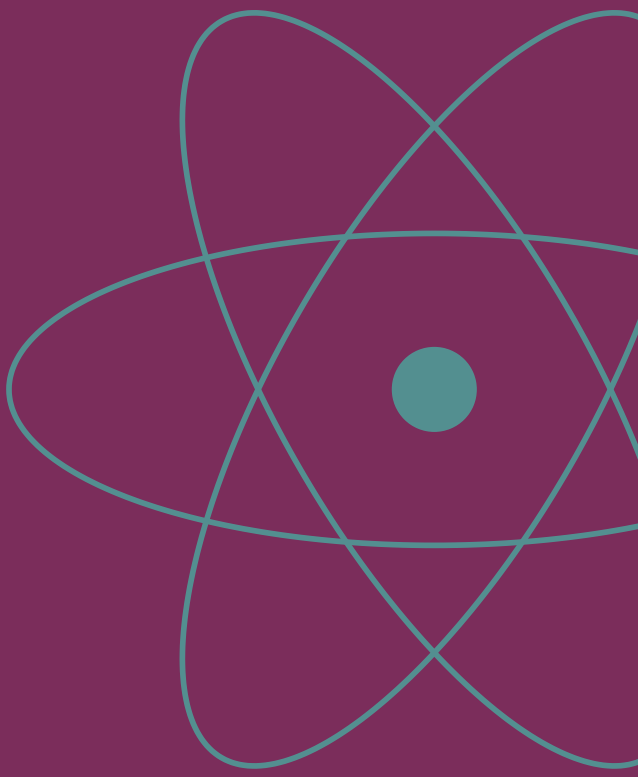
EXAM READY CHEMISTRY

Exam Ready Chemistry

GRADE 11

Study Guide, Worked Examples and Practice Tests for the Grade 11 Examination



- ✓ 6 units with clear key ideas, worked examples and “Watch out!” boxes
- ✓ 144 worked examples and 283+ practice questions at three levels
- ✓ 120 unit-quiz questions and 3 full mock exams (60 MCQ each)
- ✓ Diagnostic test · Key Facts Sheet · Top 20 Mistakes · teacher notes

Follows the units and order of the Ethiopian Grade 11 Chemistry textbook

ERMIAS WEDAJE TEGBARU

Exam Ready Chemistry

Grade 11 · Study Guide, Worked Examples and Practice Tests

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This is an independent study guide. It follows the units and order of the Ethiopian Grade 11 Chemistry student textbook, but it is not published or endorsed by the Ministry of Education. All explanations, examples and questions are original. Keep your textbook and your teacher's notes beside this book.

The answers were calculated and checked before printing, but no book is free of errors. If you find a mistake or disagree with an answer, please tell the author on Telegram (@Ermias_Wedaje) and it will be reviewed for the next edition.

How to Use This Book

Each unit follows the same pattern, so you always know where to look.

Key ideas
The rules and facts of the section, short and clear.

Worked examples
Step-by-step solutions. Cover the solution and try first.

⚠ Watch out!
The mistakes students make most often, and the right way.

Practice
Level 1 Basic · Level 2 Standard · Level 3 Challenge.

Unit quiz
20 multiple-choice questions in the style of the national examination.

For the Teacher
Timing, starters, misconceptions, activities and assessment.

For students

- Begin with the Diagnostic Test. It shows which units need the most work.
- Read the key ideas, then study each example with the solution covered.
- Do Level 1 and Level 2 practice for every section; try Level 3 when you are ready.
- Take each quiz in 30 minutes, mark it, and redo every question you got wrong.
- In the last weeks, learn the Key Facts Sheet and the Top 20 Mistakes page, and sit the three mock exams. Their answer keys show which unit each question comes from.

For teachers

- Each unit follows the textbook sections, so the book can sit beside your lessons.
- The “For the Teacher” page gives timing, starters, misconceptions and activities.
- The quizzes and mock exams can be used as class tests; every answer has a short reason.

For parents

- Ask your child to explain one worked example to you each day. Teaching is the best way to learn.
- Look at the quiz score after each unit, and celebrate progress, not only high marks.

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Diagnostic Test · Where Should I Start?

14 questions · 15 minutes. Take this test before you start the book. There are two questions on each unit. Your score only shows you where to spend your time.

1. Which scientist proposed that matter is made of indivisible atoms and gave a scientific theory in 1808?
   A. Ernest Rutherford
   B. Niels Bohr
   C. J. J. Thomson
   D. John Dalton

2. In Rutherford's experiment, a few α particles were deflected strongly because
   A. the nucleus is small, dense and positive
   B. the atom is a solid sphere
   C. neutrons attract α particles
   D. electrons are heavy

3. An ionic bond is formed by
   A. sharing of electrons
   B. transfer of electrons
   C. hydrogen atoms
   D. delocalised electrons

4. The octet rule says that atoms tend to have
   A. 10 valence electrons
   B. 18 valence electrons
   C. 8 valence electrons
   D. 2 valence electrons

5. The particles in a liquid
   A. are far apart
   B. vibrate in fixed positions
   C. are close but can move past each other
   D. do not move

6. A gas at 3.0 atm has a volume of 2.0 L. At 1.0 atm (same T) its volume is
   A. 0.67 L
   B. 6.0 L
   C. 3.0 L
   D. 2.0 L

7. The rate of a reaction is the change in
   A. energy per mole
   B. mass per unit volume
   C. temperature per unit time
   D. concentration per unit time

8. The instantaneous rate is found from
   A. the final concentration
   B. the intercept
   C. the area under the curve
   D. the slope of a tangent

9. A reaction that can go in both directions is
   A. exothermic
   B. irreversible
   C. complete
   D. reversible

10. The equilibrium constant K_c for $N_2 + O_2 \rightleftharpoons 2NO$ is
    A. $[NO]/([N_2][O_2])$
    B. $[N_2][O_2]/[NO]^2$
    C. $2[NO]/([N_2] + [O_2])$
    D. $[NO]^2/([N_2][O_2])$

11. The general formula of saturated alcohols is
    A. C_nH_{2n+2}
    B. $C_nH_{2n+1}OH$
    C. $C_nH_{2n}O$
    D. $C_nH_{2n}O_2$

12. Which alcohol cannot be oxidised by acidified dichromate?
    A. ethanol
    B. propan-1-ol
    C. 2-methylpropan-2-ol
    D. propan-2-ol

Unit 1 · Atomic Structure and Periodic Properties of the Elements

By the end of this unit you will be able to:

- describe the historical development of atomic theory and the main experiments (cathode rays, gold foil, neutron)
- name the subatomic particles, and calculate protons, neutrons, electrons, isotopes and average atomic mass
- use $c = \lambda\nu$ and $E = h\nu$, and explain atomic spectra and the Bohr model
- describe the quantum mechanical model: quantum numbers and the shapes of s, p and d orbitals
- write electronic configurations and orbital diagrams using the Aufbau, Pauli and Hund rules
- explain periodic trends in atomic radius, ionisation energy, electron affinity and electronegativity

Before you start — check yourself. (a) How many protons are in an atom with atomic number 11? (b) What is the charge of an electron? (c) Calculate $6.6 \times 10^{-34} \times 3.0 \times 10^{8}$. (d) How many electrons can an energy level hold if it has two electrons per box and 4 boxes?

Answers: (a) 11 (b) negative (c) 2.0×10^{-25} (d) 8

Key words: atom · proton · neutron · electron · isotope · orbital · quantum number · photon · ionisation energy · electronegativity

How this unit is examined

Question types that appear again and again in Ethiopian model examinations:

- Dalton and the modern atomic theory
- Experiments that revealed the electron, nucleus and neutron
- Subatomic particles, isotopes and average atomic mass
- Electromagnetic radiation, atomic spectra and the Bohr model
- Quantum numbers and orbitals
- Electronic configurations
- The periodic table and periodic trends

1.1 Dalton's Atomic Theory and the Modern Atomic Theory

Key ideas

- **Democritus** (about 400 BC) proposed that matter is made of tiny indivisible particles called **atomos**. **Dalton** (1808) turned this into a scientific theory.
- **Dalton's postulates:** (1) all matter is made of tiny particles called atoms; (2) atoms of one element are identical in mass and properties and differ from those of other elements; (3) atoms cannot be created, destroyed or divided in chemical reactions; (4) atoms combine in **simple whole-number ratios** to form compounds; (5) a chemical reaction is a rearrangement of atoms.
- **What Dalton explained:** the law of conservation of mass, the law of constant composition and the law of multiple proportions.
- **What Dalton got wrong:** atoms **can** be divided into subatomic particles, and atoms of the same element can have different masses (**isotopes**).
- **Modern atomic theory:** atoms are made of protons, neutrons and electrons; all atoms of an element have the same atomic number; atoms can be changed in nuclear reactions; atoms of one element can differ in mass (isotopes).

Example 1.1 — Which postulate fails?

Dalton said atoms of an element are identical and cannot be divided. Which part is no longer accepted?

Solution. Atoms **are** divisible (into protons, neutrons and electrons) and atoms of the same element can have different masses (isotopes).

Example 1.2 — Law of multiple proportions

Carbon forms CO (12 g C with 16 g O) and CO_2 (12 g C with 32 g O). Show the law of multiple proportions.

Solution. For a fixed 12 g of carbon the masses of oxygen are 16 g and 32 g. The ratio is 16 : 32 = **1 : 2**, a simple whole-number ratio.

Example 1.3 — Exam Booster · Conservation of mass

2.4 g of magnesium burns in air and gives 4.0 g of magnesium oxide. What mass of oxygen reacted?

Solution. 4.0 − 2.4 = **1.6 g**. Mass is conserved, because atoms are only rearranged.

Example 1.4 — Exam Booster · Who said what?

Match: (a) "atoms are indivisible particles called atomos", (b) "atoms combine in whole-number ratios".

Solution. (a) Democritus. (b) Dalton.

⚠ Watch out!

× Wrong	✓ Right
Dalton's atom was a solid sphere, so atoms never change.	Atoms can be split in nuclear reactions and have subatomic parts.
All atoms of an element have the same mass.	Isotopes of an element differ in mass.
Dalton proved atoms exist by seeing them.	He inferred them from the laws of chemical combination.

Practice 1.1

Level 1 — Basic

1. Who first used the word "atom"?
2. State one postulate of Dalton's theory.
3. Name one law that Dalton's theory explains.

Level 2 — Standard

4. Which part of Dalton's theory was disproved by the discovery of the electron?
5. Nitrogen forms N_2O (28 g N with 16 g O) and NO (14 g N with 16 g O). Show the law of multiple proportions.
6. Why did Dalton's theory become accepted while Democritus's idea did not?

Level 3 — Challenge

7. Compare Dalton's theory and the modern theory in three points.
8. 3.2 g of sulfur burns to give 6.4 g of sulfur dioxide. What mass of oxygen reacted? Which law is shown?

1.2 Early Experiments to Characterise the Atom

Key ideas

- **Cathode-ray experiment (J. J. Thomson, 1897):** rays in a discharge tube are bent by electric and magnetic fields towards the positive plate, so they are **negatively charged particles**, called **electrons**. Thomson found the charge-to-mass ratio, e/m = 1.76×10^8 C/g. His **plum-pudding model** had electrons in a positive sphere.
- **Millikan's oil-drop experiment (1909)** gave the charge of the electron, **1.60×10^{-19} C**, and so its mass, **9.11×10^{-31} kg**.
- **Radioactivity (Becquerel, Curie):** some elements emit **α particles** (He nuclei, +2), **β particles** (electrons, −1) and **γ rays** (no charge).
- **Rutherford's gold-foil experiment (1911):** α particles were fired at thin gold foil. **Most passed straight through** (the atom is mostly empty space); **a few were deflected** and **very few bounced back** (a small, dense, positive **nucleus**). This replaced the plum-pudding model by the **nuclear model**.
- **Chadwick (1932)** discovered the **neutron**, a neutral particle in the nucleus with about the same mass as the proton.

Unit 2 · Chemical Bonding

By the end of this unit you will be able to:

- explain the octet rule and describe ionic bonds, their formation and properties
- draw Lewis structures and describe polar and non-polar covalent bonds
- predict molecular shapes with the VSEPR theory and decide whether molecules are polar
- compare intermolecular forces and explain their effect on boiling points
- describe metallic bonding and the properties of metals
- use valence bond theory (hybridisation, σ and π bonds) and molecular orbital theory (bond order)
- classify crystals as ionic, covalent, molecular or metallic

Before you start — check yourself. (a) Write the configuration of Na and of Cl. (b) How many valence electrons has oxygen? (c) What is the charge on Mg when it loses its two outer electrons? (d) Which is more electronegative, F or Li?
Answers: (a) 2,8,1 and 2,8,7 (b) 6 (c) 2+ (d) F

Key words: octet rule · ionic bond · covalent bond · electronegativity · VSEPR · hybridisation · sigma bond · pi bond · bond order · hydrogen bond

How this unit is examined

Question types that appear again and again in Ethiopian model examinations:

- Ionic bonding
- Covalent bonds and Lewis structures
- Molecular geometry (VSEPR) and polarity
- Intermolecular forces
- Metallic bonding
- Valence bond and molecular orbital theories
- Types of crystal

Unit 3 · Physical States of Matter

By the end of this unit you will be able to:

- use the kinetic theory to explain the properties of solids, liquids and gases
- state and apply Boyle's, Charles's, Gay-Lussac's and Avogadro's laws
- use the ideal gas equation PV = nRT, Dalton's law of partial pressures and Graham's law
- explain real gases and the conditions where they deviate from ideal behaviour
- describe vapour pressure, boiling, evaporation, viscosity and surface tension of liquids
- describe the types and properties of solids and the energy changes in changes of state

Before you start — check yourself. (a) Convert 27 °C to kelvin. (b) Convert 2.0 atm to kPa (1 atm = 101.3 kPa). (c) Calculate 4.0 × 300 ÷ 600. (d) How many moles are in 36 g of water (M = 18 g/mol)?
Answers: (a) 300 K (b) 202.6 kPa (c) 2.0 (d) 2.0 mol

Key words: kinetic theory · pressure · Boyle's law · Charles's law · ideal gas · partial pressure · diffusion · vapour pressure · viscosity · surface tension

How this unit is examined

Question types that appear again and again in Ethiopian model examinations:

- Kinetic theory of matter
- The gas laws
- The ideal gas equation, Dalton's and Graham's laws
- Real gases
- The liquid state
- The solid state and changes of state

Unit 4 · Chemical Kinetics

By the end of this unit you will be able to:

- define the rate of a reaction and calculate average rates
- relate rates of change of reactants and products using the balanced equation
- write a rate law, determine the order and rate constant from experimental data
- explain collision theory and activation energy
- explain how concentration, temperature, surface area, catalysts and the nature of reactants change the rate
- draw and interpret reaction-energy profiles

Before you start — check yourself. (a) Calculate (0.80 − 0.50) ÷ 30. (b) If y doubles and $x \propto y^2$, by how much does x change? (c) What is the unit of concentration used in chemistry? (d) State what happens to the particles when a substance is heated.
Answers: (a) 0.010 (b) 4 times (c) mol/L (d) they move faster

Key words: rate of reaction · rate law · order of reaction · rate constant · collision theory · activation energy · catalyst · half-life · surface area · reaction profile

How this unit is examined

Question types that appear again and again in Ethiopian model examinations:

- Rate of a reaction
- Rate law and order of reaction
- Collision theory and activation energy
- Factors affecting the rate
- Catalysts and reaction profiles

Unit 6 · Some Important Oxygen-Containing Organic Compounds

By the end of this unit you will be able to:

- classify and name alcohols, ethers, aldehydes, ketones, carboxylic acids and esters using IUPAC rules
- explain the physical properties of these compounds, including hydrogen bonding
- write equations for the preparation and reactions of alcohols, carboxylic acids and esters
- distinguish the functional groups using simple chemical tests
- describe the structure, properties, hardening, rancidity and saponification of fats and oils

Before you start — check yourself. (a) Name $CH_3CH_2CH_3$. (b) Give the formula of ethene. (c) How many bonds does carbon form? (d) What is the name of the group –OH?
Answers: (a) propane (b) C_2H_4 (c) 4 (d) hydroxyl group

Key words: functional group · alcohol · ether · aldehyde · ketone · carboxylic acid · ester · esterification · saponification · rancidity

How this unit is examined

Question types that appear again and again in Ethiopian model examinations:

- Alcohols and ethers
- Aldehydes and ketones
- Carboxylic acids
- Esters
- Fats and oils

30. The ideal gas equation is

A. V = nPRT B. P = nRTV C. PT = nRV D. PV = nRT

31. The rate of a reaction is the change in

A. energy per mole
B. mass per unit volume
C. temperature per unit time
D. concentration per unit time

32. The rate of a reaction usually

A. increases with time
B. decreases with time
C. is zero at the start
D. stays the same

33. In 2A → 3B, if A is used up at 0.30 mol L^{-1} s^{-1}, B forms at

A. 0.45 mol L^{-1} s^{-1}
B. 0.20 mol L^{-1} s^{-1}
C. 0.30 mol L^{-1} s^{-1}
D. 0.90 mol L^{-1} s^{-1}

34. The instantaneous rate is found from

A. the final concentration
B. the intercept
C. the area under the curve
D. the slope of a tangent

35. A concentration falls from 0.50 to 0.20 mol/L in 10 s. The average rate is

A. 0.070
B. 0.30
C. 0.020
D. 0.030 mol L^{-1} s^{-1}

36. If rate = k[A][B], the overall order is

A. 1 B. 0 C. 3 D. 2

37. If rate = $k[A]^2$, doubling [A] makes the rate

A. half
B. two times greater
C. four times greater
D. the same

38. The unit of k for rate = k[A][B] (mol L^{-1} s^{-1}) is

A. s^{-1} B. mol L^{-1} s^{-1} C. L mol^{-1} s^{-1} D. L^2 mol^{-2} s^{-1}

39. A zero-order reaction has a rate that

A. does not depend on [A]
B. depends on $[A]^2$
C. doubles when [A] doubles
D. is zero

40. When [A] is doubled the rate is unchanged. The order in A is

A. 1 B. 0 C. 3 D. 2

41. A reaction that can go in both directions is

A. exothermic B. irreversible C. complete D. reversible

42. At dynamic equilibrium

A. forward and reverse rates are equal
B. the reaction has stopped
C. there are no reactants
D. concentrations are equal

43. Which is a condition for equilibrium?

A. a catalyst
B. a high temperature
C. an open container
D. a closed system

44. The equilibrium constant K_c for $N_2 + O_2 \rightleftharpoons 2NO$ is

A. $[NO]/([N_2][O_2])$
B. $[N_2][O_2]/[NO]^2$
C. $2[NO]/([N_2] + [O_2])$
D. $[NO]^2/([N_2][O_2])$