INTRODUCTORY INORGANIC AND PHYSICAL CHEMISTRY

STUDY GUIDE FOR

NCHE111 PEC

NCHE111PEC

FACULTY OF NATURAL SCIENCES

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MODULE CONTENTS

WORD OF WELCOME

Very welcome to the NCHE111 module.

You have enrolled for a module that will not only be useful for the rest of your degree course, but will also make a difference in you life. Chemistry is a relevant, exciting field of study with many applications in everyday life.

Chemistry is definitely interesting and you will be able to understand many things in the world around you more fully when you complete even just this first introductory module. The module is also, however, quite challenging and will take up a fair amount of time. But always remember: success only comes about through hard work!

I wish you all of the best.

Dr CE (Colin) Read

GENERAL MODULE INFORMATION

This module constitutes the basis of all the chemistry modules offered at the NWU-PUK. The credit value of the module is 12 and it therefore represents 120 notional study hours.

ASSUMED LEARNING (ADMISSION REQUIREMENTS)

The admission requirement to enrol for NCHE111 at the NWU-PUK is a National Senior Certificate with Mathematics having been passed at level 5 (60-69%) and Physical Sciences at level 4 (50-59%). The student should also have an APS score of at least 24. (Look at Regulations N1.5 and N1.6 in the Yearbook for more details.)

CONTACT DETAILS

Lecturer

Your lecturer for the course for 2018 is Dr CE (Colin) Read.

Facilitation

I expect of you to ask questions in class if there is anything that you do not understand. In order to ensure, however, that everybody has the opportunity to raise questions, we will arrange tutorial periods in collaboration with the study facilitators.

Consulting hours

I am readily available during office hours, but in order to obviate disappointment, please contact me by e-mail to make an appointment. I am in Building G8, office number F208 and my e-mail address is colin.read@nwu.ac.za. Please feel free to contact me if you have any problems. Do note, however, that problems will not be discussed telephonically or by e-mail.

WORK PROGRAMME

During the first lecture I will hand out a study programme. The programme will indicate exactly what Study Sections will be discussed during what lecture peiod, as well as dates on which assignments will be given and handed in, tests will be written and homework has to be submitted. I expect of you to come prepared, according to the programme, to each lecture.

Class times

The day, time and venue of when and where the lectures are offered will be available when you enrol in January 2018.

STUDY MATERIAL

Prescribed textbook

The prescribed textbook is *Chemistry and Chemical Reactivity*, 9th Edition, by Kotz, Treichel, Townsend and Treichel. Publishers: CENGAGE Learning. This textbook will henceforth be referred to in the Study Guide as **KT&T**.

Other textbooks that are suitable for students at the first level are also available in the Natural Sciences Branch Library. You will find that these and other introductory chemistry textbooks contain many worked-out examples for examination preparation.

Lecture materials

I always publish the *Powerpoint*-slides of my lectures on *e-Fundi* immediately after the contact sessions. You can download them from there. Apart from that, the latest teaching tests, semester assessments and examination papers together with their marking memoranda will also be available on the web to provide you with additional exercise and preparation materials.

Study Guide

This Study Guide constitutes the core of the module and will be used throughout the module as background and an overview of the work.

Practicals

For practical work in the laboratory a practical manual is required: The Manual for NCHE111 and Answer Sheets for the practical manual for NCHE111. You have to bring these to each practical session. The practical answer book will be used to do the practical reports which have to be submitted at the end of the practical session. The experiment should therefore be prepared very carefully in line with the manual prior to the practical session. Before the start of each experiment you will write a brief preparatory test to ascertain whether you have the necessary knowledge.

THE FOLLOWING IS VERY IMPORTANT!

- *Prepare for each lecture.* You must consider the module as a toolbox. You not only need to be able to identity and describe a particular tool (knowledge), you also need to be able to use it in new situations (insight). You will discover soon enough what you do not know while preparing for a lecture.
- *Attend lectures regularly.* Your objective has to be to understand the work done during a lecture fully at the end of the lecture. If you still do not understand what you had difficulty with during the preparation, you have to ask me to explain it again. Do remember that lectures are intended to assist you so that you can understand the work fully and master it yourself.
- *Test your progress.* Class tests are not intended as punishment. These are aids intended to enable you to reach the stated outcomes. If your performance is not optimal, work through the material again, ask questions in class, attend tutorial periods – briefly, remediate the problem.
- *Keep up to date.* Remember that if you once fall behind it is very difficult to catch up again.
- **If, during the course of the semester you encounter a problem that can negatively influence your performance, you have to come and discuss it. Do not wait until it is too late!**

ASSESSMENT

FORMATIVE ASSESSMENT

In the course of the semester I will use some of the following forms of formative assessment in order to monitor your progress and to help you build up a participation mark: Teaching tests, assignments, homework assignments, practicals and a semester test.

If a student repeats this chemistry module, such a student may apply **once off** for exemption from the specific module's practical component with the condition that the student achieved at least 60% as a final practical mark in the previous two years. (See 2018 yearbook).

Full information about the content and contribution by each type of formative assessment opportunity to your participation mark (the mark that will be your examination admission mark) will be given in the work programme.

Should you have been absent from any of the formative assessments as mentioned above, or if you did not hand them in, or did not write them, you have to submit a valid written excuse to me within 10 days of the date of assessment's due date. This formal written excuse must be submitted only to me. I do not accept any responsibility if you should hand it to somebody else and it is lost. The written excuse has to contain your title, full initials, surname, student number, information about the assessments that you missed as well as the date of the relevant assessment. Failure to do this can result in you obtaining zero for that assessment opportunity.

PARTICIPATION AND MODULE MARK

The calculation of your participation mark will be indicated on your work programme.

To complete the module successfully you have to obtain a final module mark of at least 50% (which is also the pass mark for any other assessment). Your examination mark must also be at least 40% (the sub-minimum) regardless of your participation mark. The final module mark is the average of the participation mark and the examination mark in the ratio 1:1

SUMMATIVE ASSESSMENT (EXAMINATION)

I will announce the date and time of the examination in class as soon as it is available. The examination lasts 3 hours. I will discuss the format of the paper with you towards the end of the semester. It usually consists of a number of theory questions (definitions, laws, proof, etc.) which will include the solution of problems. In order to obtain admission to the examination you have to obtain a proof of participation. The full requirements for this are outlined in the yearbook of the Faculty of Natural Sciences. One requirement is a *participation mark of at least 35%.*

Once you have obtained a proof of participation, you can use either of the two examination opportunities in June/July 2018. If you use both opportunities, the mark that you obtain in the section examination will determine the final module mark. **No proof of absence is required for the first opportunity.** Note, however, that it is very risky not to use the first examination opportunity, because, should you be ill during the second opportunity there will not be a third opportunity. A student who does not use either of the two opportunities, or who has not obtained a pass mark at the end of the examination will have to register for this module again in 2018, pay tuition again and attend class in order to obtain a new proof of participation in order to obtain admission to the next scheduled examination opportunities.

HOW TO USE THE STUDY GUIDE

The purpose of the Study Guide is to guide you through the learning contents of NCHE111. For that reason it is essential that you should use the Study Guide as effectively as possible. You can use the following guidelines:

- Grade 12 learning contents constitute the basis on which NCHE111 builds. In some Study Sections this is indicated as "self-study". These Study Sections have to be done your own and prepared for test and examination purposes.
- Work through the outcomes as outlined for the different levels (module, Study Unit, Study Section) very thoroughly – they indicate what you should achieve at the end of each Study Section and Study Unit, as well as the module.
- Study the study material provided in each Study Section according to the guidelines given in the Study Guide and the learning outcomes.
- Ensure that you complete all the learning activities in each Study Section of the Study Guide.
- Complete all self-evaluation questions and assess them in line with the instructions given.

ACTION WORDS

Questions, whether in tests of the examination, will always contain certain keywords or action verbs. You have to understand what there mean (in other words, what the lecturer means by them) and what is therefore expected of you in answering them. With a view to this, a brief list of such words is provided below.

COGNITIVE LEVEL	ACTION WORD	MEANING
LEVEL 1: KNOWLEDGE	Define	Give a brief, accurate description of a concept so that the meaning emerges clearly.
	Describe	Characteristics, facts or results are represented in a logical, well-formulated manner. No discussion or explanation is needed.
	List, Write, Give, Name	Give the answer (facts) point by point. No discussion or explanation is needed.
LEVEL 2: INSIGHT	Explain, discuss	Give reasons in a logical, well-structured way from illustrations, models, laws and mathematical equations.
	Illustrate	Describe a concept with the aid of an example or a sketch with or without captions
	Distinguish, compare	Facts, events or problems are placed next to each other in order to foreground similarities and differences.
	Sum up	Represent the essential information in a concise and systematic manner.
LEVEL 3: APPLICATION	Determine	Apply existing knowledge and methods (strategies) to a new problem or situation.
	Calculate	Some mathematical methods are applied to obtain a numerical answer.
	Suggest a mechanism	Give a mechanism, that is, the course of a reaction, with arrow notations and in-between steps
LEVEL 4: ANALYSIS	Analyse, discuss	Divide a problem, statement or idea into its constituent parts. Explain the importance of each part and indicate the reciprocal relationship between parts or sections
LEVEL 5: SYNTHESIS	Calculate	More mathematical methods are applied in order to find a numerical answer.
	Prove	Statements are proven by way of logical presentation of acceptable facts.
	Indicate relationship	Find and explain the relationship between different statements.
	Sum up or construe	A large mass of knowledge is summed up and organised logically and systematically while the essence of the issue is sustained.
LEVEL 6: EVALUATION	Criticize, give an evaluation	Determine the value of a statement, issue or argument by explaining whether you agree with it or differ from it. Provide reasons for you opinions. Analyse the problem and determine the value of each component. The result is summed up (synthesis) in order to develop a comprehensive and focussed value judgement.

STUDY ICONS

The following study icons are used in the text of this Study Guide:

	Study the material indicated in the textbook/article, etc.
	Test your knowledge. Complete these questions before continuing.

WARNING AGAINST PLAGIARISM

ASSIGNMENTS ARE INDIVIDUAL TASKS AND NOT GROUP ACTIVITIES. **(UNLESS EXPLICITLY INDICATED AS GROUP ACTIVITIES)**

Copying of text from other learners or from other sources (for instance the study guide, prescribed material or directly from the internet) is **not allowed** – only brief quotations are allowed and then only if indicated as such.

You should **reformulate** existing text and use your **own words** to explain what you have read. It is not acceptable to retype existing text and just acknowledge the source in a footnote – you should be able to relate the idea or concept, without repeating the original author to the letter.

The aim of the assignments is not the reproduction of existing material, but to ascertain whether you have the ability to integrate existing texts, add your own interpretation and/or critique of the texts and offer a creative solution to existing problems.

Be warned: students who submit copied text will obtain a mark of zero for the assignment and disciplinary steps may be taken by the Faculty and/or University. It is also unacceptable to do somebody else's work, to lend your work to them or to make your work available to them to copy – be careful and do not make your work available to anyone!

STUDY DIVISION A
THE BASIC BUILDING BLOCKS OF CHEMISTRY

CONTENT OF STUDY DIVISION

The time scheduled for this Study Division is an estimated 80 hours.

Study Division A is based on parts of **Chapters 1, 2, 3, 4 and 5** in **KT&T** and includes Study Units 1 to 5.

BASIC CONCEPTS OF CHEMISTRY

The time scheduled for this whole Study Unit is an estimated 7 hours.

This whole Study Unit (Study Sections 1.1 to 1.10) is self-study and has to be prepared for tests and examinations. Remember that self-study constitutes between 10% and 20% of tests, assignments and the examination.

This Study Unit is based on chapter 1 of **KT&T**, p. 1 – 43.

OUTCOMES

Following completion of Study Unit 1 you should be able to:

- Understand the differences between hypotheses, laws and theories;
- Apply kinetic-molecular theory on the characteristics of matter;
- Classify matter;
- Recognize elements, atoms, compunds and molecules;
- Identify physical and chemical characteristics;
- Describe different forms of energy;
- Know the units of measurement;
- Explain the differences between precision, accuracy, experimental errors and stadard deviation;
- Express data (numerical values) in fixed notations **as well as** exponential notations or scientific notations;
- Know what significant numbers are and write them down correctly; and
- Draw and interpret simple graphs.

CHEMISTRY AND CHEMICAL METHODS

The time scheduled for this Study Section is an estimated ¾ hour.

This Study Section is based on **KT&T**, p. 3 - 6.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand the differences between hypotheses, laws and theories;
- Understand scientific methods;
- Distinguish between quantitative and qualitative information; and
- Understand the role of coincidence and moral dilemmas and integrity in natural sciences.

CLASSIFICATION OF MATTER

The time scheduled for thisStudy Section is an estimated ¾ hour.

This Study Section is based on **KT&T**, p. 6 - 10.

OUTCOMES

Following completion of this Study Section you should be able to:

- Apply kinetic-molecular theory to the characteristics of matter;
- Recognize and describe the different phases of matter (solids, liquids and gases);
- Describe the macroscopic and microscopic levels of matter; and
- Indicate the difference between pure substances and mixtures as well as between homogeneous and heterogeneous mixtures.

ELEMENTS

The time scheduled for this Study Section is an estimated 1 hour. (Time needed for memorizing symbols and the names of elements is not included).

This Study Section is based on **KT&T**, p. 10 - 11.

OUTCOMES

Following completion of this Study Section you should be able to:

- Provide the symbols and names of the first 36 elements on the periodic table, as well as the names and symbols of the following elements Rb, Sr, Rh, Pd, Ag, Cd, Sn, Sb, Te, I, Xe, Cs, Ba, La, W, Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn, Ra, Ac, Th and U; and
- Use the terms *atom* and *element* correctly.

- Do "Review and check for section 1.4" on p. 11 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).
- Answer questions 1 and 3 on p. 21 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).

COMPOUNDS

The time scheduled for this Study Section is an estimated ¾ hour.

This Study Section is based on **KT&T**, p. 11 - 13.

OUTCOMES

Following completion of this Study Section you should be able to:

- Use the terms *compound* and *molecule* correctly; and
- Define the term *chemical formula* and use it correctly.

- Do "Review and check for section 1.5" on p. 13 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).
- Do question 5 on p. 21 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).

PHYSICAL CHARACTERISTICS

The time scheduled for this Study Section is an estimated ¾ hour.

This Study Section is based on **KT&T**, p. 13 - 15.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define the term physical characteristics of matter with examples;
- Deal with the concept density, as well as the relationship of density with volume and mass; and
- Indicate the difference between extensive and intensive characteristics of matter.

- Do "Review and check for section 1.6" on p. 15 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).
- Do question 15 on p. 21a of **KT&T** (answers are in “Appendix N”, p. A-39 in the back of the textbook).

PHYSICAL AND CHEMICAL CHANGES

The time scheduled for this Study Section is an estimated ½ hour.

This Study Section is based on **KT&T**, p. 15 - 17.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define the terms physical and chemical change, reagents and product with examples, and
- Identify and explain a chemical equation.

- Do "Review and check for section 1.7" on p. 17 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).
- Do question 7 on p. 21 of **KT&T** (answers are in “Appendix N”, p. A-38 in the back of the textbook).

UNITS OF MEASUREMENT

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 23 – 28.

OUTCOMES

Following completion of this Study Section you should be able to:

- Know and use general units of measurement in chemistry; and
- Do unit conversions (such as litre to millilitre).

- Study example 1 on p. 26 to get an idea of a typical examination question.
- Do "Review and check for section 1" on p. 28 of **KT&T** (answers are in "Appendix N", p. A-40 in the back of the textbook).
- Answer questions 3, 5, 7, 9, 13 and 15 on p. 43a of **KT&T** (answers are in "Appendix N, p. A-40 in the back of the textbook).

MEASUREMENTS: PRECISION, ACCURACY, EXPERIMENTAL ERRORS AND STANDARD DEVIATIONS

The time scheduled for this Study Section is an estimated 15 minutes.

This Study Section is based on **KT&T**, p. 29 - 31.

OUTCOMES

Following completion of this Study Section you should be able to:

- Only read through these few pages for noting.

THE MATHEMATICS OF CHEMISTRY

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 32 - 38.

OUTCOMES

Following completion of this Study Section you should be able to:

- Express numbers and use them in exponential notations as well as in scientific notations, and
- Know what a significant number is and indicate and use significant numbers in calculations.

- Work carefully through the "Problem solving tip 1" at the top of p. 34. This should help you a lot in the rest of the module where you will be doing a lot of calculations.
- Do "Review and check for section 3" on p. 37 and 38 of **KT&T** (answers are in "Appendix N", p. A-40 in the back of the textbook).
- Answer questions 23 and 25 on p. 43b of **KT&T** (answers are in "Appendix N", p. A-40 in the back of the textbook).

THE TECHNIQUE OF PROBLEM-SOLVING AND GRAPHS

The time scheduled for this Study Section is an estimated 15 minutes.

This Study Section is based on **KT&T**, p. 38 - 43.

OUTCOMES

Following completion of this Study Section you should be able to:

- Only read through these few pages for noting.

ATOMS, MOLECULES AND IONS

The time scheduled for this Study Unit is an estimated 15 hours.

This Study Unit is based on chapter 2 of **KT&T**, p. 44 – 95k.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe the structure of the atom as well as the terms atomic number and mass number;
- Describe isotopes and calculate the atomic mass of an element from the isotope abundance;
- Know the terminology of the periodic table;
- Interpret, predict and note down the formulae for ionic compounds and molecular compounds;
- Name ionic compounds and molecular compounds;
- Know some characteristics of ionic compounds;
- Explain the concept mole and use molar mass in calculations; and
- Deduce formulae for compounds from experimental data.

ATOMIC STRUCTURE – PROTONS, ELECTRONS AND NEUTRONS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 45 - 48.

OUTCOMES

Following completion of this Study Section you should be able to:

- Explain the terms electrons, protons, neutrons and general atomic structure; and
- Explain the relative mass scale and atomic mass unit.

- Study example 2.1 on p. 47 and 48 to get an idea of a typical examination question.
- Do "Review and check for section 2.2" on p. 48 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).
- Answer questions 5 and 7 on p. 95 of **KT&T** (answers are in "Appendix N", p. A-43 in the back of the textbook).

ISOTOPES

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 48 - 52.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define isotopes and write down the mass number as well as the number of neutrons for a specific isotope; and
- Do simple calculations to link the atomic mass of an element and the isotope abundance with each other.

- Study example 2.2 on p. 50 and 51 to get an ideas of a typical examination question.
- Do "Review and check for section 2.3" on p. 51 and 52 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).
- Do "Review and check for section 2.4" on p. 52 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).

THE PERIODIC TABLE

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section (Study Section 2.3) is intended for self-study and preparation for test and examination purposes. Remember that self-study constitutes between 10% and 20% of tests, assignments and the examination.

This Study Section is based on **KT&T**, p. 52 - 63.

OUTCOMES

Following completion of this Study Section you should be able to:

- Identify groups and periods on the periodic table; and
- Distinguish between the metals, metaloids, non-metals, alkaline metals, alkaline earth metals, halogens, edelgasse and the oorgangsmetale on the periodic table.

- Do "Review and check for section 2.5" on p. 63 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).
- Answer questions 25 and 27 on p. 95a and 95b of **KT&T** (answers are in "Appendix N", p. A-43 in the back of the textbook).

MOLECULES, COMPOUNDS AND FORMULAE

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 63 - 65.

OUTCOMES

Following completion of this Study Section you should be able to:

- Recognize and interpret molecular formulae, abbreviated formulae and structural formulae; and
- Know of the different molecular models that exist in chemistry.

- Do "Review and chec k for section 2.6" on p. 65 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).

IONIC COMPOUNDS: FORMULAE, NAMES AND CHARACTERISTICS

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 65 - 76.

OUTCOMES

Following completion of this Study Section you should be able to:

- Know that metals usually lose one or more electrons in order to form positive ions – called cations – and that non-metals usually take up one or more electrons to form negative ions – called anions;
- Predict the change on a metal cation for the following groups of metals: Groups 1A, 2A and 3A;
- Predict the charge on a non-metal anion for the following groups of non-metals: Groups 4A, 5A, 6A and 7A;
- Write down formulae for ionic compounds through combining cations and anions in the correct ratio so that there is no total charge for the ionic compound;
- Know the names and formulae of poly-atomic cations and anions (study table 2.4 on p. 69 of KT&T);
- Name ionic compounds and simple binary compounds of the non-metals; and
- Know Coulomb's Law and understand the importance of this law.

- Study example 2.4 and 2.5 on p. 70 and 71 to get an idea of a typical examination question.
- Do "Review and check for section 2.7" on p. 74 and 75 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).
- Answer questions 37, 39, 43, 45, 47, 49, 51 and 55 on p. 95b and 95c of **KT&T** (answers are in "Appendix N", p. A-43 and A-44 in the back of the textbook).

MOLECULAR COMPOUNDS: FORMULAE AND NAMES

The time scheduled for thisStudy Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 76 - 77.

OUTCOMES

Following completion of this Study Section you should be able to:

- Name simple binary compounds of the non-metals.

- Do "Review and check for section 2.8" on p. 77 of **KT&T** (answers are in "Appendix N", p. A-42 in the back of the textbook).

ATOMS, MOLECULES AND THE MOLE

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 77 - 84.

OUTCOMES

Following completion of this Study Section you should be able to:

- Know and understgand that the molar mass of an elements is the same as the mass in gram of Avogadro's number of atoms in this element;
- Know how to use the molar mass of an element and Avogadro number in calculations;
- Know and understand that the molar mass of a compound is the mass in gram of Avogadro's number of molecules of this compound;
- Calculate the molar mass of a compound from the formula of the compound and the periodic table; and
- Calculate the number of moles of a compound represented by a specific mass. You also have to be able to do the reverse.

- Study example 2.6 on p. 80 to get an idea of a typical examination question.
- Study interactive example 2.7 on p. 82 and 83 to get an idea of a typical examination question.
- Do "Review and check for section 2.9" on p. 83 and 84 of **KT&T** (answers are in "Appendix N", p. A-43 in the back of the textbook).
- Answer questions 61, 63, 65, 67 and 73 on p. 95c and 95d of **KT&T** (answers are in "Appendix N", p. A-44 in the back of the textbook).

CHEMICAL ANALYSIS: DETERMINATION OF COMPOUND FORMULAS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 84 - 90.

OUTCOMES

Following completion of this Study Section you should be able to:

- Express the composition of a compound in terms of the percentage composition; and
- use the percentage composition of other experimental data to calculate the empirical formulae and the molecular formulae of compounds.
- calculate the formula of a compound from mass data, and
- calculate the formula of an ionic hydrated compound.

- Study example 2.8 on p. 85 to get an idea of a typical examination question.
- Study interactive examples 2.9 and 2.10 on p. 87, 88 and 89 to get an idea of a typical examination question.
- Study example 2.11 on p. 89 and 90 to get an idea of a typical examination question.
- Answer questions 79, 81, 83, 85, 93 and 95 on p. 95d and 95e of **KT&T** (answers are in "Appendix N", p. A-44 in the back of the textbook).

CHEMICAL REACTIONS

The time scheduled for this Study Unit is an estimated 17 hours.

This Study Unit is based on sections of chapter 3 of **KT&T**, p. 96 – 137h.

Study Section 3.8 is, however, based on a section of chapter 19 of **KT&T**, p. 715 - 723.

OUTCOMES

Following completion of this Study Unit you should:

- Be able to balance simple chemical equations;
- Understand the characteristics of chemical equilibrium;
- Understand the characteristics of ionic compounds dissolved in water;
- Recognize acids and bases and understand the behaviour of acids and bases in aqueous solutions;
- Recognize the general reaction types aqueous solutions;
- Write down chemical equations for the general reaction types in aqueous solutions;
- Know general oxidation and reduction eagents; and
- Recognize oxidation-reduction reactions (redox reactions).

INTRODUCTION: BALANCING OF CHEMICAL EQUATIONS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 97 - 102.

OUTCOMES

Following completion of this Study Section you should be able to:

- Balance simple chemical equations by means of inspection; and
- Use the information in a balanced chemical equation.

- Do "Review and check for section 3.1" on p. 99 of **KT&T** (answers are in "Appendix N", p. A-46 in the back of the textbook).
- Study example 3.1 on p. 101 and 102 to get an idea of a typical examination question.
- Do "Review and check for section 3.2" on p. 102 of **KT&T** (answers are in "Appendix N", p. A-46 in the back of the textbook).
- Answer questions 1, 3 and 5 on p. 137a of **KT&T** (answers are in "Appendix N", p. A-45 and A-46 in the back of the textbook).

INTRODUCTION TO CHEMICAL EQUILIBRIUM

The time scheduled for thisStudy Section is an estimated 0 min.

Only take note of this unit. We will do a full investigation into Chemical equilibrium in Study Unit 7.

AQUEOUS SOLUTIONS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 105-110.

OUTCOMES

Following completion of this Study Section you should be able to:

- Recognize the differences between electrolytes and non-electrolytes as well as an example of each type;
- Predict the solubility of ionic compounds in water by making use of a solubility table. (Although the table in the middle of p. 108 of KT&T will be supplied to you in tests and the examination you have to make very sure that you know how to use the table. The table is also provided at the back of the Study Guide; and
- Name the ions that form when an ionic compound of an acid or a base dissolves in water.

- Study example 3.2 on p. 109 of KT&T to get an idea of a typical examination question.
- Do "Review and check for section 3.4" on p. 109 and 110 of **KT&T** (answers are in "Appendix N", p. A-46 in the back of the textbook).
- Answer questions 9, 11 and 13 on p. 137a and 137b of **KT&T** (answers are in "Appendix N", p. A-47 in the back of the textbook)

PRECIPITATION REACTIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 110-114.

OUTCOMES

Following completion of this Study Section you should:

- Be able to predict the products of a precipitation reaction;
- Write down a balanced equation for a precipitation reaction; and
- Write net ionic equations.

- Study example 3.3 on p. 111 and 112 of KT&T to get an idea of a typical examination question.
- Study "Problem Solving Tip 3.1" on p. 113. This will provide you with valuable ideas about how to write down a net ionic equation.
- Study example 3.4 on p. 113 and 114 to get an idea of a typical examination question.
- Do "Review and check for section 3.5" on p. 114 of **KT&T** (answers are in "Appendix N", p. A-46 in the back of the textbook).

ACIDS AND BASES

The time scheduled for this Study Section is an estimated 0 hours.

Only take note of this unit on p. 114-123. We will do a full investigation into Acids and bases in Study Unit 8.

GAS FORMATION REACTIONS

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 123-125.

OUTCOMES

Following completion of this Study Section you should:

- Be able to predict the products of a gas formation reaction; and
- Write down a balanced equation for a gas formation reaction.

- Study example 3.7 on p. 124 of KT&T to get an idea of a typical examination question.
- Do "Review and check for section 3.7" on p. 125 of **KT&T** (answers are in “Appendix N”, p. A-46 in the back of the textbook).

OXIDATION-REDUCTION REACTIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 125-131.

OUTCOMES

Following completion of this Study Section you should be able to:

- Identify simple and general oxidation and reduction reagents (see Table 3.3 on p. 130);
- Recognize a reaction as an oxidation-reduction-reaction (redox reaction);
- Know what compound (atom) in a reaction is oxidized and what compound (atom) in the reaction is reduced;
- Calculate the oxidation numbers of elements in a compound; and
- Understand that the oxidation numbers represent the charge on an atom when the electrons of the compound are counted according to set of guidelines.

- Study example 3.8 on p. 128 and 129 of KT&T to get an idea of a typical examination question.
- Study example 3.9 on p. 130 and 131 of KT&T to get an idea of a typical examination question.
- Do "Review and check for section 3.8" on p. 131 of **KT&T** (answers are in “Appendix N”, p. A-46 in the back of the textbook).
- Answer questions 45, 47 and 49 on p. 137c of **KT&T** (answers are in “Appendix N”, p. A-48 in the back of the textbook).

BALANCING OF OXIDATION-REDUCTION-REACTIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on chapter 19 of **KT&T**, p. 715-723.

OUTCOMES

Following completion of this Study Section you should:

- Be able to balance oxidation-reduction reaction equations (redox reactions) in a neutral medium, acid medium and base medium through the use of the half-reaction approach.

- Study example 19.1 on p. 716 and 717 of KT&T to get an idea of a typical examination question for the balancing of a redox reaction in a neutral medium.
- Study example 19.2 on p. 718, 719 and 720 of KT&T to get an idea of a typical examination question for the balancing of a redox reaction in an acid medium.
- Study example 19.3 on p. 721 and 722 of KT&T to get an idea of a typical examination question for the balancing of a redox reaction in a base medium.
- Study "Problem Solving Tip 19.1" on p. 720. This will provide you with a valuable summary of how to balance oxidation-reduction equations.

CLASSIFICATION OF REACTIONS IN AQUEOUS SOLUTIONS

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 131-135.

OUTCOMES

Following completion of this Study Section you should:

- Be able to recognize the core characteristics of the four types of reactions (precipitation, acid-base, gas-forming and redox) in aqueous solutions.

- Study example 3.10 on p. 134 to get an idea of a typical examination question.
- Do "Review and check for section 3.9" on p. 135 of **KT&T** (answers are in “Appendix N”, p. A-46 in the back of the textbook).

STOICHIOMETRY: QUANTITATIVE INFORMATION ABOUT CHEMICAL REACTIONS

The time scheduled for this Study Unit is an estimated 16 hours.

This whole Study Unit is based on chapter 4 of **KT&T**, p. 139-179h and a small section of chapter 13 of **KT&T**, p. 470-473.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Do stoichiometric calculations by making use of balanced chemical reaction equations;
- Understand what a limiting reagent in a chemical reaction is and and calculate which of the reagents in a balanced reaction equation is the limiting reagent;
- Calculate the theoretical percentage yield of a chemical reaction;
- Use stoichiometry in order to analyse a mixture of compounds and to determine the formula of a compound; and
- Define, calculate and use concentrations in solution stoichiometry.

MASS RELATIONSHIPS IN CHEMICAL REACTIONS: STOICHIOMETRY

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 139-143.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand the principles of the retention of matter – what the basis is of chemical stoichiometry;
- Calculate the mass of mole amount of one reagent or product from the mass of the mole amount of another reagent or product by making use of a balanced chemical equation. You should also be able to switch between mass amounts and mole amounts; and
- Use quantity tables to order stoichiometric information.

- Study "Problem Solving Tip 4.1" on p. 141. This will provide you with valuable ideas about how to tackle a stoichiometric calculation.
- Study example 4.1 on p. 141 and 142 to get an idea of a typical examination question.
- Do "Review and check for section 4.1" on p. 143 of **KT&T** (answers are in “Appendix N”, p. A-50 in the back of the textbook).
- Answer questions 1 and 3 on p. 179a of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).

REACTIONS IN WHICH ONE REAGENT IS PRESENT IN LIMITED AMOUNT (LIMITING REAGENTS)

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 143-147.

OUTCOMES

Following completion of this Study Section you should be able to:

- Calculate which of or two reagents is a limiting reagent; and
- Calculate the yield of a product based on the limiting reagent.

- Study example 4.2 on p. 145 and 146 to get an idea of a typical examination question.
- Do "Review and check for section 4.2" on p. 147 of **KT&T** (answers are in “Appendix N”, p. A-50 in the back of the textbook).
- Answer questions 11, 13, 15 and 17 on p. 179b of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).

PERCENTAGE YIELD

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 147-150.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand and describe the difference between real yield, theoretical yield and percentage yield; and
- Calculate the real yield, theoretical yield and percentage yield.

- Do "Review and check for section 4.3" on p. 149 of **KT&T** (answers are in “Appendix N”, p. A-50 in the back of the textbook).

CHEMICAL EQUATIONS AND CHEMICAL ANALYSIS

The time scheduled for this Study Section is an estimated 4 hours.

This Study Section is based on **KT&T**, p. 150-156.

OUTCOMES

Following completion of this Study Section you should:

- Be able to use stoichiometry to analyse a mixture of compounds; and
- Determine the empirical formula of an unknown compound through the use of stoichiometric principles.

- Study example 4.3 on p. 152 to get an idea of a typical examination question.
- Study example 4.4 on p. 153 and 154 to get an idea of a typical examination question.
- Study example 4.5 on p. 155 and 156 to get a further sense of a typical examination question.
- Do Review and check for section 4.4" on p. 156 of **KT&T** (answers are in “Appendix N”, p. A-50 in the back of the textbook).
- Answer questions 25, 27 and 29 on p. 179c of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).

MEASUREMENT OF CONCENTRATIONS OF COMPOUNDS IN SOLUTION

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 156-161 and **KT&T**, p. 471-473.

OUTCOMES

Following completion of this Study Section you should be able to:

- Calculate the concentration of dissolved compound in a solution in units of mole per litre (molarity);
- Express the concentration of a dissolved compound in a solution in other units such as molality; mole fraction; mass percentage and parts per million (ppm)(chapter 13, p. 471 – 473);
- Use concentrations in further calculations;
- Describe how to prepare a solution with a given concentration from a soluble compound and a solvent; and
- Describe how do prepare a solution through dilution from a more concentrated solution.

- Study example 4.6 on p. 158 and 4.7 on p. 161 to get an idea of typical examination questions.
- Study "Problem Solving Tip 4.3" on p. 160. This will provide you with valuable ideas about how to prepare a solution by means of dilution.
- Do "Review and check for section 4.5" on p. 161 of **KT&T** (answers are in “Appendix N”, p. A-50 in the back of the textbook).
- Do "Review and check for section 13.1" on p. 472 of **KT&T** (answers are in “Appendix N”, p. A-82 in the back of the textbook).
- Answer questions 39, 41, 43 and 45 on p. 179d of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).

PH, A CONCENTRATION SCALE FOR ACIDS AND BASES

The time scheduled for this Study Unit is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 161-164.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Calculate the pH of a solution from the hydronium ion (H_3O^+ ion) concentration in the solution; and
- Calculate the concentration of the hydronium ion in the solution from the pH of the solution.

- Study example 4.8 on p. 163 and 164 to get an idea of a typical examination question.
- Do "Review and check for section 4.6" on p. 164 of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).

STOICHIOMETRY OF REACTIONS IN AQUEOUS SOLUTIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 164-172.

OUTCOMES

Following completion of this Study Section you should be able to:

- Solve stoichiometric problems through the use of concentrations;
- Explain how a titration is done;
- Explain the procedure of standardization of a solution; and
- Calculate the concentration of mole amounts of reagents from titration values.

- Study "Problem Solving Tip 4.4" on p. 166. This will provide you with valuable ideas about how to prepare a solution by means of dilution.
- Study example 4.9 on p. 165 to get an idea of a typical examination question.
- Study example 4.10 on p. 167 and 168 to get further ideas about typical examination questions.
- Study example 4.11 on p. 168 and 169 to get an idea of a typical examination question.
- Study examples 4.12 and 4.13 on p. 169-171 to get further ideas about typical examination questions.
- Do "Review and check for section 4.7" on p. 172 of **KT&T** (answers are in “Appendix N”, p. A-51 in the back of the textbook).
- Answer questions 63, 65 and 67 on p. 179e of **KT&T** (answers are in “Appendix N”, p. A-52 in the back of the textbook).

PRINCIPLES OF CHEMICAL REACTIVITY: ENERGY AND CHEMICAL REACTIONS

The time scheduled for this Study Unit is an estimated 17 hours.

This Study Unit is based on parts of chapter 5 of **KT&T**, p. 181-217b.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Assess the transfer of energy as heat (warmth) which is accociated with changes in termperature and changes in condition;
- Understand and be able to apply the first main law of thermo-dynamics;
- Define and apply functions of condition (enthalpy and internal energy);
- Describe how energy changes can be measured; and
- Calculate the energy released or needed for physical changes to occur or a chemical reaction to happen.

ENERGY: BASIC PRINCIPLES

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 182-184.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe the nature of energy transfers as warmth (heat); and
- Recognize the language of thermo-dynamics and to use it, for example, the law on energy preservation, thermic equilibrium, system and environment, exothermic reactons and endothermic reactions.

- Do "Review and check for section 5.1" on p. 184 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).

SPECIFIC WARMTH (HEAT) CAPACITY: HEAT AND COOLING

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 184-189.

OUTCOMES

Following completion of this Study Section you should be able to:

- Use specific heat capacity in calculations of energy transfer as heat and temperature changes; and
- Understand the sign conventions in thermo-dynamics.

- Study example 5.1 on p. 186 to get an idea of a typical examination question.
- Study "Problem Solving Tip 5.1" on p. 187. This will provide you with valuable information about how to calculate the change in temperature (ΔT).
- Study example 5.2 on p. 188 to get an idea of a typical examination question.
- Do "Review and check for section 5.2" on p. 189 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).
- Answer questions 5, 7, 9 and 11 on p. 217 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).

ENERGY AND CHANGES OF CONDITIONS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 189-193.

OUTCOMES

Following completion of this Study Section you should be able to:

- Use the enthalpy (heat) of melting and the enthalpy of evaporation to calculate the energy transfers as warmth (heat) during changes of conditions.

- Study example e 5.3 and 5.4 on p. 190 - 192 to get an idea of typical examination questions.
- Do "Review and check for section 5.3" on p. 192 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).
- Answer questions 17, 19 and 21 on p. 217a of **KT&T** (answers are in “Appendix N”, p. A-55 in the back of the textbook).

THE FIRST LAW OF THERMO-DYNAMICS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 193-198.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand the basis of the first law of thermo-dynamics;
- Understand how energy transfer warmth (heat) and labour done on a system or through a system contributes to changes in the internal energy of the system; and
- Recognize condition functions of which the value are only determined through the condition of the system and not via the route through which the condition wasd obtained.

- Do "Review and check for section 5.4" on p. 198 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).

ENTHALPY CHANGEE FOR CHEMICAL REACTIONS

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 198-201.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe how energy changes are measured; and
- Know that when a process occurs under constant pressure, the energy transfer as heat is the same as the change in enthalpy, ΔH.

- Study example 5.6 on p. 200 to get an idea of a typical examination question.
- Do "Review and check for section 5.5" on p. 201 of **KT&T** (answers are in “Appendix N”, p. A-54 in the back of the textbook).

CALORIMETRY

The time scheduled for this Study Unit is an estimated 0 hours.

Only take note of Study Section 5.6, p. 201-205.

ENTHALPY CALCULATIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 205-213.

OUTCOMES

Following completion of this Study Section you should be able to:

- Calculate the energy generated or needed to effect physical and chemical changes by making use of tables with thermodynamic data (data will be supplied to you).;
- Apply Hess' Law to calculate the change in enthalpy, $\Delta_r H^o$, for a reaction;
- Know how to draw energy vlak level diagrams and to interpret them; and
- Use the standard molar enthalpy of formation, $\Delta_f H^o$, to calculate the enthalpy change for a reaction, $\Delta_r H^o$.

- Study example 5.9 on p. 207 and 208 to get an idea of a typical examination question.
- Study "Problem Solving Tip 5.2" on p. 207. This will provide you with valuable ideas about how to use the Law of Hess.
- Study example 5.10 on p. 210 and 211 to get a further good idea of typical examination questions.
- Do "Review and check for section 5.7" on p. 212 and 213 of **KT&T** (answers are in "Appendix N", p. A-54 in the back of the textbook).
- Answer questions 49 and 51 on p. 217c of **KT&T** (answers are in "Appendix N", p. A-55 in the back of the textbook).

PRODUCT OR REAGENT ADVANTAGED REACTIONS AND THERMO-DYNAMICS

The time scheduled for this Study Section is an estimated 1 hour.

This Study Section is based on **KT&T**, p. 213-214.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand and know that product advantaged reactions mostly have negative values for $\Delta_r H^o$ and that reagent advantaged reactions have positive values for $\Delta_r H^o$, but that is not always true – there are exceptions.

STUDY DIVISION B
THE CONTROL OF CHEMICAL REACTIONS

CONTENTS OF STUDY DIVISION

The time scheduled for this STUDY DIVISION is an estimated 80 hours.

STUDY DIVISION B is based on parts of **Chapter 14, 15, 16 and 17** in **KT&T** and includes Study Units 6, 7, 8 and 9.

CHEMICAL KINETICS: THE RATES OF CHEMICAL REACTIONS

The time scheduled for this Study Unit is an estimated 15 hours.

Study Unit 6 is based on sections of **Chapter 14,** p. 507 – 553k of **KT&T**.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Understand and describe what is meant by the rate of a reaction and the conditions (factors) that caninfluence the rate of a reaction;
- Deduce rate equations, rate constants and reaction orders from experimentally derived data;
- Use integrated laws of rate;
- Understand collision theory and calculate activation energy with the aid of the theory; and
- Find a relationship between reaction mechanisms and laws of rate.

RATES OF CHEMICAL REACTIONS

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 508-512.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define the rate of a reaction in words and with a mathematical equation; and
- Deduce initial, average and instantaneous reaction rate from available concentration-time-data.

- Study example e 14.1 and 14.2 on p. 510 - 512 to get an idea of typical examination questions.
- Do "Review and check for section 14.1" on p. 512 of **KT&T** (answers are in “Appendix N”, p. A-86 in the back of the textbook).
- Answer questions 1, 3 and 5 on p. 553 of **KT&T** (answers are in “Appendix N”, p. A-86 in the back of the textbook).

REACTION CONDITIONS AND RATE

The time scheduled for this Study Section is an estimated 1½ hours.

Hierdie Study Section is based on **KT&T**, p. 512-514.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe the factors (reagent concentration, temperature, presence of catalyst and the physical conditions of the reagents) that can influence the rate of a reaction.

THE EFFECT OF CONCENTRATION ON THE REACTION RATE

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 515-520.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define the different parts (rate constant and reaction orders) of a rate equation;
- Understand the importance and be able to apply a rate equation in calculations; and
- Deduce a rate equation from experimental data.

- Study examples 14.3 and 14.4 on p. 518 - 519 to get an idea of typical examination questions.
- Study “Problem-solving Tip 14.1" on p. 520. This will give you a good idea how to determine a Rate Equation.
- Do "Review and check for section 14.3" on p. 520 of **KT&T** (answers are in “Appendix N”, p. A-86 in the back of the textbook).

CONCENTRATION/TIME RELATIONSHIPS: INTEGRATED RATE LAWS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 520-529.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe the relationship between reagent concentration and time for zero-order, first-order and second-order reactions and to use these in calculations;
- Apply graphic methods (compile and interpret graphs) for the determination of orders of reaction and rate constants from experimental data; and
- Use the concept of half-life ($t_{½}$) for especially first-order reactions.

- Study example e 14.5, 14.6 and 14.7 on p. 521 to 523 to get an idea of typical examination questions.
- Study example 14.8 and 14.9 on p. 527 and 528 to get even more of an idea of a typical examination question.
- Do "Review and check for section 14.4" on p. 528 of **KT&T** (answers are in “Appendix N”, p. A-86 in the back of the textbook).

A MICROSCOPIC VIEW OF REACTION RATES

The time scheduled for this Study Section is an estimated 0 hours.

Only take note of Study Section 6.5, p. 529 - 539.

REACTION MECHANISMS

The time scheduled for this Study Section is an estimated 0 hours.

Only take note of Study Section 6.6, p. 539 - 549.

PRINCIPLES OF CHEMICAL REACTIVITY: EQUILIBRIUM

The time scheduled for this Study Unit is an estimated 13 hours.

Study Unit 7 is based on sections of **Chapter 15,** p. 555-583h of **KT&T**.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Understand and write down the nature and characteristics of chemical equilibrium;
- Understand and be able to use in calculations the importance of the equilibrium constant, K, and the reaction quotient, Q, of both these concepts;
- Write down equilibrium constants for reactions in solution and the gas phase;
- Combine chemical reaction equations in order to obtain a new reaction equation te kry and to deduce the ooreenstemmende equilibrium constant;
- Determine the reaction quotient and equilibrium constant to determine the direction of a reaction;
- Determine the equilibrium constant through the use of equilibrium and starting concentrations; and
- Apply Le Chatelier's principle.

CHEMICAL EQUILIBRIUM: A SURVEY

The time scheduled for this Study Section is an estimated ½ hour.

This Study Section is based on **KT&T**, p. 556-557.

OUTCOMES

Following completion of this Study Section you should be able to:

- Understand that chemical reactions are reversible and that equilibriums are dynamic in nature.

- Do "Review and check for section 15.1" on p. 557 of **KT&T** (answers are in “Appendix N”, p. A-89 in the back of the textbook).

THE EQUILIBRIUM CONSTANT AND REACTION QUOTIENT

The time scheduled for this Study Section is an estimated 3½ hours.

This Study Section is based on **KT&T**, p. 557-564.

OUTCOMES

Following completion of this Study Section you should be able to:

- Write down the reaction quotient, Q, and the equilibrium constant, K, for a chemical reaction;
- Know that the concentrations of solid, pure liquids and solvents are not included in the equilibrium constant expression;
- Know that a high value for K (K > 1) indicates that a reaction product has been advantaged and that a low value for K (K < 1) indicates that a reaction reagent is advantaged;
- Know that the equilibrium consentrations can be expressed in terms of reagent and product concentrations (in mole per litre) and that K is then represented as K_C. Alternatively, the concentration of gases is represented by the partial pressures and in such cases K is represented as $K_{BL;\ en}$
- Use the reaction quotient, Q, to determine whether a reaction is product advantaged, reagent advantaged or at equilibrium.

- Study example 15.1 on p. 560 and 561 to get an idea of a typical examination question.
- Study example 15.2 on p. 563 and 564 to get a further idea of a typical examination question.
- Do "Review and check for section 15.2" on p. 564 of **KT&T** (answers are in “Appendix N”, p. A-89 in the back of the textbook).
- Answer questions 1, 3 and 5 on p. 583a of **KT&T** (answers are in “Appendix N”, p. A-89 and A-90 in the back of the textbook).

DETERMINATION OF AN EQUILIBRIUM CONSTANT

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 564-566.

OUTCOMES

Following completion of this Study Section you should be able to:

- Calculate an equilibrium constant from given reagent and product concentrations.

- Study example 15.3 on p. 565 and 566 to get an idea of a typical examination question.
- Do "Review and check for section 15.3" on p. 566 of **KT&T** (answers are in “Appendix N”, p. A-89 in the back of the textbook).

THE USE OF EQUILIBRIUM CONSTANTS IN CALCULATIONS

The time scheduled for this Study Section is an estimated 3 hours.

This Study Section is based on **KT&T**, p. 567-571.

OUTCOMES

Following completion of this Study Section you should be able to:

- Use equilibrium constants to calculate the concentrations (or pressure) of a reagent of a product in equilibrium.

- Study example 15.4 on p. 567 and 568 to get an idea of a typical examination question.
- Study example 15.5 on p. 570 to get an idea of a typical examination question.
- Study "Problem Solving Tip 15.1" on p. 571. This will provide you with valuable ideas about when to use a quadratic equation. **In the back of KT&T, in Appendix A, pages A-1 to A-5 there is a good explanation about how to use logarhythms and how to solve a quadratic equation. Study this if you do not know how to do it.**
- Do "Review and check for section 15.4" on p. 571 of **KT&T** (answers are in “Appendix N”, p. A-89 in the back of the textbook).

BALANCED REACTION EQUATIONS AND EQUILIBRIUM CONSTANTS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 571-575.

OUTCOMES

Following completion of this Study Section you should be able to:

- Know how the equilibrium constant, K, changes when other stoichiometrical co-efficients are used in a balanced reaction equation when the reaction equation is inverted when various reaction equations are added up to establish a new net equation.

- Study example 15.6 on p. 573 and 574 to get an idea of a typical examination question.
- Study "Problem Solving Tip 15.2" on p. 574. This will provide you with valuable ideas about how the equilibrium constant, K, changes when other stoichiometrical co-efficients are used in a balanced reaction and when the reaction is inverted or if various reaction equations are added together to establish a new net equation.
- Do "Review and check for section 15.5" on p. 574 of **KT&T** (answers are in “Appendix N”, p. A-89 in the back of the textbook).

DISRUPTION OF A CHEMICAL EQUILIBRIUM

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section (Study Section 10.7) is intended for self-study for purposes of preparation for tests and examination. Remember that self-study constitutes between 10% and 20% of tests, assignments and the examination.

This Study Section is based on **KT&T**, p. 575-582.

OUTCOMES

Following completion of this Study Section you shouldbe able:

- By making use of Le Chatelier's principle, to predict the effect of a disruption on a chemical equilibrium (change in temperature, change in concentration, change in volume or a change in pressure).

- Study example 15.7 on p. 576 and 577 to get an idea of a typical examination question.
- Do "Review and check for section 15.6" on p. 581 of **KT&T** (answers are in "Appendix N", p. A-89 in the back of the textbook).

Leereenheid 8

PRINCIPLES OF CHEMICAL REACTIVITY: DIE CHEMISTRY OF ACIDS AND BASES

The time scheduled for this Study Unit is an estimated 26 hours.

Study Unit 8 is based on KT&T, **Chapter 16**, pp. 585-629j.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Understand an apply the theories of Brønsted-Lowry and Lewis;
- Apply the principles of chemical equilibrium on acids and bases in aqueous solutions;
- Predict the outcome of reactions of acids and bases; and
- Understand the influence of structure and binding on acid-base-characteristics.

THE BRØNSTED-LOWRY CONCEPT OF ACIDS AND BASES

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 586-589.

OUTCOMES

Following completion of this Study Section you should be able to:

- Define and use the Brønsted concept of acids and bases;
- Recognize monoprotic and polyprotic acids and bases and write down balanced reaction equations for their ionization in water;
- Know when a compound is amphiprotic; and
- Recognize Brønsted-acids and bases in a reaction and be able to identify the conjugated acid and base.

- Do "Review and check for section 16.1" on p. 588 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).
- Answer questions 1, 3, 5 and 7 on p. 629a of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).

WATER AND THE PH SCALE

The time scheduled for this Study Section is an estimated 2½ hours.

This Study Section is based on **KT&T**, p. 589-592.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe what is meant by the auto-ionization of water;;
- Define and be able to use the ionization constant of water, $K_{W;}$
- Know what the pH-scale is and be able to use the pH concept; and
- Do simple calculations.

- Study example 16.1 on p. 590 to get an idea of a typical examination question.
- Do "Review and check for section 16.2" on p. 592 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).
- Answer questions 9, 11 and 13 on p. 629a of **KT&T** (answers are in “Appendix N”, p. A-92 and A-93 in the back of the textbook).

EQUILIBRIUM CONSTANTS FOR ACIDS AND BASES

The time scheduled for this Study Section is an estimated 4 hours.

This Study Section is based on **KT&T**, p. 592-598.

OUTCOMES

Following completion of this Study Section you shouldbe able to:

- Write down equilibrium constant expressions for weak acids and weak bases;
- caluclate pK_a from K_a (of K_a vanaf pK_a) and understand how the pKa correlates with the acid strength; and
- understand the relationship between the conjugated basis of K_a for a weak acid and K_b for the weak acid.

- Study "Problem Solving Tip 16.1" on p. 594. This will give you valuable information as to when an acid or a base is strong or weak.
- Do "Review and check for section 16.3" on p. 598 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).
- Answer questions 15, 17, 19 and 21 on p. 629b of **KT&T** (answers are in “Appendix N”, p. A-93 in the back of the textbook).

ACID-BASE CHARACTERISTICS OF SALTS

The time scheduled for this Study Section is an estimated 3½ hours.

This Study Section is based on **KT&T**, p. 598-600.

OUTCOMES

Following completion of this Study Section you should be able to:

- Predict whether salts dissolved in water will deliver a neutral, acidic or basic solution.

- Study example 16.2 on p. 599 and 600 to get an idea of a typical examination question.
- Study "Problem Solving Tip 16.2" on p. 600. It will provide you with valuable ideas about how to predict whether acids dissolved in water will be neutral, acid or base by nature.
- Do "Review and check for section 16.4" on p. 600 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).

PREDICTIONS OF THE DIRECTION OF ACID-BASE REACTIONS

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 601-603.

OUTCOMES

Following completion of this Study Section you should be able to:

- Write down equations for acid-base reactions and then to deduce on the basis of these whether the reaction will be product-advantaged or reagent advantaged by equilibrium.

- Study example 16.3 on p. 602 to get an idea of a typical examination question.
- Do "Review and check for section 16.5" on p. 603 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).

TYPES OF ACID-BASE REACTIONS

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 603-605.

OUTCOMES

Following completion of this Study Section you shouldbe able to:

- Understand and to know what is the results will be of the following types of acid-base reactions:
  - the reaction of a strong acid with a strong base;
  - the reaction of a weak acid with a strong base;
  - the reaction of a strong acid with a weak base; and
  - the reaction of a weak acid with a weak base.

- Do "Review and check for section 16.6" on p. 605 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).

Leergedeelte 8.7

CALCULATIONS WITH EQUILIBRIUM CONSTANTS

The time scheduled for this Study Section is an estimated 5 hours.

This Study Section is based on **KT&T**, p. 605-615.

OUTCOMES

Following completion of this Study Section you should be able to:

- Calculate the equilibrium constant of a weak acid, K_a, and the equilibrium constant of a weak basis, K_b, from experimental data; and
- Use equilibrium constants and other information to calculate the pH of a solution of a weak acid or a weak base.

- Study example 16.4 on p. 605 and 606 to get an idea of a typical examination question.
- Study example 16.5 on p. 607 and 608 to get further ideas of a typical examination question.
- Study example 16.6 on p. 609 and 610 to get further ideas of a typical examination question.
- Also study examples 16.7 and 16.8 on p. 610 tot 614 to get an idea of a typical examination question.
- Study "Problem Solving Tip 16.3" on p. 615. This will provide you with valuable ideas about what the pH of a solution will be once you have mixed equal amounts of acid and base.
- Do "Review and check for section 16.7" on p. 615 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).

POLYPROTIC ACIDS AND BASES

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 615-617.

OUTCOMES

Following completion of this Study Section you should be able to:

- Know what a polyprotic acid or base is; and
- Know how to handle poliprotic acids and bases in calculations of the pH or polyprotic acid or base solutions.

- Study example 16.9 on p. 616 and 617 to get an idea of a typical examination question.
- Do "Review and check for section 16.8" on p. 617 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).
- Answer questions 67 and 69 on p. 629d of **KT&T** (answers are in “Appendix N”, p. A-93 in the back of the textbook).

MOLECULAR STRUCTURE, BINDING AND ACID-BASE ACTION

The time scheduled for this Study Section is an estimated 0 hours.

Only take note of Study Section 8.9, p. 617 - 622.

THE LEWIS CONCEPT OF ACIDS AND BASES

The time scheduled for this Study Section is an estimated 1½ hours.

This Study Section is based on **KT&T**, p. 622-627.

OUTCOMES

Following completion of this Study Section you should be able to:

- Classify a compound as a Lewis-acid (an electron pair receiver) or as a Lewis-base (electron pair donor).

- Do "Review and check for section 16.10" on p. 627 of **KT&T** (answers are in “Appendix N”, p. A-92 in the back of the textbook).
- Answer questions 79 and 81 on p. 629e of **KT&T** (answers are in “Appendix N”, p. A-93 in the back of the textbook).

PRINCIPLES OF CHEMICAL REACTIVITY: OTHER ASPECTS OF AQUEOUS EQUILIBRIUMS

The time scheduled for this Study Unit is an estimated 21 hours.

Study Unit 9 is based on KT&T, **Chapter 17**, p. 631-677h.

OUTCOMES

Following completion of this Study Unit you should be able to:

- Understand what is meant by the common ion effect;
- Understand how the pH of an aqueous solutioln can be controlled by using buffer solutions;
- Evaluate and calculate an aqueous solution during an acid-base-titration; and
- Apply chemical equilibrium concepts and evaluate the solubility of ionic compounds.

THE COMMON ION EFFECT

The time scheduled for this Study Section is an estimated 4 hours.

This Study Section is based on **KT&T**, p. 632-635.

OUTCOMES

Following completion of this Study Section you shoulde able to:

- Understand the term common ion effect and be able to apply it; and
- Predict the effect that the addition of a common ion would have on a weak acid or base, and predict the pH.

- Study example 17.1 on p. 634 and 635 to get an idea of a typical examination question.
- Do "Review and check for section 17.1" on p. 635 of **KT&T** (answers are in “Appendix N”, p. A-96 in the back of the textbook).
- Answer questions 1, 3 and 5 on p. 677 of **KT&T** (answers are in “Appendix N”, p. A-96 in the back of the textbook).

PH CONTROL: BUFFER SOLUTIONS

The time scheduled for this Study Section is an estimated 5 hours.

This Study Section is based on **KT&T**, p. 636-644.

OUTCOMES

Following completion of this Study Section you should be able to:

- Describe the function of a buffer solution;
- Use the Henderson-Hasselbach equation (equation 17.2 on p. 638) calculate the pH of a buffer solution with a given composition;
- Describe how to prepare a buffer solution with a given pH; and
- Calculate the pH of a buffer solution before and after the addition of an acid or base.

- Study example 17.2 on p. 637 to get an idea of a typical examination question.
- Study examples 17.3 and 17.4 on p. 639 tot 641 to get more of an idea of a typical examination question.
- Study "Problem Solving Tip 17.1" on p. 641. This will provide you with a valuable summary of the most important aspect of buffer solutions.
- Study example 17.5 on p. 642 and 643 to get more of an idea of a typical examination question.
- Do "Review and check for section 17.2" on p. 643 and 644 of **KT&T** (answers are in "Appendix N", p. A-96 in the back of the textbook).

ACID-BASE TITRATIONS

The time scheduled for this Study Section is an estimated 4½ hours.

This Study Section is based on **KT&T**, p. 644-655.

OUTCOMES

Following completion of this Study Section you should be able to:

- Predict the pH of an acid-base reaction at the equivalence point of an acid-base titration;
- Understand and be able to point out differences between the titration curves of strong acids/weak acids with strong bases/weak bases; and
- Describe the function and working of an indicator in an acid-base titration.

- Study example 17.6 on p. 658 to 650 to get an idea of a typical examination question.
- Study example 17.7 on p. 652 and 653 to get more of an idea of a typical examination question.
- Study "Problem Solving Tip 17.2" on p. 654. It will give you valuable insight into how to calculate the pH at different stages of an acid-base titration.
- Do "Review and check for section 17.3" on p. 655 of **KT&T** (answers are in “Appendix N”, p. A-96 in the back of the textbook).

SOLUBILITY OF SALTS

The time scheduled for this Study Section is an estimated 3½ hours.

This Study Section is based on **KT&T**, p. 655-666.

OUTCOMES

Following completion of this Study Section you should be able to:

- Write down equilibrium constant expressions which indicate the relationship between the concentration of ions in solutions with the K_{sp}-values with insoluble salts;
- Calculate K_{sp}-values from experimental data;
- Estimate the solubility of a salt on the basis of the K_{sp}-value of the salt;
- Calculate the solubility of a salt in the presence of a shared ion; and
- Understand how the hydrolysis of basic anions affects the solubility of salts.

- Study examples 17.8, 17.9 and 17.10 on p. 657 tot 660 to get an idea of typical examination questions.
- Also study examples 17.11 and 17.12 on p. 662 and 664 to get more of an idea of a typical examination question.
- Do "Review and check for section 17.4" on p. 666 of **KT&T** (answers are in “Appendix N”, p. A-96 in the back of the textbook).

PRECIPITATION REACTIONS

The time scheduled for this Study Section is an estimated 2 hours.

This Study Section is based on **KT&T**, p. 667-670.

OUTCOMES

Following completion of this Study Section you should be able to:

- Predict whether a precipitate will form when the ion concentrations are known; and
- Effect and calculate the ion concentrations needed for the precipitation of an insoluble salt.

- Study examples 17.13, 17.14 and 17.15 on p. 668 tot 670 to get an idea of typical examination questions.
- Do "Review and check for section 17.5" on p. 670 of **KT&T** (answers are in “Appendix N”, p. A-96 in the back of the textbook).

THE EQUILIBRIUMS OF COMPLEX IONS

The time scheduled for this Study Section is an estimated 0 hour.

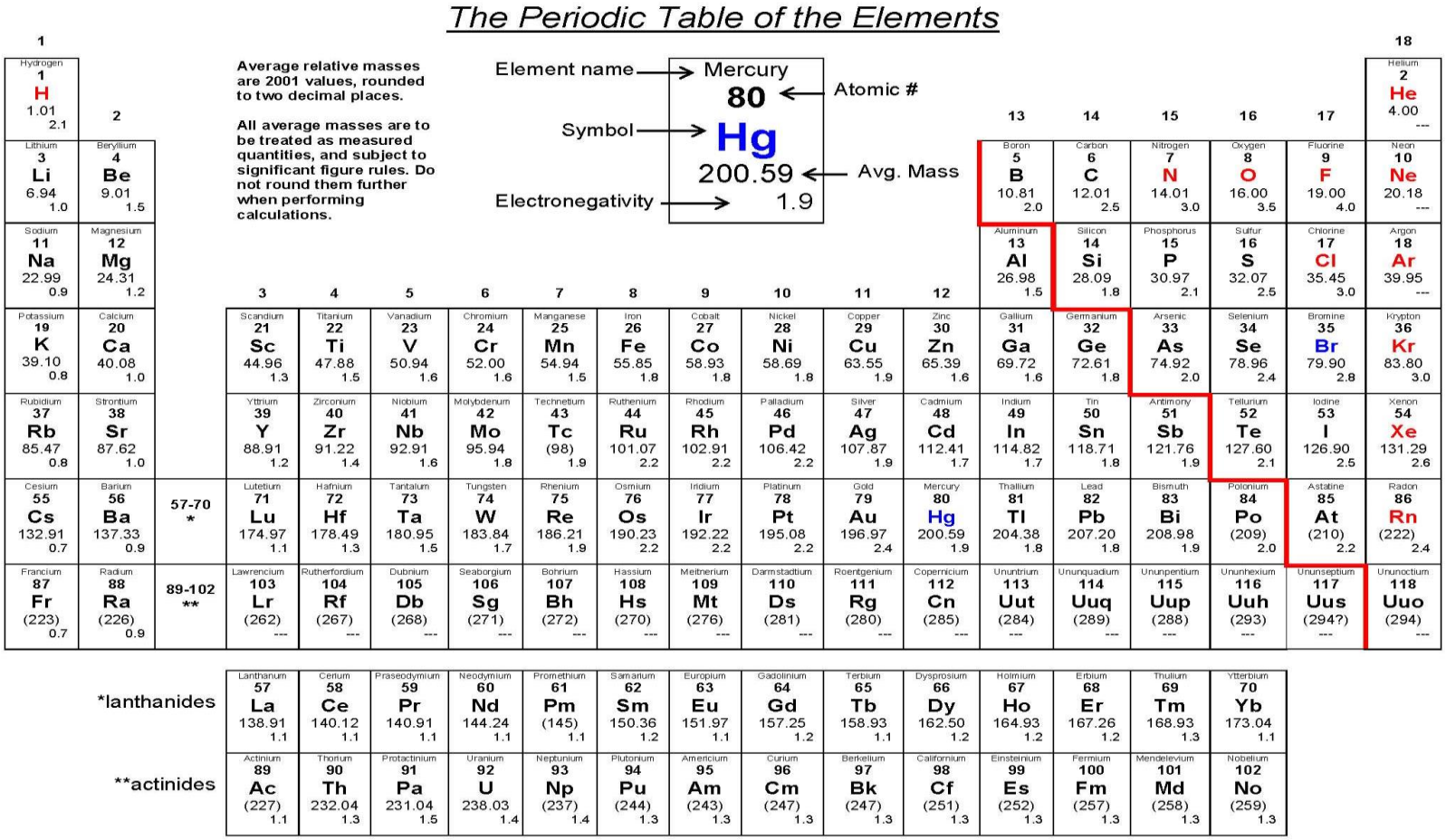
Only take note of Study Section 9.6, p. 670 - 672.

THE SOLUBILITY OF COMPLEX IONS

The time scheduled for this Study Section is an estimated 0 hour.

Only take note of Study Section 9.7, p. 672 - 674.

APPENDIX


The Periodic Table of the Elements
Average relative masses are 2001 values, rounded to two decimal places.
All average masses are to be treated as measured quantities, and subject to significant figure rules. Do not round them further when performing calculations.
Element name
Mercury
80
Atomic #
Symbol
Hg
200.59
Avg. Mass
Electronegativity
1.9
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Hydrogen 1 H 1.01 2.1
Helium 2 He 4.00 ---
Lithium 3 Li 6.94 1.0
Beryllium 4 Be 9.01 1.5
Boron 5 B 10.81 2.0
Carbon 6 C 12.01 2.5
Nitrogen 7 N 14.01 3.0
Oxygen 8 O 16.00 3.5
Fluorine 9 F 19.00 4.0
Neon 10 Ne 20.18 ---
Sodium 11 Na 22.99 0.9
Magnesium 12 Mg 24.31 1.2
Aluminum 13 Al 26.98 1.5
Silicon 14 Si 28.09 1.8
Phosphorus 15 P 30.97 2.1
Sulfur 16 S 32.07 2.5
Chlorine 17 Cl 35.45 3.0
Argon 18 Ar 39.95 ---
Potassium 19 K 39.10 0.8
Calcium 20 Ca 40.08 1.0
Scandium 21 Sc 44.96 1.3
Titanium 22 Ti 47.88 1.5
Vanadium 23 V 50.94 1.6
Chromium 24 Cr 52.00 1.6
Manganese 25 Mn 54.94 1.5
Iron 26 Fe 55.85 1.8
Cobalt 27 Co 58.93 1.8
Nickel 28 Ni 58.69 1.8
Copper 29 Cu 63.55 1.9
Zinc 30 Zn 65.39 1.6
Gallium 31 Ga 69.72 1.6
Germanium 32 Ge 72.61 1.8
Arsenic 33 As 74.92 2.0
Selenium 34 Se 78.96 2.4
Bromine 35 Br 79.90 2.8
Krypton 36 Kr 83.80 3.0
Rubidium 37 Rb 85.47 0.8
Strontium 38 Sr 87.62 1.0
Yttrium 39 Y 88.91 1.2
Zirconium 40 Zr 91.22 1.4
Niobium 41 Nb 92.91 1.6
Molybdenum 42 Mo 95.94 1.8
Technetium 43 Tc (98) 1.9
Ruthenium 44 Ru 101.07 2.2
Rhodium 45 Rh 102.91 2.2
Palladium 46 Pd 106.42 2.2
Silver 47 Ag 107.87 1.9
Cadmium 48 Cd 112.41 1.7
Indium 49 In 114.82 1.7
Tin 50 Sn 118.71 1.8
Antimony 51 Sb 121.76 1.9
Tellurium 52 Te 127.60 2.1
Iodine 53 I 126.90 2.5
Xenon 54 Xe 131.29 2.6
Cesium 55 Cs 132.91 0.7
Barium 56 Ba 137.33 0.9
57-70 *
Lutetium 71 Lu 174.97 1.1
Hafnium 72 Hf 178.49 1.3
Tantalum 73 Ta 180.95 1.5
Tungsten 74 W 183.84 1.7
Rhenium 75 Re 186.21 1.9
Osmium 76 Os 190.23 2.2
Iridium 77 Ir 192.22 2.2
Platinum 78 Pt 195.08 2.2
Gold 79 Au 196.97 2.4
Mercury 80 Hg 200.59 1.9
Thallium 81 Tl 204.38 1.8
Lead 82 Pb 207.20 1.8
Bismuth 83 Bi 208.98 1.9
Polonium 84 Po (209) 2.0
Astatine 85 At (210) 2.2
Radon 86 Rn (222) 2.4
Francium 87 Fr (223) 0.7
Radium 88 Ra (226) 0.9
89-102 **
Lawrencium 103 Lr (262) ---
Rutherfordium 104 Rf (267) ---
Dubnium 105 Db (268) ---
Seaborgium 106 Sg (271) ---
Bohrium 107 Bh (272) ---
Hassium 108 Hs (270) ---
Meitnerium 109 Mt (276) ---
Darmstadtium 110 Ds (281) ---
Roentgenium 111 Rg (280) ---
Copernicium 112 Cn (285) ---
Ununtrium 113 Uut (284) ---
Ununquadium 114 Uuq (289) ---
Ununpentium 115 Uup (288) ---
Ununhexium 116 Uuh (293) ---
Ununseptium 117 Uus (294?) ---
Ununoctium 118 Uuo (294) ---
*lanthanides
Lanthanum 57 La 138.91 1.1
Cerium 58 Ce 140.12 1.1
Praseodymium 59 Pr 140.91 1.1
Neodymium 60 Nd 144.24 1.1
Promethium 61 Pm (145) 1.1
Samarium 62 Sm 150.36 1.2
Europium 63 Eu 151.97 1.1
Gadolinium 64 Gd 157.25 1.2
Terbium 65 Tb 158.93 1.1
Dysprosium 66 Dy 162.50 1.2
Holmium 67 Ho 164.93 1.2
Erbium 68 Er 167.26 1.2
Thulium 69 Tm 168.93 1.3
Ytterbium 70 Yb 173.04 1.1
**actinides
Actinium 89 Ac (227) 1.1
Thorium 90 Th 232.04 1.3
Protactinium 91 Pa 231.04 1.5
Uranium 92 U 238.03 1.4
Neptunium 93 Np (237) 1.4
Plutonium 94 Pu (244) 1.3
Americium 95 Am (243) 1.3
Curium 96 Cm (247) 1.3
Berkelium 97 Bk (247) 1.3
Californium 98 Cf (251) 1.3
Einsteinium 99 Es (252) 1.3
Fermium 100 Fm (257) 1.3
Mendelevium 101 Md (258) 1.3
Nobelium 102 No (259) 1.3

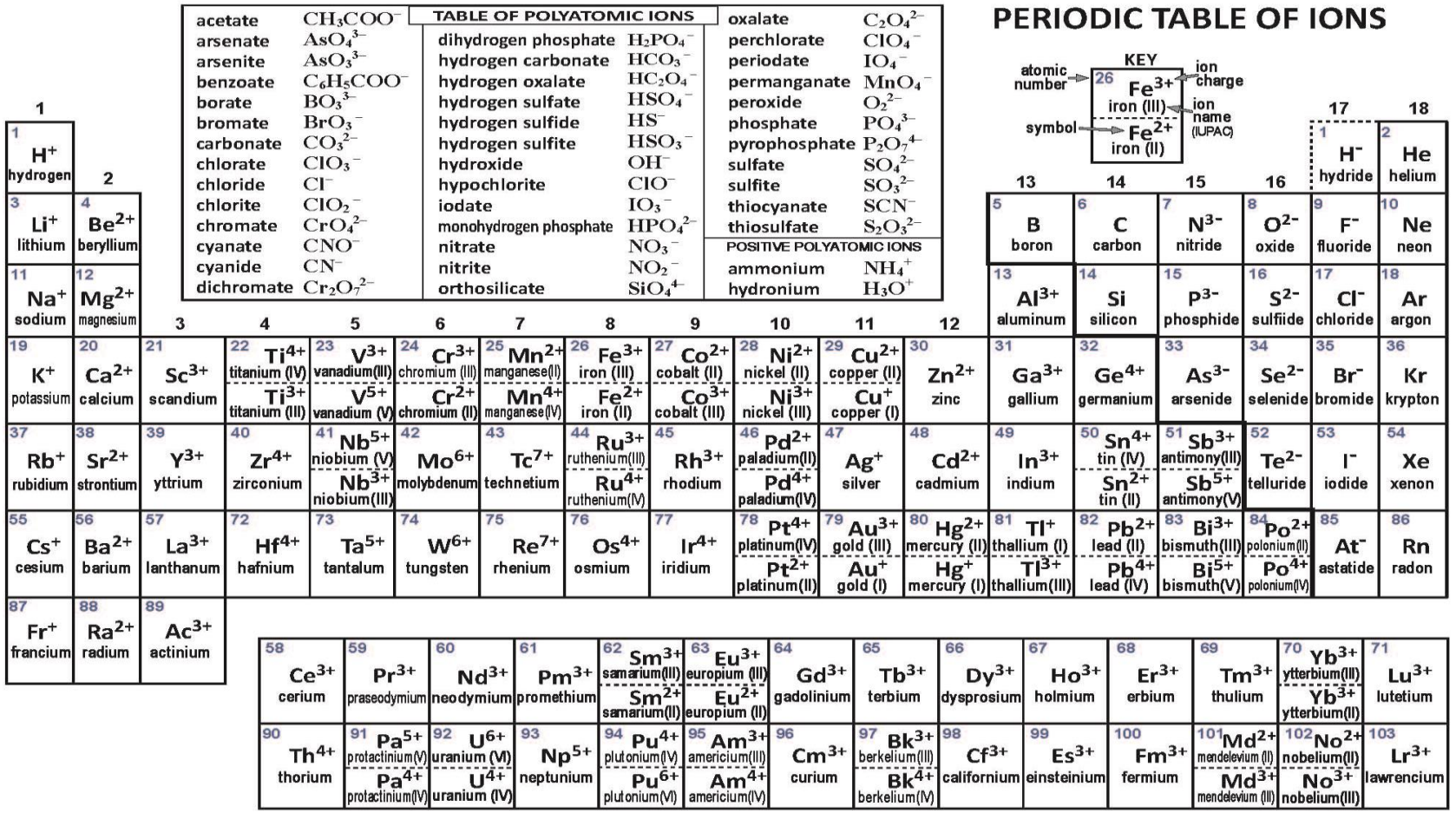


TABLE OF POLYATOMIC IONS
acetate CH_3COO^-
arsenate AsO_4^{3-}
arsenite AsO_3^{3-}
benzoate $C_6H_5COO^-$
borate BO_3^{3-}
bromate BrO_3^-
carbonate CO_3^{2-}
chlorate ClO_3^-
chloride Cl^-
chlorite ClO_2^-
chromate CrO_4^{2-}
cyanate CNO^-
cyanide CN^-
dichromate $Cr_2O_7^{2-}$
dihydrogen phosphate $H_2PO_4^-$
hydrogen carbonate HCO_3^-
hydrogen oxalate $HC_2O_4^-$
hydrogen sulfate HSO_4^-
hydrogen sulfide HS^-
hydrogen sulfite HSO_3^-
hydroxide OH^-
hypochlorite ClO^-
iodate IO_3^-
monohydrogen phosphate HPO_4^{2-}
nitrate NO_3^-
nitrite NO_2^-
orthosilicate SiO_4^{4-}
oxalate $C_2O_4^{2-}$
perchlorate ClO_4^-
periodate IO_4^-
permanganate MnO_4^-
peroxide O_2^{2-}
phosphate PO_4^{3-}
pyrophosphate $P_2O_7^{4-}$
sulfate SO_4^{2-}
sulfite SO_3^{2-}
thiocyanate SCN^-
thiosulfate $S_2O_3^{2-}$
POSITIVE POLYATOMIC IONS
ammonium NH_4^+
hydronium H_3O^+
PERIODIC TABLE OF IONS
KEY
atomic number
26 Fe^{3+} iron (III)
Fe^{2+} iron (II)
ion charge
ion name (IUPAC)
symbol
1 H^+ hydrogen
2 Be^{2+} beryllium
3 Li^+ lithium
4 Na^+ sodium
5 B boron
6 C carbon
7 N^{3-} nitride
8 O^{2-} oxide
9 F^- fluoride
10 Ne neon
11 Al^{3+} aluminum
12 Si silicon
13 P^{3-} phosphide
14 S^{2-} sulfiide
15 Cl^- chloride
16 Ar argon
17 K^+ potassium
18 Ca^{2+} calcium
19 Sc^{3+} scandium
20 Ti^{4+} titanium (IV) / Ti^{3+} titanium (III)
21 V^{3+} vanadium(III) / V^{5+} vanadium (V)
22 Cr^{3+} chromium (III) / Cr^{2+} chromium (II)
23 Mn^{2+} manganese(II) / Mn^{4+} manganese(IV)
24 Fe^{3+} iron (III) / Fe^{2+} iron (II)
25 Co^{2+} cobalt (II) / Co^{3+} cobalt (III)
26 Ni^{2+} nickel (II) / Ni^{3+} nickel (III)
27 Cu^{2+} copper (II) / Cu^+ copper (I)
28 Zn^{2+} zinc
29 Ga^{3+} gallium
30 Ge^{4+} germanium
31 As^{3-} arsenide
32 Se^{2-} selenide
33 Br^- bromide
34 Kr krypton
35 Rb^+ rubidium
36 Sr^{2+} strontium
37 Y^{3+} yttrium
38 Zr^{4+} zirconium
39 Nb^{5+} niobium (V) / Nb^{3+} niobium(III)
40 Mo^{6+} molybdenum
41 Tc^{7+} technetium
42 Ru^{3+} ruthenium(III) / Ru^{4+} ruthenium(IV)
43 Rh^{3+} rhodium
44 Pd^{2+} paladium(II) / Pd^{4+} paladium(IV)
45 Ag^+ silver
46 Cd^{2+} cadmium
47 In^{3+} indium
48 Sn^{4+} tin (IV) / Sn^{2+} tin (II)
49 Sb^{3+} antimony(III) / Sb^{5+} antimony(V)
50 Te^{2-} telluride
51 I^- iodide
52 Xe xenon
53 Cs^+ cesium
54 Ba^{2+} barium
55 La^{3+} lanthanum
56 Hf^{4+} hafnium
57 Ta^{5+} tantalum
58 W^{6+} tungsten
59 Re^{7+} rhenium
60 Os^{4+} osmium
61 Ir^{4+} iridium
62 Pt^{4+} platinum(IV) / Pt^{2+} platinum(II)
63 Au^{3+} gold (III) / Au^+ gold (I)
64 Hg^{2+} mercury (II) / Hg^+ mercury (I)
65 Tl^+ thallium (I) / Tl^{3+} thallium(III)
66 Pb^{2+} lead (II) / Pb^{4+} lead (IV)
67 Bi^{3+} bismuth(III) / Bi^{5+} bismuth(V)
68 Po^{2+} polonium(II) / Po^{4+} polonium(IV)
69 At^- astatide
70 Rn radon
71 Fr^+ francium
72 Ra^{2+} radium
73 Ac^{3+} actinium
58 Ce^{3+} cerium
59 Pr^{3+} praseodymium
60 Nd^{3+} neodymium
61 Pm^{3+} promethium
62 Sm^{3+} samarium(III) / Sm^{2+} samarium(II)
63 Eu^{3+} europium (III) / Eu^{2+} europium (II)
64 Gd^{3+} gadolinium
65 Tb^{3+} terbium
66 Dy^{3+} dysprosium
67 Ho^{3+} holmium
68 Er^{3+} erbium
69 Tm^{3+} thulium
70 Yb^{3+} ytterbium(III) / Yb^{3+} ytterbium(II)
71 Lu^{3+} lutetium
90 Th^{4+} thorium
91 Pa^{5+} protactinium(V) / Pa^{4+} protactinium(IV)
92 U^{6+} uranium (VI) / U^{4+} uranium (IV)
93 Np^{5+} neptunium
94 Pu^{4+} plutonium(IV) / Pu^{6+} plutonium(VI)
95 Am^{3+} americium(III) / Am^{4+} americium(IV)
96 Cm^{3+} curium
97 Bk^{3+} berkelium(III) / Bk^{4+} berkelium(IV)
98 Cf^{3+} californium
99 Es^{3+} einsteinium
100 Fm^{3+} fermium
101 Md^{2+} mendelevium (II) / Md^{3+} mendelevium (III)
102 No^{2+} nobelium(II) / No^{3+} nobelium(III)
103 Lr^{3+} lawrencium

TABEL 1: Oplosbaarheidstabel.

TABLE 1: Solubility Table.

Soluble compounds		**Exceptions**
Almost all salts of Na^+, K^+ and NH_4^+		
All salts of Cl^-, Br^- and I^-	⇔	Halides of Ag^+, Hg_2^{2+} and Pb^{2+}
Compounds containing F^-	⇔	Fluorides of Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+} and Pb^{2+}
Salts of nitrate, NO_3^-; chlorate, ClO_3^-; perchlorate, ClO_4^-; acetate, CH_3COO^-		$KClO_4$
Salts of sulfate, SO_4^{2-}	⇔	Sulfates of Sr^{2+}, Ba^{2+} and Pb^{2+}

Insoluble compounds		**Exceptions**
All salts of carbonate, CO_3^{2-}; phosphate, PO_4^{3-} oxalate, $C_2O_4^{2-}$; chromate, CrO_4^{2-}; sulfide, S^{2-} Most metal hydroxides OH^- and oxides, O^{2-}	⇔	Salts of NH_4^+ and alkali metal cations