q1. Define chemistry.
Answer: Chemistry is the branch of science that studies matter, its composition, its properties and the changes that matter undergoes.

Q2. Name four main branches of chemistry.
Answer: Physical chemistry, organic chemistry, inorganic chemistry and biochemistry (analytical, environmental, industrial and nuclear chemistry are other branches).

Q3. What is the difference between science and technology?
Answer: Science is knowledge gained by observation and experiment, while technology is the practical use of that knowledge to make useful things.

Q4. What is a hypothesis?
Answer: A hypothesis is a testable idea or explanation proposed to answer a question; it is tested by experiment before it is accepted.

Q5. Give one example of an interdisciplinary field of chemistry.
Answer: Geochemistry combines chemistry with geology to study the chemical composition of the Earth and its rocks.

Chapter 1: Nature of Science in Chemistry

Long Questions (with answers)

Q1. Describe the steps of the scientific method and explain why experiments are repeated.
Answer: Observation of a problem leads to a question, then a hypothesis is formed. The hypothesis is tested by a controlled experiment and the results are recorded and analysed. If the results support the hypothesis it is accepted for the time being; if not, it is changed. Experiments are repeated to check that the results are reliable and not caused by a mistake, and the findings are shared so other scientists can test them too.

Q2. Explain how chemistry, technology and engineering work together, with examples.
Answer: Chemistry provides the knowledge, for example that soap molecules remove grease. Technology applies that knowledge to manufacture soap on a large scale. Engineering designs the factory, the machines and the safe processes used to make it. In the same way, chemistry explains how medicines work, technology produces them as tablets, and engineering builds the plants that make them safely and cheaply.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. The study of matter, its composition and its changes is called
(a) Physics (b) Biology (c) Chemistry (d) Geology

Q2. Which branch of chemistry deals with carbon compounds?
(a) Inorganic chemistry (b) Organic chemistry (c) Physical chemistry (d) Analytical chemistry

Q3. Which branch studies the chemistry of living things?
(a) Biochemistry (b) Geochemistry (c) Nuclear chemistry (d) Industrial chemistry

Q4. A testable idea proposed to answer a question is a
(a) Law (b) Theory (c) Hypothesis (d) Fact

Q5. Science, technology and engineering are related because
(a) They are the same thing (b) Technology uses scientific knowledge (c) Engineering needs no science (d) Science needs no experiments

Q6. Which field combines chemistry with the study of the Earth?
(a) Astrochemistry (b) Geochemistry (c) Medicinal chemistry (d) Materials chemistry

Q7. A theory is
(a) A guess with no evidence (b) A well-tested explanation supported by evidence (c) A single experiment (d) A law of nature

Q8. Which of these is an application of chemistry in daily life?
(a) Making medicines (b) Growing crops without fertiliser (c) Making maps (d) Writing poems

Q9. Analytical chemistry is mainly concerned with
(a) Making plastics (b) Identifying and measuring substances (c) Studying stars (d) Treating disease

Q10. The first step of the scientific method is usually
(a) Writing a conclusion (b) Making an observation (c) Sharing results (d) Forming a law

Chapter 2: Matter

Study Notes

- **Matter** is anything that has mass and occupies space. Everything around us, including air, water and living things, is matter.
- **States of matter:** solids have a fixed shape and volume; liquids have a fixed volume but take the shape of their container; gases have neither a fixed shape nor a fixed volume. **Plasma** is a fourth state, a hot ionised gas found in the Sun and in lightning. **Bose-Einstein condensate** is a state formed at temperatures near absolute zero.
- **Particles in matter:** solids vibrate in fixed positions, liquids slide past one another, and gas particles move freely and rapidly in all directions.
- **Elements** are pure substances made of one kind of atom, for example iron, oxygen and gold. **Compounds** are formed when two or more elements combine chemically in a fixed ratio, for example water (H2O) and common salt (NaCl).
- **Mixtures** contain two or more substances mixed physically in any ratio; they can be separated by physical methods. **Allotropes** are different forms of the same element, for example diamond and graphite are allotropes of carbon.
- **Solutions** are homogeneous mixtures such as salt water. **Colloids** have particles larger than in a solution but too small to see, for example milk and fog. **Suspensions** have large particles that settle on standing, for example muddy water.

Short Questions (with answers)

Q1. Define matter.
Answer: Matter is anything that has mass and occupies space.

Q2. Name the four common states of matter.
Answer: Solid, liquid, gas and plasma.

Q3. What is the difference between a compound and a mixture?
Answer: A compound is formed by chemical combination in a fixed ratio and can only be separated by chemical means, while a mixture is a physical combination in any ratio and can be separated by physical methods.

Q4. Give two examples of allotropes of carbon.
Answer: Diamond and graphite (buckminsterfullerene is another allotrope).

Q5. Why is air called a mixture?
Answer: Air contains nitrogen, oxygen, carbon dioxide and other gases mixed physically in no fixed ratio, and its components can be separated by physical methods.

Chapter 2: Matter

Long Questions (with answers)

Q1. Compare solids, liquids and gases in terms of particle arrangement and movement.
Answer: In a solid the particles are closely packed in fixed positions and only vibrate. In a liquid the particles are close together but can slide past one another, so a liquid flows and takes the shape of its container. In a gas the particles are far apart and move freely and rapidly in all directions, so a gas spreads out to fill its container and can be compressed easily. This explains why solids keep their shape, liquids flow, and gases have no fixed shape or volume.

Q2. Explain solutions, colloids and suspensions with one example of each and state how they differ.
Answer: A solution is a homogeneous mixture with very small particles that do not settle and cannot be seen, for example salt dissolved in water. A colloid has larger particles that scatter light but do not settle, for example milk. A suspension has the largest particles, which are visible and settle on standing, for example muddy water. The three differ in particle size, whether the particles settle, and whether the mixture looks uniform.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Anything that has mass and occupies space is
(a) Energy (b) Matter (c) Light (d) Force

Q2. Which state of matter has a fixed shape and volume?
(a) Liquid (b) Gas (c) Solid (d) Plasma

Q3. Plasma is found in
(a) Ice (b) The Sun (c) Muddy water (d) Salt water

Q4. Water (H2O) is an example of a
(a) Element (b) Mixture (c) Compound (d) Colloid

Q5. Which of these is an element?
(a) Water (b) Common salt (c) Iron (d) Air

Q6. Diamond and graphite are
(a) Isotopes (b) Allotropes of carbon (c) Compounds (d) Mixtures

Q7. Milk is an example of a
(a) True solution (b) Colloid (c) Suspension (d) Pure substance

Q8. In a suspension the particles
(a) Never settle (b) Settle on standing (c) Cannot be seen (d) Dissolve completely

Q9. Which pair is a mixture?
(a) Air and brass (b) Water and salt (c) Iron and oxygen (d) Carbon and diamond

Q10. Gas particles differ from solid particles because they
(a) Vibrate in fixed positions (b) Move freely and rapidly (c) Are closely packed (d) Cannot be compressed

Chapter 3: Atomic Structure

Study Notes

- **An atom** is the smallest particle of an element that keeps the properties of that element. Atoms are made of three subatomic particles: **protons** (positive, in the nucleus), **neutrons** (no charge, in the nucleus) and **electrons** (negative, moving around the nucleus).
- **Atomic number (Z)** is the number of protons in an atom. **Mass number (A)** is the total number of protons and neutrons. For a neutral atom, the number of electrons equals the number of protons. Neutrons = A - Z.
- **Isotopes** are atoms of the same element with the same number of protons but different numbers of neutrons, for example carbon-12 and carbon-14, and hydrogen, deuterium and tritium.
- **Dalton's atomic theory:** all matter is made of tiny indivisible atoms; atoms of the same element are alike; atoms combine in simple whole-number ratios.
- **Thomson** discovered the electron and proposed the plum-pudding model. **Rutherford's** gold-foil experiment showed that most of an atom is empty space, with a small, dense, positively charged nucleus at the centre.
- **Bohr's model:** electrons move in fixed energy levels or shells (K, L, M, N) around the nucleus. An electron absorbs energy to jump to a higher shell and releases energy as light when it falls back. The maximum number of electrons in a shell is 2n2, where n is the shell number.

Short Questions (with answers)

Q1. What are the three subatomic particles?
Answer: Proton (positive), neutron (no charge) and electron (negative).

Q2. Define atomic number.
Answer: The atomic number (Z) is the number of protons in the nucleus of an atom.

Q3. How do you find the number of neutrons in an atom?
Answer: Neutrons = mass number - atomic number (A - Z).

Q4. What are isotopes? Give one example.
Answer: Isotopes are atoms of the same element with the same protons but different neutrons, for example carbon-12 and carbon-14.

Q5. Who discovered the electron?
Answer: J. J. Thomson discovered the electron.

Chapter 3: Atomic Structure

Long Questions (with answers)

Q1. Describe Rutherford's gold-foil experiment and the conclusions drawn from it.
Answer: Rutherford fired alpha particles at a thin gold foil. Most particles passed straight through, a few were deflected at small angles, and a very small number bounced back. From this he concluded that most of an atom is empty space, that there is a small, dense, positively charged nucleus at the centre, and that the electrons occupy the space around the nucleus. The large deflection of a few particles showed the nucleus is very small compared with the whole atom.

Q2. Explain Bohr's model of the atom and how it explains the emission of light.
Answer: Bohr proposed that electrons move in fixed energy levels or shells around the nucleus and do not radiate energy while in a shell. When an electron absorbs energy it jumps to a higher shell; when it falls back to a lower shell it releases the extra energy as light of a fixed wavelength. This explains why each element gives a line spectrum with its own set of colours. The maximum number of electrons in shell n is 2n2, so the K shell holds 2, the L shell 8 and the M shell 18.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. The centre of an atom is called the
(a) Shell (b) Nucleus (c) Orbit (d) Electron cloud

Q2. A proton carries
(a) Negative charge (b) No charge (c) Positive charge (d) Double charge

Q3. The atomic number of an atom is the number of
(a) Neutrons (b) Protons (c) Protons + neutrons (d) Electrons + neutrons

Q4. Mass number =
(a) Protons - neutrons (b) Protons + neutrons (c) Electrons + protons (d) Neutrons - protons

Q5. Isotopes of an element differ in their number of
(a) Protons (b) Electrons (c) Neutrons (d) Shells

Q6. Carbon-12 and carbon-14 are
(a) Isobars (b) Isotopes (c) Allotropes (d) Ions

Q7. The electron was discovered by
(a) Rutherford (b) Bohr (c) Dalton (d) Thomson

Q8. In Bohr's model, electrons move in
(a) Random paths (b) Fixed energy levels (c) The nucleus (d) Straight lines

Q9. The maximum number of electrons in the L shell is
(a) 2 (b) 8 (c) 18 (d) 32

Q10. Most of the mass of an atom is in the
(a) Electrons (b) Nucleus (c) Shells (d) Empty space

Chapter 4: Chemical Bonding

Study Notes

- Atoms form chemical bonds to become more stable, usually by gaining the **stable electronic configuration of a noble gas** (the octet rule: eight electrons in the outer shell, or two for the first shell).
- **Valence electrons** are the electrons in the outermost shell; they take part in bonding. Metals tend to lose electrons and form positive ions (cations); non-metals tend to gain electrons and form negative ions (anions).
- **Ionic (electrovalent) bond:** formed by the transfer of electrons from a metal to a non-metal, for example NaCl. Ionic compounds are hard, have high melting points, conduct electricity when molten or dissolved, and are usually soluble in water.
- **Covalent bond:** formed by the sharing of electron pairs between non-metal atoms, for example H2, O2, H2O and CH4. A single bond shares one pair, a double bond two pairs and a triple bond three pairs.
- **Metallic bond:** positive metal ions are held in a 'sea' of free electrons, which explains why metals conduct electricity and heat, are shiny, malleable and ductile.
- **Electron-dot (Lewis) structures** show the valence electrons as dots around the symbol of an element and help to show how bonds form. The type of bond affects the properties of the compound: ionic compounds are usually solids with high melting points, while simple covalent compounds are often gases or liquids with low melting points.

Short Questions (with answers)

Q1. Why do atoms form chemical bonds?
Answer: Atoms form bonds to become more stable by gaining the electronic configuration of a noble gas, usually eight electrons in the outer shell.

Q2. What are valence electrons?
Answer: Valence electrons are the electrons in the outermost shell of an atom; they take part in chemical bonding.

Q3. Define an ionic bond.
Answer: An ionic bond is formed by the transfer of one or more electrons from a metal atom to a non-metal atom, producing oppositely charged ions that attract each other.

Q4. What is a covalent bond?
Answer: A covalent bond is formed when two atoms share one or more pairs of electrons.

Q5. Name the bond in sodium chloride.
Answer: Ionic (electrovalent) bond.

Chapter 4: Chemical Bonding

Long Questions (with answers)

Q1. Compare ionic and covalent compounds and their properties.
Answer: Ionic compounds are formed by electron transfer between a metal and a non-metal; they are hard crystalline solids with high melting and boiling points, they conduct electricity when molten or in solution but not as solids, and they are often soluble in water, for example NaCl. Covalent compounds are formed by electron sharing between non-metals; they are often gases, liquids or soft solids with low melting and boiling points, they do not conduct electricity, and they are often soluble in organic solvents, for example methane and water.

Q2. Explain the metallic bond and how it explains the properties of metals.
Answer: In a metallic bond, metal atoms lose their valence electrons into a shared 'sea' of free electrons that surrounds the positive metal ions and holds them together. The free electrons carry charge and heat, so metals are good conductors of electricity and heat. The layers of ions can slide over one another without breaking the bond, so metals are malleable and ductile, and the free electrons reflect light, giving metals their shine.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Atoms bond mainly to achieve
(a) More electrons (b) A noble gas configuration (c) A larger size (d) A higher mass

Q2. The electrons in the outermost shell are called
(a) Core electrons (b) Valence electrons (c) Free electrons (d) Paired electrons

Q3. An ionic bond is formed by
(a) Sharing electrons (b) Transfer of electrons (c) Sharing protons (d) Transfer of neutrons

Q4. Sodium chloride is held together by
(a) Covalent bonds (b) Metallic bonds (c) Ionic bonds (d) Hydrogen bonds

Q5. A double covalent bond shares
(a) One pair of electrons (b) Two pairs of electrons (c) Three pairs of electrons (d) Four pairs of electrons

Q6. Which substance has covalent bonding?
(a) NaCl (b) MgO (c) H2O (d) KCl

Q7. Metals conduct electricity because of
(a) Fixed ions (b) A sea of free electrons (c) Covalent bonds (d) No electrons

Q8. Ionic compounds conduct electricity when
(a) Solid (b) Molten or dissolved (c) Frozen (d) Never

Q9. A cation is formed when an atom
(a) Gains electrons (b) Loses electrons (c) Gains protons (d) Loses neutrons

Q10. Which property belongs to ionic compounds?
(a) Low melting point (b) High melting point (c) Gas at room temperature (d) Do not dissolve in water

Chapter 5: Stoichiometry

Study Notes

- **Stoichiometry** is the study of the amounts of reactants and products in a chemical reaction, using balanced equations.
- **Chemical formula:** a formula shows the elements in a compound and the number of atoms of each, for example H2SO4. The **valency** of an element is its combining power. The formula of an ionic compound is written so that the total positive charge equals the total negative charge.
- **Empirical formula** is the simplest whole-number ratio of atoms in a compound; the **molecular formula** shows the actual number of atoms in a molecule. Molecular formula = n x empirical formula.
- **The mole** is the amount of substance containing as many particles as there are atoms in 12 g of carbon-12. One mole contains **Avogadro's number**, 6.02 x 10^23 particles. **Molar mass** is the mass of one mole of a substance in grams, equal to its relative atomic or molecular mass.
- **Percentage composition** = (mass of the element in the compound / molar mass of the compound) x 100. It is used to work out the empirical formula from experimental data.
- **Balanced equations:** the number of atoms of each element must be the same on both sides. The coefficients give the mole ratio in which substances react, for example 2H2 + O2 -> 2H2O means 2 moles of hydrogen react with 1 mole of oxygen.

Short Questions (with answers)

Q1. Define stoichiometry.
Answer: Stoichiometry is the study of the amounts of reactants and products in a chemical reaction, using balanced chemical equations.

Q2. What is Avogadro's number?
Answer: Avogadro's number is 6.02 x 10^23, the number of particles in one mole of a substance.

Q3. Define molar mass.
Answer: Molar mass is the mass of one mole of a substance in grams; it is numerically equal to its relative atomic or molecular mass.

Q4. What is the difference between an empirical and a molecular formula?
Answer: The empirical formula is the simplest whole-number ratio of atoms in a compound, while the molecular formula shows the actual number of atoms in one molecule.

Q5. Why must a chemical equation be balanced?
Answer: It must be balanced so that the number of atoms of each element is the same on both sides, as required by the law of conservation of mass.

Chapter 5: Stoichiometry

Long Questions (with answers)

Q1. Explain the mole concept and use it to find the number of molecules in 18 g of water.
Answer: One mole of any substance contains 6.02 x 10^23 particles (Avogadro's number). The molar mass of water is 18 g/mol (2 x 1 for hydrogen + 16 for oxygen), so 18 g of water is 1 mole. One mole contains 6.02 x 10^23 molecules, so 18 g of water contains 6.02 x 10^23 molecules of water. In the same way, the number of moles = mass / molar mass, and the number of particles = moles x 6.02 x 10^23.

Q2. Describe how the empirical formula of a compound is worked out from its percentage composition.
Answer: First, the percentage of each element is divided by its atomic mass to get the relative number of moles. Then each value is divided by the smallest value to get a simple ratio. If the ratio is not in whole numbers, it is multiplied by a small number to make it whole. The whole numbers give the empirical formula. For example, a compound with equal moles of carbon and hydrogen has the empirical formula CH; if its molecular mass is 26, the molecular formula is C2H2.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. One mole of a substance contains
(a) 6.02 x 10^23 particles (b) 6.02 x 10^22 particles (c) 12 particles (d) 100 particles

Q2. The molar mass of water (H2O) is
(a) 16 g/mol (b) 18 g/mol (c) 20 g/mol (d) 10 g/mol

Q3. The empirical formula of C6H12 is
(a) C6H12 (b) CH2 (c) C3H6 (d) CH

Q4. In the equation 2H2 + O2 -> 2H2O, the mole ratio of H2 to O2 is
(a) 1:1 (b) 2:1 (c) 1:2 (d) 2:2

Q5. Avogadro's number is named after
(a) Dalton (b) Avogadro (c) Bohr (d) Thomson

Q6. The valency of oxygen is usually
(a) 1 (b) 2 (c) 3 (d) 4

Q7. How many moles are there in 40 g of NaOH (molar mass 40 g/mol)?
(a) 0.5 mol (b) 1 mol (c) 2 mol (d) 4 mol

Q8. Percentage composition is calculated as
(a) (mass of element / molar mass) x 100 (b) (molar mass / mass of element) x 100 (c) mass x molar mass (d) moles x 100

Q9. The formula of common salt is
(a) KCl (b) NaCl (c) CaCl2 (d) HCl

Q10. A balanced equation must have equal numbers of
(a) Molecules on both sides (b) Atoms of each element on both sides (c) Electrons on both sides (d) Ions on both sides

Chapter 6: Electrochemistry

Study Notes

- **Electrochemistry** is the study of the relationship between electricity and chemical reactions.
- **Oxidation** is the loss of electrons (or gain of oxygen, or loss of hydrogen); **reduction** is the gain of electrons (or loss of oxygen, or gain of hydrogen). Oxidation and reduction always occur together in a **redox reaction**.
- **Oxidation number** is the charge an atom would have if the electrons in its bonds were assigned to the more electronegative atom. In a redox reaction, the oxidation number of one substance increases (oxidised) while that of another decreases (reduced).
- **Oxidising agent** is the substance that oxidises another and is itself reduced, for example oxygen and chlorine. **Reducing agent** is the substance that reduces another and is itself oxidised, for example hydrogen and carbon.
- **Electrochemical cells:** in a galvanic (voltaic) cell, a spontaneous redox reaction produces electricity; in an electrolytic cell, electricity is used to drive a non-spontaneous chemical change, for example the electrolysis of water or of brine.
- **Corrosion** is the slow eating away of a metal by air and water, for example the rusting of iron. Rust is hydrated iron(III) oxide. It can be prevented by painting, oiling, galvanising (coating with zinc) and using sacrificial protection.

Short Questions (with answers)

Q1. Define oxidation.
Answer: Oxidation is the loss of electrons by an atom, ion or molecule (it can also be described as gain of oxygen or loss of hydrogen).

Q2. What is a redox reaction?
Answer: A redox reaction is a reaction in which oxidation and reduction occur at the same time.

Q3. What is an oxidising agent?
Answer: An oxidising agent is a substance that oxidises another substance and is itself reduced in the reaction.

Q4. What is rust?
Answer: Rust is hydrated iron(III) oxide, formed when iron reacts with oxygen and water.

Q5. Name two methods of preventing rusting.
Answer: Painting and galvanising (coating iron with zinc).

Chapter 6: Electrochemistry

Long Questions (with answers)

Q1. Explain oxidation and reduction using the reaction between zinc and copper sulphate.
Answer: When zinc is placed in copper sulphate solution, zinc displaces copper: Zn + CuSO4 -> ZnSO4 + Cu. Zinc loses two electrons (Zn -> Zn2+ + 2e-) so zinc is oxidised and acts as the reducing agent. Copper ions gain the two electrons (Cu2+ + 2e- -> Cu) so copper is reduced and copper sulphate acts as the oxidising agent. The oxidation number of zinc rises from 0 to +2 while that of copper falls from +2 to 0, showing that oxidation and reduction happen together.

Q2. Describe how a galvanic cell produces electricity and how it differs from an electrolytic cell.
Answer: In a galvanic cell, a spontaneous redox reaction takes place in two half-cells connected by a salt bridge; electrons flow from the anode (where oxidation occurs) to the cathode (where reduction occurs) through an external wire, producing an electric current. In an electrolytic cell the opposite happens: an external supply of electricity forces a non-spontaneous reaction, for example splitting water into hydrogen and oxygen. A galvanic cell changes chemical energy into electrical energy, while an electrolytic cell changes electrical energy into chemical energy.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Oxidation is
(a) Gain of electrons (b) Loss of electrons (c) Gain of neutrons (d) Loss of protons

Q2. In a redox reaction, oxidation and reduction
(a) Occur separately (b) Occur together (c) Never occur (d) Cancel each other out

Q3. Which substance is an oxidising agent?
(a) Hydrogen (b) Carbon (c) Oxygen (d) Zinc

Q4. The oxidation number of an element in its free state is
(a) +1 (b) -1 (c) 0 (d) +2

Q5. Rusting of iron needs
(a) Oxygen only (b) Water only (c) Oxygen and water (d) Carbon dioxide only

Q6. Galvanising means coating iron with
(a) Copper (b) Zinc (c) Tin (d) Lead

Q7. In a galvanic cell, oxidation occurs at the
(a) Cathode (b) Anode (c) Salt bridge (d) Electrolyte

Q8. Electrolysis uses electricity to
(a) Produce a spontaneous reaction (b) Drive a non-spontaneous reaction (c) Stop all reactions (d) Make a magnet

Q9. Which is the reducing agent in the reaction Zn + CuSO4 -> ZnSO4 + Cu?
(a) CuSO4 (b) Cu (c) Zn (d) ZnSO4

Q10. Rust is
(a) Iron(II) oxide (b) Hydrated iron(III) oxide (c) Iron sulphate (d) Iron carbonate

Chapter 7: Chemical Energetics

Study Notes

- **Chemical energetics** is the study of energy changes in chemical reactions. The **system** is the part being studied (the reacting chemicals) and the **surroundings** are everything else.
- **Exothermic reactions** release heat to the surroundings, so the surroundings get warmer; examples are burning fuels and neutralisation. **Endothermic reactions** take in heat from the surroundings, so the surroundings get cooler; examples are photosynthesis and the dissolving of ammonium nitrate in water.
- **Enthalpy change (delta H)** is the heat change of a reaction at constant pressure. For an exothermic reaction delta H is negative; for an endothermic reaction delta H is positive.
- **Activation energy** is the minimum energy that reacting particles need before they can react. A catalyst lowers the activation energy and speeds up a reaction without being used up.
- **Bond energy:** energy is needed to break bonds (endothermic) and energy is released when new bonds form (exothermic). The overall enthalpy change is the difference between the energy used to break bonds and the energy released when bonds form.
- **Energy profile diagrams** show the energy of the reactants, the activation energy peak and the energy of the products. In an exothermic reaction the products are at a lower energy than the reactants; in an endothermic reaction they are at a higher energy.

Short Questions (with answers)

Q1. Define an exothermic reaction.
Answer: An exothermic reaction is a reaction that releases heat energy to the surroundings.

Q2. Give one example of an endothermic reaction.
Answer: Photosynthesis, or dissolving ammonium nitrate in water.

Q3. What is activation energy?
Answer: Activation energy is the minimum energy that reacting particles must have before they can react.

Q4. What is the sign of delta H for an exothermic reaction?
Answer: Negative.

Q5. How does a catalyst speed up a reaction?
Answer: A catalyst lowers the activation energy, so more particles can react; it is not used up in the reaction.

Chapter 7: Chemical Energetics

Long Questions (with answers)

Q1. Compare exothermic and endothermic reactions with examples.

Answer: An exothermic reaction releases heat to the surroundings, the temperature of the surroundings rises, and the enthalpy change is negative; burning natural gas and neutralisation are examples. An endothermic reaction takes in heat from the surroundings, the temperature of the surroundings falls, and the enthalpy change is positive; photosynthesis and the thermal decomposition of calcium carbonate are examples. In both cases energy is conserved: it is transferred between the system and the surroundings, not created or destroyed.

Q2. Explain how bond breaking and bond making decide whether a reaction is exothermic or endothermic.

Answer: Breaking bonds always needs energy, so it is endothermic. Making new bonds always releases energy, so it is exothermic. In a reaction both happen. If more energy is released when the new bonds form than is used to break the old bonds, the reaction is exothermic overall. If more energy is used to break bonds than is released when new bonds form, the reaction is endothermic overall. The difference between the two amounts is the enthalpy change of the reaction.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. A reaction that releases heat is called

(a) Endothermic (b) Exothermic (c) Reversible (d) Neutral

Q2. In an endothermic reaction the surroundings

(a) Get warmer (b) Get cooler (c) Stay the same (d) Catch fire

Q3. Delta H is negative for

(a) Endothermic reactions (b) Exothermic reactions (c) All reactions (d) No reactions

Q4. Activation energy is the

(a) Total energy of the products (b) Minimum energy needed to start a reaction (c) Energy released by a reaction (d) Energy of the reactants

Q5. A catalyst works by

(a) Raising activation energy (b) Lowering activation energy (c) Being used up (d) Cooling the mixture

Q6. Energy is needed to

(a) Make bonds (b) Break bonds (c) Cool a gas (d) Freeze water

Q7. Burning of a fuel is an example of

(a) An endothermic reaction (b) An exothermic reaction (c) A physical change only (d) A reversible reaction

Q8. Photosynthesis is

(a) Exothermic (b) Endothermic (c) Neutral (d) Explosive

Q9. In an energy profile diagram for an exothermic reaction, the products are

(a) Higher in energy than the reactants (b) Lower in energy than the reactants (c) At the same energy (d) At zero energy

Q10. Neutralisation of an acid by a base is

(a) Endothermic (b) Exothermic (c) Neither (d) Always slow

Chapter 8: Chemical Equilibrium

Study Notes

- A reaction is **reversible** when the products can react to form the reactants again, shown by a double arrow. An **irreversible** reaction goes only in one direction, for example burning.
- **Chemical equilibrium** is the state in a reversible reaction in a closed system when the rate of the forward reaction equals the rate of the reverse reaction. The concentrations of reactants and products stay constant, but the reactions continue: this is called **dynamic equilibrium**.
- **Le Chatelier's principle:** if a change is made to a system at equilibrium, the system shifts to oppose the change and restore equilibrium.
- **Effect of concentration:** adding more reactant shifts the equilibrium towards the products; removing a product also shifts it towards the products.
- **Effect of temperature:** raising the temperature favours the endothermic direction; lowering it favours the exothermic direction.
- **Effect of pressure:** increasing the pressure favours the side with fewer gas molecules; decreasing it favours the side with more gas molecules. A catalyst speeds up both directions equally, so it helps equilibrium to be reached faster but does not change the position of equilibrium.

Short Questions (with answers)

Q1. What is a reversible reaction?
Answer: A reversible reaction is one in which the products can react together to form the original reactants again.

Q2. Define chemical equilibrium.
Answer: Chemical equilibrium is the state in a closed system when the forward and reverse reaction rates are equal, so concentrations stay constant.

Q3. What does dynamic equilibrium mean?
Answer: It means the forward and reverse reactions continue at equal rates, so there is no overall change even though the reactions have not stopped.

Q4. State Le Chatelier's principle.
Answer: If a change is made to a system at equilibrium, the system shifts to oppose the change and restore equilibrium.

Q5. Does a catalyst change the position of equilibrium?
Answer: No, a catalyst speeds up both directions equally and only helps equilibrium to be reached faster.

Chapter 8: Chemical Equilibrium

Long Questions (with answers)

Q1. Explain dynamic equilibrium using a reversible reaction in a closed container.
Answer: In a closed container, a reversible reaction starts with only reactants, so the forward reaction is fast and the reverse reaction is slow. As products build up, the forward rate falls and the reverse rate rises until the two rates are equal. At that point the concentrations of reactants and products stop changing, but both reactions are still happening: every molecule that reacts in the forward direction is balanced by one reacting in the reverse direction. This is dynamic equilibrium. If the container were open and a product escaped, equilibrium could not be reached.

Q2. Use Le Chatelier's principle to predict the effect of temperature and pressure on the manufacture of ammonia, N2 + 3H2 -> 2NH3.
Answer: The forward reaction that makes ammonia is exothermic, so lowering the temperature favours the forward direction and gives more ammonia, while raising the temperature favours the reverse direction. There are four gas molecules on the left and two on the right, so increasing the pressure favours the forward direction and gives more ammonia. In practice a moderate temperature and high pressure are used, with a catalyst, to balance a good yield with a fast rate.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. A reversible reaction is shown by
(a) A single arrow (b) A double arrow (c) No arrow (d) A curved arrow

Q2. At equilibrium the forward and reverse rates are
(a) Equal (b) Zero (c) Very different (d) Infinite

Q3. Equilibrium can only be reached in a
(a) Open system (b) Closed system (c) Cold system (d) Empty container

Q4. Adding more reactant shifts equilibrium towards the
(a) Reactants (b) Products (c) Catalyst (d) Solids

Q5. Raising the temperature favours the
(a) Exothermic direction if temperature falls (b) Endothermic direction (c) Side with more gas (d) Catalyst

Q6. Increasing pressure favours the side with
(a) More gas molecules (b) Fewer gas molecules (c) More liquid (d) Higher temperature

Q7. A catalyst in an equilibrium reaction
(a) Changes the position of equilibrium (b) Only speeds up reaching equilibrium (c) Stops the reverse reaction (d) Removes the products

Q8. Burning wood is an example of a
(a) Reversible reaction (b) Irreversible reaction (c) Equilibrium (d) Slow reaction

Q9. In dynamic equilibrium, concentrations
(a) Keep rising (b) Keep falling (c) Stay constant (d) Become zero

Q10. Removing a product from an equilibrium mixture shifts it towards the
(a) Reactants (b) Products (c) Left only (d) Catalyst

Chapter 9: Acids and Bases

Study Notes

- An **acid** is a substance that produces hydrogen ions (H+) in water, or donates a proton. Common acids are hydrochloric acid (HCl), sulphuric acid (H2SO4), nitric acid (HNO3) and ethanoic acid (CH3COOH).
- A **base** is a substance that neutralises an acid; an **alkali** is a base that dissolves in water, for example sodium hydroxide (NaOH) and ammonia solution. Bases produce hydroxide ions (OH-) in water.
- **Bronsted-Lowry concept:** an acid is a proton donor and a base is a proton acceptor. When an acid donates a proton it becomes its conjugate base; when a base accepts a proton it becomes its conjugate acid.
- **Properties of acids:** sour taste, turn blue litmus red, react with metals to give hydrogen gas, react with carbonates to give carbon dioxide, and conduct electricity in solution. **Strong acids** (HCl, H2SO4, HNO3) ionise completely in water; **weak acids** (ethanoic acid, carbonic acid) ionise only partly.
- **pH scale:** pH measures how acidic or alkaline a solution is, from 0 to 14. pH 7 is neutral, below 7 is acidic and above 7 is alkaline. The pH can be measured with universal indicator or a pH meter.
- **Neutralisation:** acid + base -> salt + water, for example HCl + NaOH -> NaCl + H2O. **Salts** are formed when the hydrogen of an acid is replaced by a metal or ammonium ion. Neutralisation is used to treat acidic soil with lime and to treat indigestion with antacids.

Short Questions (with answers)

Q1. Define an acid.
Answer: An acid is a substance that produces hydrogen ions (H+) in water, or donates a proton to a base.

Q2. What is the difference between a base and an alkali?
Answer: A base is any substance that neutralises an acid; an alkali is a base that dissolves in water, for example sodium hydroxide.

Q3. What is the pH of a neutral solution?
Answer: pH 7.

Q4. Name one strong acid and one weak acid.
Answer: Strong acid: hydrochloric acid (HCl). Weak acid: ethanoic acid (CH3COOH).

Q5. What are the products of neutralisation?
Answer: A salt and water.

Chapter 9: Acids and Bases

Long Questions (with answers)

Q1. Explain the Bronsted-Lowry concept of acids and bases with an example.
Answer: According to Bronsted and Lowry, an acid is a proton (H+) donor and a base is a proton acceptor. In the reaction HCl + NH3 -> NH4+ + Cl-, hydrogen chloride donates a proton so it is the acid, and ammonia accepts the proton so it is the base. After donating its proton, HCl becomes Cl-, its conjugate base; after accepting a proton, NH3 becomes NH4+, its conjugate acid. The pair HCl/Cl- and the pair NH4+/NH3 are conjugate acid-base pairs.

Q2. Describe how the pH scale works and give uses of neutralisation in daily life.
Answer: The pH scale runs from 0 to 14 and measures the concentration of hydrogen ions. Solutions with pH below 7 are acidic, pH 7 is neutral and solutions above 7 are alkaline; the lower the pH the stronger the acid. Universal indicator shows the pH by colour, and a pH meter measures it electrically. Neutralisation is used in daily life: farmers add lime (calcium oxide or hydroxide) to acidic soil, antacid tablets neutralise excess stomach acid, and toothpaste, which is mildly alkaline, neutralises acids made by bacteria in the mouth.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. An acid produces in water
(a) OH- ions (b) H+ ions (c) Na+ ions (d) Electrons

Q2. Which of these is a strong acid?
(a) Ethanoic acid (b) Carbonic acid (c) Hydrochloric acid (d) Citric acid

Q3. A base that dissolves in water is called an
(a) Acid (b) Alkali (c) Salt (d) Oxide

Q4. The pH of an alkaline solution is
(a) Below 7 (b) 7 (c) Above 7 (d) 0

Q5. Acids turn blue litmus
(a) Red (b) Green (c) Yellow (d) Colourless

Q6. Acid + metal ->
(a) Salt + water (b) Salt + hydrogen (c) Salt + oxygen (d) Salt + carbon dioxide

Q7. The products of HCl + NaOH are
(a) NaCl + H2O (b) NaOH + HCl (c) NaCl + H2 (d) Na2O + H2O

Q8. In the Bronsted-Lowry concept, a base is a
(a) Proton donor (b) Proton acceptor (c) Electron donor (d) Neutron donor

Q9. Which substance is used to treat acidic soil?
(a) Lime (b) Vinegar (c) Salt (d) Sand

Q10. A weak acid differs from a strong acid because it
(a) Ionises completely (b) Ionises only partly (c) Has no hydrogen (d) Is always dilute

Chapter 10: Periodic Table and Group Properties

Study Notes

- The **periodic table** arranges the elements in order of increasing atomic number. Horizontal rows are **periods** and vertical columns are **groups**. Elements in the same group have the same number of valence electrons and similar properties.
- The table is divided into **blocks**: the s-block (groups 1 and 2), the p-block (groups 13 to 18), the d-block (transition metals, groups 3 to 12) and the f-block (lanthanides and actinides, placed below the table).
- **Periodic trends:** atomic radius decreases across a period (stronger nuclear pull) and increases down a group (new shells added). Ionisation energy generally increases across a period and decreases down a group. Electronegativity also increases across a period and decreases down a group.
- **Group 1 (alkali metals)** — lithium, sodium, potassium — have one valence electron, are soft, reactive metals that react vigorously with water and are stored in oil. Reactivity increases down the group.
- **Group 2 (alkaline earth metals)** — magnesium, calcium — have two valence electrons and are less reactive than group 1. **Group 17 (halogens)** — fluorine, chlorine, bromine, iodine — have seven valence electrons, are reactive non-metals, and reactivity decreases down the group.
- **Group 18 (noble gases)** — helium, neon, argon — have full outer shells, are very unreactive and are used in light bulbs and balloons. **Transition metals** are hard, strong, good conductors and often form coloured compounds.

Short Questions (with answers)

Q1. What is a period in the periodic table?
Answer: A period is a horizontal row of elements in the periodic table.

Q2. How many valence electrons do group 1 elements have?
Answer: One valence electron.

Q3. Which group contains the noble gases?
Answer: Group 18.

Q4. What happens to atomic radius down a group?
Answer: It increases, because a new electron shell is added in each period.

Q5. Name one halogen.
Answer: Fluorine, chlorine, bromine or iodine.

Chapter 10: Periodic Table and Group Properties

Long Questions (with answers)

Q1. Describe the periodic trends in atomic radius and ionisation energy across a period and down a group, and explain why they occur.

Answer: Across a period, atomic radius decreases because the nuclear charge increases and pulls the electrons closer, while the electrons are added to the same shell. Down a group the radius increases because each period adds a new shell, and the extra shielding outweighs the larger nuclear charge. Ionisation energy is the energy needed to remove an outer electron: it increases across a period because the smaller atom holds its electrons more tightly, and it decreases down a group because the outer electron is further from the nucleus and more shielded.

Q2. Compare the properties and reactivity of group 1 metals and group 17 halogens.

Answer: Group 1 metals (alkali metals) have one valence electron, which they lose easily to form +1 ions; they are soft, reactive metals, and their reactivity increases down the group because the outer electron is further from the nucleus. Group 17 elements (halogens) have seven valence electrons, which they gain to form -1 ions; they are reactive non-metals, and their reactivity decreases down the group because the incoming electron is further from the nucleus. Both groups are very reactive because they are one electron away from a stable noble gas configuration.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Elements in the periodic table are arranged by increasing

(a) Mass number (b) Atomic number (c) Density (d) Melting point

Q2. A vertical column in the periodic table is a

(a) Period (b) Group (c) Block (d) Shell

Q3. Elements in the same group have the same number of

(a) Protons (b) Valence electrons (c) Neutrons (d) Shells

Q4. Atomic radius across a period

(a) Increases (b) Decreases (c) Stays the same (d) Doubles

Q5. The s-block contains groups

(a) 1 and 2 (b) 13 to 18 (c) 3 to 12 (d) 17 and 18

Q6. Which element is a noble gas?

(a) Chlorine (b) Sodium (c) Argon (d) Oxygen

Q7. Reactivity of alkali metals down the group

(a) Decreases (b) Increases (c) Stays the same (d) Becomes zero

Q8. Halogens have how many valence electrons?

(a) 1 (b) 2 (c) 7 (d) 8

Q9. Transition metals are found in the

(a) s-block (b) p-block (c) d-block (d) f-block

Q10. Ionisation energy down a group generally

(a) Increases (b) Decreases (c) Stays the same (d) Doubles

Chapter 11: Environmental Chemistry

Study Notes

- **Environmental chemistry** studies the chemical processes in air, water and soil and how human activity changes them.
- **Composition of air:** about 78% nitrogen, 21% oxygen, about 0.04% carbon dioxide, argon and small amounts of other gases and water vapour.
- **Air pollutants:** carbon monoxide (from incomplete burning of fuel), sulphur dioxide (from burning coal and oil), nitrogen oxides (from vehicle engines and power stations), smoke, dust and unburnt hydrocarbons. These cause smog, breathing problems and damage to buildings.
- **Ozone layer:** ozone (O3) in the upper atmosphere absorbs harmful ultraviolet radiation from the Sun. Chlorofluorocarbons (CFCs) damage the ozone layer, letting more ultraviolet radiation reach the Earth.
- **Greenhouse effect and global warming:** carbon dioxide, methane and other greenhouse gases trap heat in the atmosphere. Burning fossil fuels increases carbon dioxide, which raises the Earth's temperature, melts glaciers and changes rainfall patterns.
- **Acid rain** is formed when sulphur dioxide and nitrogen oxides dissolve in rainwater to make sulphuric and nitric acids; it damages buildings, forests and lakes. Water pollution is caused by sewage, industrial waste, fertilisers and pesticides; it can be reduced by treating waste water before it is released.

Short Questions (with answers)

Q1. What are the two main gases in air?
Answer: Nitrogen (about 78%) and oxygen (about 21%).

Q2. Name one source of sulphur dioxide.
Answer: Burning coal or oil containing sulphur, for example in power stations and factories.

Q3. What is the function of the ozone layer?
Answer: It absorbs harmful ultraviolet radiation from the Sun.

Q4. What is the greenhouse effect?
Answer: Greenhouse gases such as carbon dioxide trap heat in the atmosphere, warming the Earth.

Q5. How is acid rain formed?
Answer: Sulphur dioxide and nitrogen oxides dissolve in rainwater to form sulphuric and nitric acids.

Chapter 11: Environmental Chemistry

Long Questions (with answers)

Q1. Explain the greenhouse effect and how human activity increases global warming.
Answer: Greenhouse gases such as carbon dioxide, methane and water vapour allow sunlight to reach the Earth but absorb the heat radiated back from the surface, keeping the planet warm enough for life. Human activity increases these gases: burning fossil fuels releases carbon dioxide, cutting down forests removes trees that absorb it, and farming and waste release methane. More greenhouse gas traps more heat, so the average temperature rises; this melts glaciers, raises sea levels and changes weather and rainfall patterns.

Q2. Describe the causes and effects of acid rain and how it can be reduced.
Answer: Acid rain is caused by sulphur dioxide from burning coal and oil and nitrogen oxides from vehicles and power stations. These gases dissolve in clouds to form sulphuric acid and nitric acid, which fall as rain. Acid rain damages buildings and statues made of limestone and marble, harms forests and crops, and makes lakes too acidic for fish. It can be reduced by using low-sulphur fuels, fitting filters and scrubbers to chimneys, using catalytic converters in vehicles and using renewable energy instead of fossil fuels.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Air is about how much nitrogen?
(a) 21% (b) 78% (c) 50% (d) 90%

Q2. Oxygen makes up about what share of air?
(a) 78% (b) 21% (c) 1% (d) 50%

Q3. Carbon monoxide is mainly produced by
(a) Complete burning of fuel (b) Incomplete burning of fuel (c) Photosynthesis (d) Rainfall

Q4. The ozone layer protects us from
(a) Infrared radiation (b) Ultraviolet radiation (c) Sound waves (d) Radio waves

Q5. Which gas is a major greenhouse gas?
(a) Oxygen (b) Nitrogen (c) Carbon dioxide (d) Argon

Q6. CFCs are harmful because they
(a) Damage the ozone layer (b) Increase oxygen (c) Cool the Earth (d) Clean the air

Q7. Acid rain is mainly caused by
(a) Oxygen and nitrogen (b) Sulphur dioxide and nitrogen oxides (c) Carbon monoxide only (d) Dust only

Q8. Global warming can melt
(a) Rocks (b) Glaciers (c) Metals (d) Sand

Q9. Which practice reduces air pollution?
(a) Burning more coal (b) Using renewable energy (c) Removing car filters (d) Burning rubbish

Q10. Water pollution is caused by
(a) Sewage and industrial waste (b) Clean rain (c) Oxygen (d) Sunlight

Chapter 12: Organic Chemistry

Study Notes

- **Organic chemistry** is the study of carbon compounds, especially those containing carbon and hydrogen. Carbon can form four covalent bonds and can join to other carbon atoms in long chains and rings, which is why there are millions of organic compounds.
- **Hydrocarbons** are compounds of carbon and hydrogen only. **Alkanes** are saturated hydrocarbons with single bonds only, for example methane (CH4), ethane (C2H6) and propane (C3H8). Their general formula is CnH2n+2.
- **Alkenes** are unsaturated hydrocarbons with at least one carbon-carbon double bond, for example ethene (C2H4); their general formula is CnH2n. **Alkynes** contain a triple bond, for example ethyne (C2H2), with general formula CnH2n-2.
- **Structural formula** shows how the atoms in a molecule are joined together. The same molecular formula can give different structures, called **isomers**.
- **Homologous series:** a family of compounds with the same functional group and general formula, in which each member differs from the next by a -CH2- group, for example the alkanes and the alcohols.
- **Functional groups** are atoms or groups of atoms that give a compound its characteristic properties: -OH (alcohol), -COOH (carboxylic acid), -CHO (aldehyde), -CO- (ketone) and -NH2 (amine). Organic compounds are used as fuels, plastics, medicines, soaps, solvents and food.

Short Questions (with answers)

Q1. What is organic chemistry?
Answer: Organic chemistry is the study of carbon compounds, especially compounds of carbon and hydrogen.

Q2. What are hydrocarbons?
Answer: Hydrocarbons are compounds made of carbon and hydrogen only.

Q3. Give the general formula of alkanes.
Answer: CnH2n+2.

Q4. What is a functional group?
Answer: A functional group is an atom or group of atoms that gives a compound its characteristic chemical properties.

Q5. Give one example of an alkene.
Answer: Ethene (C2H4).

Chapter 12: Organic Chemistry

Long Questions (with answers)

Q1. Compare alkanes and alkenes in structure, formula and reactions.
Answer: Alkanes are saturated hydrocarbons with only single carbon-carbon bonds and the general formula CnH2n+2; they are fairly unreactive and mainly undergo combustion and substitution reactions. Alkenes are unsaturated hydrocarbons with at least one carbon-carbon double bond and the general formula CnH2n; the double bond makes them more reactive and they undergo addition reactions, for example ethene reacts with bromine water, which is decolourised, and with hydrogen to form an alkane. Both are hydrocarbons, but alkenes are more reactive because of the double bond.

Q2. Explain what a homologous series is, using the alkanes as an example.
Answer: A homologous series is a family of compounds with the same functional group and the same general formula, in which each member differs from the next by a -CH2- group. The alkanes (methane CH4, ethane C2H6, propane C3H8, butane C4H10) form a homologous series with the general formula CnH2n+2. Members of a series show a gradual change in physical properties such as boiling point, which rises with molecular size, but they have similar chemical properties because they have the same functional group.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Organic chemistry is the study of compounds of
(a) Silicon (b) Carbon (c) Nitrogen (d) Sulphur

Q2. Methane (CH4) is an example of a
(a) Alkene (b) Alkane (c) Alkyne (d) Alcohol

Q3. The general formula of alkanes is
(a) CnH2n (b) CnH2n+2 (c) CnH2n-2 (d) CnH2n+1

Q4. Ethene (C2H4) is an
(a) Alkane (b) Alkene (c) Alkyne (d) Alcohol

Q5. A triple bond is found in
(a) Alkanes (b) Alkenes (c) Alkynes (d) Alcohols

Q6. Members of a homologous series differ by
(a) -CH2- (b) -CH3 (c) -OH (d) -COOH

Q7. The functional group -OH belongs to
(a) Carboxylic acids (b) Alcohols (c) Aldehydes (d) Ketones

Q8. The functional group -COOH belongs to
(a) Alcohols (b) Carboxylic acids (c) Amines (d) Alkenes

Q9. Isomers are compounds with
(a) The same formula but different structures (b) Different formulas (c) The same structure (d) No carbon

Q10. Carbon can form how many covalent bonds?
(a) 2 (b) 3 (c) 4 (d) 5

Chapter 13: Biochemistry

Study Notes

- **Biochemistry** is the study of the chemical substances and processes in living things. The main groups of biochemicals are carbohydrates, proteins, lipids, nucleic acids, vitamins and minerals.
- **Carbohydrates** are compounds of carbon, hydrogen and oxygen and are the main source of energy. Simple sugars such as glucose and fructose are monosaccharides; sucrose and lactose are disaccharides; starch and cellulose are polysaccharides. Starch is the storage carbohydrate in plants.
- **Proteins** are made of amino acids joined together. They build and repair body tissues, make enzymes and hormones, and defend the body against disease. Meat, eggs, milk, beans and lentils are rich in protein.
- **Lipids** (fats and oils) store energy, insulate the body and protect organs. Saturated fats are usually solid at room temperature, while unsaturated fats (oils) are liquid. Too much fat in the diet can cause heart disease.
- **Nucleic acids** — DNA and RNA — store and pass on genetic information. DNA is a double helix made of nucleotides, each containing a sugar, a phosphate group and a nitrogenous base. DNA controls how proteins are made.
- **Balanced diet:** the body needs the right amounts of carbohydrates, proteins, fats, vitamins, minerals and water. Vitamins and minerals are needed in small amounts for health, for example vitamin C prevents scurvy, vitamin D and calcium keep bones strong, and iron prevents anaemia.

Short Questions (with answers)

Q1. What is biochemistry?
Answer: Biochemistry is the study of the chemical substances and processes in living things.

Q2. Name the three main energy-giving nutrients.
Answer: Carbohydrates, proteins and lipids (fats).

Q3. Give one example of a monosaccharide.
Answer: Glucose or fructose.

Q4. What are proteins made of?
Answer: Amino acids joined together.

Q5. What is the function of DNA?
Answer: DNA stores genetic information and controls how proteins are made.

Chapter 13: Biochemistry

Long Questions (with answers)

Q1. Describe carbohydrates, proteins and lipids and their roles in the body.
Answer: Carbohydrates are compounds of carbon, hydrogen and oxygen and are the body's main source of energy; glucose is used in respiration, and excess is stored as starch in plants and glycogen in animals. Proteins are made of amino acids and build and repair tissues, make enzymes and hormones, and help fight disease. Lipids store energy, provide insulation and protect organs; they are found in butter, ghee, oils and nuts. A balanced diet must contain all three in the right amounts, along with vitamins, minerals and water.

Q2. Explain the structure and function of nucleic acids.
Answer: Nucleic acids are DNA and RNA. DNA is made of two strands wound into a double helix; each strand is a chain of nucleotides, and each nucleotide contains a sugar (deoxyribose), a phosphate group and one of four nitrogenous bases (adenine, thymine, cytosine or guanine). The order of the bases is the genetic code that tells the cell which proteins to make. RNA carries the code from DNA to the ribosomes, where proteins are made. In this way nucleic acids store and pass on the instructions for life.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Biochemistry is the study of chemistry in
(a) Rocks (b) Living things (c) The atmosphere (d) Metals

Q2. The main source of energy in the body is
(a) Vitamins (b) Carbohydrates (c) Minerals (d) Water

Q3. Glucose is a
(a) Disaccharide (b) Monosaccharide (c) Polysaccharide (d) Lipid

Q4. Starch is the storage carbohydrate in
(a) Animals (b) Plants (c) Bacteria (d) Fungi

Q5. Proteins are made of
(a) Fatty acids (b) Amino acids (c) Sugars (d) Nucleotides

Q6. Which food is rich in protein?
(a) Rice (b) Eggs (c) Sugar (d) Butter

Q7. DNA is shaped like a
(a) Single strand (b) Double helix (c) Ring (d) Sheet

Q8. Lack of iron in the diet causes
(a) Scurvy (b) Anaemia (c) Rickets (d) Goitre

Q9. Vitamin C prevents
(a) Rickets (b) Scurvy (c) Anaemia (d) Night blindness

Q10. Fats and oils belong to the group called
(a) Carbohydrates (b) Proteins (c) Lipids (d) Nucleic acids

Chapter 14: Empirical Data Collection and Analysis

Study Notes

- **Empirical data** are data collected by observation and measurement in experiments. Good science depends on collecting data carefully, recording it honestly and analysing it to draw conclusions.
- **SI units:** the standard units used in science are the metre (m) for length, kilogram (kg) for mass, second (s) for time, kelvin (K) for temperature, mole (mol) for amount of substance and ampere (A) for electric current. Volumes in chemistry are often measured in cubic centimetres (cm3) and decimetres cubed (dm3); 1 dm3 = 1000 cm3.
- **Prefixes:** milli- (m) means 10^-3, centi- (c) means 10^-2, kilo- (k) means 10^3 and mega- (M) means 10^6. For example, 1 km = 1000 m and 1 mg = 0.001 g.
- **Accuracy** means how close a measurement is to the true value; **precision** means how close repeated measurements are to each other. A measurement can be precise but not accurate.
- **Errors:** random errors vary from one measurement to another and can be reduced by repeating measurements and taking an average. Systematic errors affect all measurements in the same way, for example a balance that reads 0.5 g too high, and must be found and corrected.
- **Significant figures:** results should be given to the right number of significant figures, matching the least precise measurement used. Data are presented in tables and graphs so that patterns can be seen; the independent variable is plotted on the x-axis and the dependent variable on the y-axis.

Short Questions (with answers)

Q1. What is empirical data?
Answer: Empirical data are data collected by observation and measurement in experiments.

Q2. Name the SI unit of mass.
Answer: Kilogram (kg).

Q3. How many cubic centimetres are in 1 dm3?
Answer: 1000 cm3.

Q4. What is the difference between accuracy and precision?
Answer: Accuracy is how close a measurement is to the true value; precision is how close repeated measurements are to each other.

Q5. Which variable is plotted on the x-axis of a graph?
Answer: The independent variable.

Chapter 14: Empirical Data Collection and Analysis

Long Questions (with answers)

Q1. Explain random and systematic errors and how each can be reduced.
Answer: Random errors vary from one measurement to another, for example a slightly different reading each time a volume is measured; they are caused by small, unpredictable changes and can be reduced by repeating measurements and taking an average. Systematic errors affect every measurement in the same way, for example a balance that always reads too high or a measuring cylinder read from the wrong angle; repeating the measurement does not remove them. They must be found, for example by checking the apparatus against a known value, and corrected or allowed for.

Q2. Describe how experimental data should be recorded and presented, including significant figures.
Answer: Data should be recorded directly and honestly in a table, with headings and units, at the time of the experiment. Repeated readings are averaged to reduce random error. The result is given to the number of significant figures that matches the least precise measurement used; for example, a volume measured to 0.1 cm3 should not be quoted to 0.001 cm3. Data are then presented in a table or a graph, with the independent variable on the x-axis and the dependent variable on the y-axis, so that patterns and relationships can be seen clearly.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Empirical data are collected by
(a) Guessing (b) Observation and measurement (c) Reading books only (d) Copying others

Q2. The SI unit of length is the
(a) Kilogram (b) Metre (c) Second (d) Mole

Q3. The SI unit of temperature is the
(a) Degree Celsius (b) Kelvin (c) Fahrenheit (d) Joule

Q4. 1 km is equal to
(a) 100 m (b) 1000 m (c) 10 m (d) 10000 m

Q5. A measurement that is close to the true value is
(a) Precise (b) Accurate (c) Wrong (d) Estimated

Q6. Repeated measurements close to each other show
(a) Accuracy (b) Precision (c) Error (d) Bias

Q7. Repeating measurements and averaging reduces
(a) Systematic errors (b) Random errors (c) All errors (d) Human error only

Q8. A balance that always reads 0.5 g too high causes a
(a) Random error (b) Systematic error (c) No error (d) Precision error

Q9. The dependent variable is plotted on the
(a) x-axis (b) y-axis (c) Title (d) Table

Q10. 1 dm3 equals
(a) 10 cm3 (b) 100 cm3 (c) 1000 cm3 (d) 1 cm3

Chapter 15: Separation Techniques

Study Notes

- **Separation techniques** are physical methods used to separate the components of a mixture. The method chosen depends on the properties of the substances, such as particle size, solubility, density and boiling point.
- **Filtration** separates an insoluble solid from a liquid, for example sand from water, using filter paper. The solid left on the paper is the residue and the liquid that passes through is the filtrate.
- **Evaporation and crystallisation:** evaporation removes the solvent to leave the dissolved solid, for example salt from sea water. Crystallisation is a slower, controlled method that gives pure crystals, for example pure salt or sugar crystals.
- **Distillation** separates liquids with different boiling points or a solid from a liquid: the mixture is heated, the vapour is cooled in a condenser and the pure liquid (distillate) is collected. **Fractional distillation** uses a fractionating column to separate liquids with close boiling points, for example the fractions of crude oil.
- **Separating funnel:** two liquids that do not mix, such as oil and water, can be separated by letting the denser liquid run off from the bottom of the funnel. **Sublimation** is used when one solid changes directly into a gas, for example separating ammonium chloride from common salt.
- **Purity** can be checked by melting point and boiling point: a pure substance melts and boils at a sharp, fixed temperature, while an impure substance melts over a range of temperatures. **Chromatography** is introduced here as a method that separates the coloured components of a mixture; it is studied in detail in the next chapter.

Short Questions (with answers)

Q1. What is filtration used for?
Answer: Filtration separates an insoluble solid from a liquid, for example sand from water.

Q2. What is the liquid that passes through filter paper called?
Answer: The filtrate.

Q3. How can pure salt be obtained from sea water?
Answer: By evaporation or crystallisation of the sea water.

Q4. What is the difference between simple and fractional distillation?
Answer: Simple distillation separates substances with well-separated boiling points, while fractional distillation uses a fractionating column to separate liquids with close boiling points.

Q5. How is the purity of a substance checked?
Answer: By its melting point and boiling point: a pure substance melts and boils at a sharp, fixed temperature.

Chapter 15: Separation Techniques

Long Questions (with answers)

Q1. Describe how fractional distillation separates the fractions of crude oil.

Answer: Crude oil is heated until it vaporises and the vapour is passed up a fractionating column, which is hot at the bottom and cooler at the top. As the vapour rises and cools, each fraction condenses at the level where the temperature equals its boiling point: fractions with high boiling points, such as bitumen and fuel oil, condense near the bottom, while fractions with low boiling points, such as petrol and gases, rise to the top before condensing. The liquids are collected separately, so the mixture is separated by boiling point.

Q2. Explain how filtration, evaporation and crystallisation are used together to obtain pure salt from a mixture of salt and sand.

Answer: First the mixture is stirred with water: the salt dissolves but the sand does not. The mixture is filtered; the sand stays on the filter paper as the residue and the salt solution passes through as the filtrate. The filtrate is then heated gently to evaporate most of the water, and on cooling, pure salt crystals form; these are the product of crystallisation. The crystals are filtered off and dried. Each step uses a different property: solubility in water, particle size for filtration, and the fact that the solvent evaporates before the solid.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Filtration separates

(a) Two liquids (b) An insoluble solid from a liquid (c) Two gases (d) Two solids

Q2. The solid left on filter paper is the

(a) Filtrate (b) Residue (c) Distillate (d) Solvent

Q3. Evaporation is used to obtain salt from

(a) Sand (b) Sea water (c) Oil (d) Air

Q4. Distillation separates substances by their

(a) Density (b) Boiling points (c) Colour (d) Mass

Q5. A separating funnel is used for liquids that

(a) Mix completely (b) Do not mix (c) Are gases (d) Are solids

Q6. Sublimation can separate ammonium chloride from salt because ammonium chloride

(a) Dissolves in water (b) Changes directly into a gas (c) Melts easily (d) Is magnetic

Q7. Fractional distillation uses a

(a) Filter paper (b) Fractionating column (c) Magnet (d) Separating funnel

Q8. A pure substance has a

(a) Range of melting points (b) Sharp, fixed melting point (c) No melting point (d) Very low melting point

Q9. Petrol is separated from crude oil by

(a) Filtration (b) Fractional distillation (c) Sublimation (d) Crystallisation

Q10. In distillation, the vapour is cooled in a

(a) Filter (b) Condenser (c) Funnel (d) Beaker

Chapter 16: Qualitative Analysis

Study Notes

- **Qualitative analysis** is the identification of the substances or ions present in a sample, without measuring how much of each is present. (Quantitative analysis measures the amount.)
- **Tests for gases:** hydrogen burns with a 'pop' when a lighted splint is held at the mouth of a test tube. Oxygen relights a glowing splint. Carbon dioxide turns limewater milky. Ammonia turns damp red litmus paper blue and has a sharp smell. Chlorine bleaches damp litmus paper.
- **Flame test:** a clean nichrome wire is dipped in the sample and held in a Bunsen flame. Lithium gives a crimson flame, sodium a golden yellow flame, potassium a lilac flame, calcium a brick-red flame and copper a blue-green flame.
- **Paper chromatography:** a spot of the mixture is placed on chromatography paper and the bottom edge is dipped in a solvent. The solvent rises up the paper and carries the substances with it; different substances move at different speeds and separate into spots.
- **Chromatogram analysis:** the position of each spot is compared with known substances. The **Rf value** = distance moved by the substance / distance moved by the solvent front. Substances with the same Rf value under the same conditions are likely to be the same substance.
- **Observation and inference:** an observation is what is seen, for example a white precipitate; an inference is the conclusion drawn from it, for example that a certain ion is present. A good report records the test, the observation and the inference separately.

Short Questions (with answers)

Q1. What is qualitative analysis?
Answer: Qualitative analysis is the identification of the substances or ions present in a sample, without measuring their amounts.

Q2. How is hydrogen gas tested?
Answer: Hydrogen burns with a 'pop' sound when a lighted splint is held at the mouth of the test tube.

Q3. How is carbon dioxide tested?
Answer: Carbon dioxide turns limewater milky.

Q4. What colour flame does sodium give in a flame test?
Answer: Golden yellow.

Q5. What is the Rf value?
Answer: Rf value = distance moved by the substance / distance moved by the solvent front.

Chapter 16: Qualitative Analysis

Long Questions (with answers)

Q1. Describe the tests for hydrogen, oxygen, carbon dioxide and ammonia, and state what is observed in each.

Answer: Hydrogen is tested with a lighted splint, which burns with a 'pop'. Oxygen is tested with a glowing splint, which relights. Carbon dioxide is tested by bubbling it through limewater, which turns milky because calcium carbonate forms. Ammonia is tested with damp red litmus paper, which turns blue, and it also has a sharp, choking smell. Each test gives a different, characteristic observation, so the gas can be identified with confidence.

Q2. Explain paper chromatography and how a chromatogram is used to identify substances.

Answer: In paper chromatography a small spot of the mixture is placed near the bottom of chromatography paper and the edge is dipped in a solvent. The solvent rises up the paper by capillary action and carries the dissolved substances with it. Different substances are attracted differently to the paper and the solvent, so they move at different speeds and separate into spots. The chromatogram is analysed by measuring the Rf value of each spot (distance moved by the substance divided by distance moved by the solvent front) and comparing it with the Rf values of known substances run under the same conditions; matching Rf values suggest the same substance.

Multiple-Choice Questions

Choose the correct answer for each question. Answers are given in the key at the end of the book.

Q1. Qualitative analysis finds out

(a) How much of a substance is present (b) What substances are present (c) The mass of a sample (d) The temperature of a reaction

Q2. Hydrogen gas burns with a

(a) Pop (b) Blue flame only (c) Yellow flame (d) No sound

Q3. Oxygen gas

(a) Relights a glowing splint (b) Turns limewater milky (c) Turns litmus blue (d) Pops with a splint

Q4. Carbon dioxide turns limewater

(a) Blue (b) Milky (c) Red (d) Colourless

Q5. Ammonia turns damp red litmus paper

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

Q6. Sodium gives a flame of what colour?

(a) Crimson (b) Lilac (c) Golden yellow (d) Brick red

Q7. Potassium gives a flame of what colour?

(a) Golden yellow (b) Crimson (c) Lilac (d) Blue-green

Q8. In chromatography, the solvent rises by

(a) Heating (b) Capillary action (c) Filtration (d) Evaporation

Q9. Rf value =

(a) Distance of solvent / distance of substance (b) Distance of substance / distance of solvent front (c) Distance x time (d) Mass / volume

Q10. An inference is

(a) What is seen in a test (b) The conclusion drawn from an observation (c) A measurement (d) A chemical formula

MCQ Answer Key

Answers for all 160 MCQs, chapter by chapter. (a), (b), (c), (d) refer to the options in order.

Chapter 1: Q1 (c), Q2 (b), Q3 (a), Q4 (c), Q5 (b), Q6 (b), Q7 (b), Q8 (a), Q9 (b), Q10 (b)

Chapter 2: Q1 (b), Q2 (c), Q3 (b), Q4 (c), Q5 (c), Q6 (b), Q7 (b), Q8 (b), Q9 (a), Q10 (b)

Chapter 3: Q1 (b), Q2 (c), Q3 (b), Q4 (b), Q5 (c), Q6 (b), Q7 (d), Q8 (b), Q9 (b), Q10 (b)

Chapter 4: Q1 (b), Q2 (b), Q3 (b), Q4 (c), Q5 (b), Q6 (c), Q7 (b), Q8 (b), Q9 (b), Q10 (b)

Chapter 5: Q1 (a), Q2 (b), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (a), Q9 (b), Q10 (b)

Chapter 6: Q1 (b), Q2 (b), Q3 (c), Q4 (c), Q5 (c), Q6 (b), Q7 (b), Q8 (b), Q9 (c), Q10 (b)

Chapter 7: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (b), Q9 (b), Q10 (b)

Chapter 8: Q1 (b), Q2 (a), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (b), Q9 (c), Q10 (b)

Chapter 9: Q1 (b), Q2 (c), Q3 (b), Q4 (c), Q5 (a), Q6 (b), Q7 (a), Q8 (b), Q9 (a), Q10 (b)

Chapter 10: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (a), Q6 (c), Q7 (b), Q8 (c), Q9 (c), Q10 (b)

Chapter 11: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (c), Q6 (a), Q7 (b), Q8 (b), Q9 (b), Q10 (a)

Chapter 12: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (c), Q6 (a), Q7 (b), Q8 (b), Q9 (a), Q10 (c)

Chapter 13: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (b), Q9 (b), Q10 (c)

Chapter 14: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (b), Q9 (b), Q10 (c)

Chapter 15: Q1 (b), Q2 (b), Q3 (b), Q4 (b), Q5 (b), Q6 (b), Q7 (b), Q8 (b), Q9 (b), Q10 (b)

Chapter 16: Q1 (b), Q2 (a), Q3 (a), Q4 (b), Q5 (a), Q6 (c), Q7 (c), Q8 (b), Q9 (b), Q10 (b)