INTRODUCTORY INORGANIC AND PHYSICAL CHEMISTRY

STUDY GUIDE FOR

CHEM 111 PEC

FACULTY OF NATURAL SCIENCES

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Edited nn.

- Page layout by Susan van Biljon, Graphikos.

Printing arrangements and distribution by Department Logistics (Distribution Centre).

Printed by Nashua Digidoc 018 299 2827

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WORD OF WELCOME

Very welcome to the CHEM 111 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 huge difference in your 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 that 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 CHEM 111 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 2014 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 period, 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 2014.

STUDY MATERIAL

Prescribed textbook

The prescribed textbook is *Chemistry and Chemical Reactivity*, 8th Edition, by JC Kotz, P Treichel and JR Townsend. Publishers: BROOKS/COLE 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 *eFundi* 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 CHEM111 and Answer Sheets for the practical manual for CHEM111. 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 fully understand the work done during a particular lecture at the end of that lecture. If you still do not understand sections of the work with which you had difficulty 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.

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 ten 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 a zero mark 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 three 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 2014. If you use both opportunities, the mark that you obtain in the second 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 2015, 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 CHEM 111. 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 CHEM 111 builds. In some study sections this is indicated as "self-study". These study sections have to be done on 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 have achieved at the end of each study section and study unit, as well as on completion of 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 words. You have to understand what these mean (in other words, what the lecturer requires by using them) and what is therefore required 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 in the light of an example or a sketch with or without captions
	Distinguish, compare	Facts, events or problems are juxtapositioned to highlight 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	Criticise, give an evaluation	Determine the value of a statement, issue or argument by explaining whether you agree with it or not. 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 SPECIFICALLY INDICATED AS A GROUP ACTIVITY).

Copying of text from other students or from sources (for example, the Study Guide, prescribed study material or directly from the internet) is **inadmissible** – only brief quotes are admissible and only when indicated as such.

You have to be able to **reformulate and use your own words** in order to explain what you have read. It is not acceptable simply to retype existing material/text/information and to acknowledge the source in a footnote – you should be able to reproduce the idea/concept without quoting the original author verbatim.

The purpose of the assignments is not simply to give a verbatim report of existing material, but to determine whether you have developed the ability to integrate existing texts, to formulate your own interpretation and/or critical assessment and to provide a creative solution to existing problems.

Be warned: Students who submit unacknowledged copied text will receive a zero mark for the assignment and disciplinary steps might be taken by the Faculty and/or the University against such students. It is also unacceptable to do somebody else's work for him/her or to allow anybody else to copy your work. You should therefore never allow anybody else access to your work.

STUDY DIVISION A
THE BASIC BUILDING BLOCKS OF CHEMISTRY

CONTENT OF STUDY DIVISION

The time scheduled for this study division is an estimated 75 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**, pp 1-49.

OUTCOMES

On 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;
- recognise elements, atoms, compounds 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 standard 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.

STUDY UNIT CONTENT

CHEMISTRY AND CHEMICAL METHODS

The time scheduled for this study section is an estimated ¾ hour.

This study section is based on **KT&T**, pp 2-5.

OUTCOMES

On 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 this study section is an estimated ¾ hour.

This study section is based on **KT&T**, pp 6-10.

OUTCOMES

On completion of this study section, you should be able to:

- Apply kinetic-molecular theory to the characteristics of matter;
- recognise 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 memorising symbols and the names of elements is not included.)

This study section is based on **KT&T**, pp 1011.

OUTCOMES

On 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 can be found in “Appendix P”, p A63 in the back of the textbook).
- Answer questions1 and 3 on p 20 of **KT&T** (answers can be found in “Appendix R”, pA75 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**, pp 12-13.

OUTCOMES

On 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 can be found in “Appendix P”, p A63 in the back of the textbook).
- Do question 5 on p 20 of **KT&T** (answers can be found in “Appendix R”, p A75 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**, pp 13-15.

OUTCOMES

On 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 can be found in “Appendix P”, p A63 in the back of the textbook).
- Do question 15 on p 21 of **KT&T** (answers can be found in “Appendix R”, p A75 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**, pp 15-16.

OUTCOMES

On 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 pp 16 of **KT&T** (answers can be found in “Appendix P”, p A63 in the back of the textbook).
- Do question 7 on p 0 of **KT&T** (answers can be found in “Appendix R”, p A75 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**,pp 25-30.

OUTCOMES

On 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 28 to get an idea of a typical examination question.
- Do “Review and check for section 1” on p 30 of **KT&T** (answers can be found in “Appendix P”, p A63 in the back of the textbook).
- Answer questions 3, 5, 7, 9, 13 and 15 on pp 44 and 45 of **KT&T** (answers can be found in “Appendix R”, p A76 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**,pp 30-33.

OUTCOMES

On completion of this study section, you should be able to:

- Only read through these few pages for taking cognisance.

THE MATHEMATICS OF CHEMISTRY

The time scheduled for this study section is an estimated 1 hour.

This study section is based on **KT&T**, pp 33-39.

OUTCOMES

On 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 35. This should help you a lot in the rest of the module where you will be doing numerous calculations.
- Do “Review and check for section 3” on p 39 of **KT&T** (answers can be found in “Appendix P”, p A63 in the back of the textbook).
- Answer questions 23 and 25 on p 45 of **KT&T** (answers can be found in “Appendix R”, p A76 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**, pp 39-44.

OUTCOMES

On completion of this study section, you should be able to:

- Only read through these few pages for taking cognisance.

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 50-109.

OUTCOMES

On 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.

STUDY UNIT CONTENT

ATOMIC STRUCTURE, PROTONS, ELECTRONS AND ATOMIC MASS

The time scheduled for this study section is an estimated 2 hours.

This study section is based on **KT&T**, pp 51-53.

OUTCOMES

On 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 53 to get an idea of a typical examination question.
- Do “Review and check for section 2.2” on p 53 of **KT&T** (answers can be found in “Appendix P”, p A63 in the back of the textbook).
- Answer questions 5 and 7 on p 98 of **KT&T** (answers can be found in “Appendix R”, p A77 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**, pp 54-58.

OUTCOMES

On 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 pp 56 and 57 to get an idea of a typical examination question . Do “Review and check for section 2.3” on p 55 of **KT&T** (answers can be found in “Appendix P”, p A63 in the back of the textbook).
- Do “Review and check for section 2.4” on p 57 of **KT&T** (answers can be found in “Appendix P”, p A63 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**, pp 58-66.

OUTCOMES

On 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, noble gases and the transition metals on the periodic table.

- Do “Review and check for section 2.5” on p 66 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 23, 25 and 27 on p 99 of **KT&T** (answers can be found in “Appendix R”,p A77 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**, pp 66-69.

OUTCOMES

On completion of this study section, you should be able to:

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

- Do “Review and check for section 2.6” on p 69 of **KT&T** (answers can be found in “Appendix P”, p A64 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**, pp 69-78.

OUTCOMES

On 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 pp 72 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 examples 2.4 and 2.5 on p 73 and 74 to get an idea of a typical examination question.
- Do "Review and check for section 2.7" on p 78 of **KT&T** (answers can be found in "Appendix P", p A64 in the back of the textbook).
- Answer questions 37, 39, 43, 45, 47, 49, 51 and 55 on p 100 of **KT&T** (answers can be found in "Appendix R", p A78 in the back of the textbook).

MOLECULAR COMPOUNDS: FORMULAE AND NAMES

The time scheduled for this study section is an estimated 1 hour.

This study section is based on **KT&T**, pp 78-79.

OUTCOMES

On 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 79 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 57 and 59 on p 101 of **KT&T** (answers can be found in "Appendix R”, p A78 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**, pp 80-85.

OUTCOMES

On completion of this study section, you should be able to:

- Know and understand that the molar mass of an element 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 82 to get an idea of a typical examination question.
- Study interactive example 2.7 on pp 84 and 85 to get an idea of a typical examination question.
- Do "Review and check for section 2.9" on p 85 of **KT&T** (answers can be found in "Appendix P", p A64 in the back of the textbook).
- Answer questions 61, 63, 65 and 67 on p 101 of **KT&T** (answers can be found in "Appendix R", p A78 in the back of the textbook).

DETERMINATION OF THE PERCENTAGE COMPOSITION, EMPIRICAL FORMULAE AND MOLECULAR FORMULAE OF A COMPOUND

The time scheduled for this study section is an estimated 2 hours.

This study section is based on **KT&T**,pp 85-94.

OUTCOMES

On 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.

- Study example 2.8 on pp 86 and 87 to get an idea of a typical examination question.
- Study interactive examples 2.9 and 2.10 on pp 88, 89 and 90 to get an idea of a typical examination question.
- Study example 2.11 on pp 90 and 91 to get an idea of a typical examination question.
- Do “Review and check for section 2.10” on pp 93 and 94 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 81, 83, 85 and 91 on p 102 of **KT&T** (answers can be found in “Appendix R”, p A78 in the back of the textbook).

HYDRATED COMPOUNDS

The time scheduled for this study section is an estimated 1½ hours.

This study section is based on **KT&T**, pp 94-96.

OUTCOMES

On completion of this study section, you should be able to:

- Use experimental data in order to calculate the number of water molecules in a hydrated compound.

- Study interactive example 2.12 on pp 95 and 96 to get an idea of a typical examination question.
- Do “Review and check for section 2.11” on p 96 of **KT&T** (answers can be found in “Appendix P”, p A64 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**, pp 110-154.

Study Section 3.8 is, however, based on a section of Chapter 20 of **KT&T**, pp 896-903.

OUTCOMES

On 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;
- recognise acids and bases and understand the behaviour of acids and bases in aqueous solutions;
- recognise the general reaction types of aqueous solutions;
- write down chemical equations for the general reaction types in aqueous solutions;
- know general oxidation and reduction reagents; and
- recognise oxidation-reduction reactions (redox reactions).

STUDY UNIT CONTENT

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**, pp 111-116.

OUTCOMES

On 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 113 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Study interactive example 3.1 on pp 115 and 116 to get an idea of a typical examination question.
- Do “Review and check for section 3.2” on p 116 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 1, 3 and 5 on p 148 of **KT&T** (answers can be found in "Appendix R”, p A80 in the back of the textbook).

INTRODUCTION TO CHEMICAL EQUILIBRIUM

The time scheduled for this study section is an estimated 1 hour.

This study section is based on **KT&T**, pp 116-119.

OUTCOMES

On completion of this study section, you should be able to:

- Know that chemical reactions are reversible;
- understand and be able to describe the term dynamic equilibrium; and
- recognise the difference between reagent-advantaged and product-advantaged reactions in equilibrium.

- Do “Review and check for section 3.3” on p 119 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Do question 7 on p 148 of **KT&T** (answers can be found in “Appendix R”, p A80 in the back of the textbook

AQUEOUS SOLUTIONS

The time scheduled for this study section is an estimated 2 hours.

This study section is based on **KT&T**, pp 119-128.

OUTCOMES

On completion of this study section, you should be able to:

- Recognise 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 table 3.10 on p 122 of KT&T will be supplied to you in tests and in 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 are formed when an ionic compound of an acid or a base dissolves in water.

- Study example 3.2 on pp 122 and 123 of KT&T to get an idea of a typical examination question.
- Do “Review and check for section 3.4” on p 123 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 9, 11 and 13 on pp 148 and 149 of **KT&T** (answers can be found in “Appendix R”, p A80 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**, pp 123-128.

OUTCOMES

On 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 125 of KT&T to get an idea of a typical examination question.
- Study "Problem Solving Tip 3.1" on p 126. This will provide you with valuable ideas about how to write down a net ionic equation.
- Study interactive example 3.4 on p 127 to get an idea of a typical examination question.
- Do "Review and check for section 3.5" on pp 127 and 128 of **KT&T** (answers can be found in "Appendix P", p A64 in the back of the textbook).
- Answer questions 17, 19 and 35 on pp 149 and 150 of **KT&T** (answers can be found in "Appendix R", p A80 in the back of the textbook)

ACIDS AND BASES

The time scheduled for this study section is an estimated 3 hours.

This study section is based on **KT&T**, pp 128-135.

OUTCOMES

On completion of this study section, you should be able to:

- Know the names and formulae of general acids and bases (see Table 3.1, p 129);
- categorise acids and bases as being a weak or a strong acid/base;
- define and use the Arrhenius concept of acids and bases;
- recognise compounds that are amphiprotic;
- identify Brønsted acid and Brønsted base in an acid-base reaction;
- predict the products of an acid-base reaction; and
- understand that the net ionic equation for the reaction of a strong acid with a strong base is the following: $\mathbf{H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(\mathit{l})}$

- Study example 3.5 on p 131 of KT&T to get an idea of a typical examination question.
- Study example 3.6 on p 134 of KT&T to get an idea of a typical examination question.
- Do “Review and check for section 3.6” on p 135 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 21, 23, 27 and 29 on p 149 of **KT&T** (answers can be found in “Appendix R”, p A80 in the back of the textbook).

GAS FORMATION REACTIONS

The time scheduled for this study section is an estimated 1½ hours.

This study section is based on **KT&T**, pp 136-137.

OUTCOMES

On 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 137 of KT&T to get an idea of a typical examination question.
- Do “Review and check for section 3.7” on p 137 of **KT&T** (answers can be found in “Appendix P”, p A64 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**, pp 137-144.

OUTCOMES

On completion of this study section, you should be able to:

- Identify simple and general oxidation and reduction reagents (see Table 3.3 on p 142);
- recognise a reaction as an oxidation-reduction reaction (redox reaction);
- know what compound (atom) in a reaction is oxidised 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 a set of guidelines.

- Study example 3.8 on pp 140 and 141 of KT&T to get an idea of a typical examination question.
- Study example 3.9 on p 143 of KT&T to get an idea of a typical examination question.
- Do “Review and check for section 3.8” on pp 143 and 144 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 45, 47 and 49 on p 150 of **KT&T** (answers can be found in “Appendix R”,p A80 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 20 of **KT&T** on pp896-903.

OUTCOMES

On 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 interactive example 20.1 on pp 897, 898 and 899 of KT&T to get an idea of a typical examination question for the balancing of a redox reaction in a neutral medium.
- Study interactive example 20.2 on pp 899, 900 and 901 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 20.3 on pp 901 and 902 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 20.1" on p 903. This will provide you with a valuable summary of how to balance oxidation-reduction equations.
- Do "Review and check for section 20.1" on p 903 of **KT&T** (answers can be found in "Appendix P", p A70 in the back of the textbook).
- Answer questions 1, 3 and 5 on p 937 of **KT&T** (answers can be found in "Appendix R",p A121 in the back of the textbook).

Study Section 3.9

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**, pp 144-146.

OUTCOMES

On 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 interactive example 3.10 on pp 145 and 146 to get an idea of a typical examination question.
- Do “Review and check for section 3.9” on p 146 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Answer questions 53 and 57 on p 151 of **KT&T** (answers can be found in “Appendix R”, p A81 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 entire study unit is based on Chapter 4 of **KT&T**, pp 156-207 and a small section of Chapter 14 of **KT&T**, pp 618-620.

OUTCOMES

On 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 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.

STUDY UNIT CONTENT

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**, pp 157-161.

OUTCOMES

On 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 organise stoichiometric information.

- Study "Problem Solving Tip 4.1" on p 159. This will provide you with valuable ideas about how to tackle a stoichiometric calculation.
- Study interactive example 4.1 on pp 159 and 160 to get an idea of a typical examination question.
- Do "Review and check for section 4.1" on p 161 of **KT&T** (answers can be found in "Appendix P", p A64 in the back of the textbook).
- Answer questions 1 and 3 on p 195 of **KT&T** (answers can be found in "Appendix R", p A82 in the back of the textbook).

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

The time scheduled for this study section is an estimated 2 hours.

This study section is based on **KT&T**, pp 161-165.

OUTCOMES

On 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 interactive example 4.2 on pp 163 and 164 to get an idea of a typical examination question.
- Do “Review and check for section 4.2” on p 164 of **KT&T** (answers can be found in “Appendix P”, p A64 in the back of the textbook).
- Study “Problem Solving Tip 4.2” on p 165. This will provide you with valuable ideas as to how to use molar amounts in chemical equations in order to calculate a limiting reagent.
- Answer questions 11, 13, 15 and 17 on p 196 of **KT&T** (answers can be found in “Appendix R”, pp A82 and A83 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- 165 and 166.

OUTCOMES

On 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 166 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 19 and 21 on p 196 of **KT&T** (answers can be found in “Appendix R”, p A83 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**, pp 166-172.

OUTCOMES

On 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 pp 168 and 169 to get an idea of a typical examination question.
- Study interactive example 4.4 on pp 170 and 171 to get an idea of a typical examination question.
- Study example 4.5 on pp 171 and 172 to get a further sense of a typical examination question.
- Do “Review and check for section 4.4” on p 172 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 23, 25, 27, 29 and 33 on pp 196 and 197 of **KT&T** (answers can be found in “Appendix R”, p A83 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**, pp 173-178 and **KT&T**, pp 618-620.

OUTCOMES

On 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 14, pp 618-620);
- 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 pp 175 and 4.7 on p 177 to get an idea of typical examination questions.
- Study "Problem Solving Tip 4.3" on p 177. This will provide you with valuable ideas about how to prepare a solution by means of dilution.
- Study example 14.1 on pp 619 and 620 to get an idea of a typical examination question.
- Do "Review and check for section 4.5" on p 177 of **KT&T** (answers can be found in "Appendix P", p A65 in the back of the textbook).
- Do "Review and check for section 14.1" on p 620 of **KT&T** (answers can be found in "Appendix P", p A68 in the back of the textbook).
- Answer questions 37, 39, 41, 43, 45, 47 and 49 on p 197 and 198 of **KT&T** (answers can be found in "Appendix R", p A83 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**, pp 178-180.

OUTCOMES

On 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 180 to get an idea of a typical examination question.
- Do “Review and check for section 4.6” on p . 180 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 53, 55 and 57 on p 198 of **KT&T** (answers can be found in “Appendix R”, p A83 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**, pp 181-188.

OUTCOMES

On 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 standardisation of a solution; and
- calculate the concentration of mole amounts of reagents from titration values.

- Study "Problem Solving Tip 4.4" on p 181. This will provide you with valuable ideas about how to prepare a solution by means of dilution.
- Study interactive example 4.9 on p 182 to get an idea of a typical examination question.
- Study interactive example 4.10 on pp 183 and 184 to get further ideas about typical examination questions.
- Study example 4.11 on p 185 to get an idea of a typical examination question.
- Study interactive example 4.12 on pp 185 and 186 to get further ideas about typical examination questions.
- Study example 4.13 on pp 186, 187 and 188 to get an idea of a typical examination question.
- Do "Review and check for section 4.7" on p 188 of **KT&T** (answers can be found in "Appendix P", p A65 in the back of the textbook).
- Answer questions 59, 63, 67 and 71 on pp 198 and 199 of **KT&T** (answers can be found in "Appendix R", p A83 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.

The entire study unit is based on parts of chapter 5 of **KT&T**, pp 208-250.

OUTCOMES

On completion of this study unit you should be able to:

- Assess the transfer of energy as heat (warmth) which is associated with changes in temperature and changes in condition;
- understand and be able to apply the first main law of thermodynamics;
- 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.

STUDY UNIT CONTENT

ENERGY: BASIC PRINCIPLES

The time scheduled for this study section is an estimated 2 hours.

This study section is based on **KT&T**, pp 209 - 212.

OUTCOMES

On completion of this study section, you should be able to:

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

- Do “Review and check for section 5.1” on p 212 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 1 and 3 on p 239 of **KT&T** (answers can be found in “Appendix R”, p A84 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**, pp 212-216.

OUTCOMES

On 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 thermodynamics.

- Study interactive example 5.1 on p 213 to get an idea of a typical examination question.
- Study "Problem Solving Tip 5.1" on p 215. This will provide you with valuable information about how to calculate the change in temperature (ΔT).
- Study interactive example 5.2 on p 215 to get an idea of a typical examination question.
- Do "Review and check for section 5.2" on pp 215 and 216 of **KT&T** (answers can be found in "Appendix P", p A65 in the back of the textbook).
- Answer questions 5, 7, 9 and 11 on p 240 of **KT&T** (answers can be found in "Appendix R", p A84 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**, pp 216-219.

OUTCOMES

On 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 interactive examples 5.3 and 5.4 on pp 217 and 218 to get an idea of typical examination questions.
- Do “Review and check for section 5.3” on p 219 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 17, 19 and 21 on p 240 of **KT&T** (answers can be found in “Appendix R”, p A85 in the back of the textbook).

THE FIRST LAW OF THERMODYNAMICS

The time scheduled for this study section is an estimated 3 hours.

This study section is based on **KT&T**, pp 219-223.

OUTCOMES

On completion of this study section, you should be able to:

- Understand the basis of the first law of thermodynamics;
- 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
- recognise condition functions of which the value are only determined through the condition of the system and not via the route through which the condition was obtained.

- Do “Review and check for section 5.4” on p 223 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).

ENTHALPY CHANGES FOR CHEMICAL REACTIONS

The time scheduled for this study section is an estimated 2½ hours.

This study section is based on **KT&T**, pp 224-226.

OUTCOMES

On 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 interactive example 5.5 on pp 225 and 226 to get an idea of a typical examination question.
- Do “Review and check for section 5.5” on p 226 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).
- Answer questions 25 and 27 on p 241 of **KT&T** (answers can be found in “Appendix R”, p A85 in the back of the textbook).

CALORIMETRY

The time scheduled for this study section is an estimated 1½ 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**,pp 226-230.

OUTCOMES

On completion of this study section, you should be able to:

- Describe how to measure the amount of energy transferred as heat during a reaction by means of calorimetry.

- Study interactive examples 5.6 and 5.7 on pp 227, 228 and 229 to get an idea of typical examination questions.
- Do “Review and check for section 5.6” on p 230 of **KT&T** (answers can be found in “Appendix P”, p A65 in the back of the textbook).

ENTHALPY CALCULATIONS

The time scheduled for this study section is an estimated 3 hours.

This study section is based on **KT&T**, pp 230-236.

OUTCOMES

On 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 (Appendix L, pp A-26 to A-31 in the back of the textbook);
- apply Hess' Law to calculate the change in enthalpy, $\Delta_r H^o$, for a reaction;
- know how to draw energy-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 interactive example 5.8 on p 232 to get an idea of a typical examination question.
- Study "Problem Solving Tip 5.2" on p 233. This will provide you with valuable ideas about how to use the Law of Hess.
- Study interactive example 5.9 on p 235 to get a further good idea of typical examination questions.
- Do "Review and check for section 5.7" on pp 235 and 236 of **KT&T** (answers can be found in "Appendix P", p A65 in the back of the textbook).
- Answer questions 41, 43, 45 and 49 on pp 242 and 243 of **KT&T** (answers can be found in "Appendix R", p A85 in the back of the textbook).

PRODUCT- OR REAGENT-ADVANTAGED REACTIONS AND THERMODYNAMICS

The time scheduled for this study section is an estimated 1 hour.

This study section is based on **KT&T**, pp 236-238.

OUTCOMES

On 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 MANAGEMENT OF CHEMICAL REACTIONS

CONTENTS of STUDY DIVISION

The time scheduled for this Study Division is an estimated 75 hours.

Study Division B is based on parts of **Chapters 15, 16, 17 and 18** 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 15,** pp 668-718 of **KT&T**.

OUTCOMES

On 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 can influence 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.

CONTENT OF STUDY UNIT

RATES OF CHEMICAL REACTIONS

The time scheduled for this study section is an estimated 2½ hours.

This study section is based on **KT&T**, pp 669-674.

OUTCOMES

On 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 examples 15.1 and 15.2 on pp 672 and 673 to get an idea of typical examination questions.
- Do “Review and check for section 15.1” on pp 673 and 674 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).
- Answer questions 1, 3 and 5 on p 708 of **KT&T** (answers can be found in “Appendix R”, p A111 in the back of the textbook).

REACTION CONDITIONS AND RATE

The time scheduled for this study section is an estimated 1½ hours.

This study section is based on **KT&T**, pp 674-675.

OUTCOMES

On 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**, pp 675-681.

OUTCOMES

On 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 interactive example 15.3 on p 679 to get an idea of a typical examination question.
- Study example 15.4 on p 680 to get even more of an idea of a typical examination question.
- Do “Review and check for section 15.3” on p 681 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).
- Answer questions 7 and 11 on p 709 of **KT&T** (answers can be found in “Appendix R”, p A111 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**, pp 681-689.

OUTCOMES

On 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 examples 15.5, 15.6 and 15.7 on pp 682 to 684 to get an idea of typical examination questions.
- Study example 15.8 on pp 687 and 688 to get even more of an idea of a typical examination question.
- Study interactive example 15.9 on p 688 to get another idea of a typical examination question.
- Do “Review and check for section 15.4” on pp 688 and 689 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).

Study Section 6.5

A MICROSCOPIC VIEW OF REACTION RATES

The time scheduled for this study section is an estimated 3 hours.

This study section (Study Section 6.5) 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**, pp 689-697.

OUTCOMES

On completion of this study section, you should be able to:

- Describe the collision theory of reaction rates;
- create a link between the activating energy (E_a) of a reaction with the rate of a reaction;
- use collision theory to describe the effect of reagent concentration on reaction rate;
- understand the effect of molecular orientation on reaction rate;
- describe the effect of temperature on reaction rate by making use of collision theory and the Arrhenius equation;
- use equations 15.5 (p 693), 15.6 (p 693) and 15.7 (p 694) to calculate the activating energy from rate constants at different temperatures; and
- describe the function and effect of a catalyst on activating energy.

- Study examples 15.10 and 15.11 on pp 693, 694 and 695 to get an idea of typical examination questions.
- Do “Review and check for section 15.5” on p 697 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).

REACTION MECHANISMS

The time scheduled for this study section is an estimated 2 hours.

This study section (Study Section 6.6) 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**,pp 697-706.

OUTCOMES

On completion of this study section, you should be able to:

- Understand the concept of a reaction mechanism;
- describe the elementary steps of a mechanism; and
- define the rate-determining step in a mechanism and identify all the intermediate reaction.

- Study example 15.12 on pp 699 and 700 to get an idea of a typical examination question.
- Study example 15.13 on p 703 to get even more of an idea of a typical examination question.
- Study “Problem Solving Tip 15.1” on p 705. This will provide you with valuable ideas about the linking of rate equations and reaction mechanisms.
- Study example 15.14 on pp 705 and 706 to get even more of an idea of a typical examination question.
- Do “Review and check for section 15.6” on p 706 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).

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 16,** pp 720-754 of **KT&T**.

OUTCOMES

On 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 in gas phase;
- combine chemical reaction equations in order to obtain a new reaction equation and to deduce the corresponding 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.

CONTENTS OF STUDY UNIT 7

CHEMICAL EQUILIBRIUM: A SURVEY

The time scheduled for this study section is an estimated ½ hour.

This study section is based on **KT&T**, pp 721-722.

OUTCOMES

On 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 16.1” on p 722 of **KT&T** (answers can be found in “Appendix P”, p A68 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**, pp 722-730.

OUTCOMES

On 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 concentrations 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}; and
- use the reaction quotient, Q, to determine whether a reaction is product-advantaged, reagent-advantaged or at equilibrium.

- Study example 16.1 on p 725 to get an idea of a typical examination question.
- Study interactive example 16.2 on p 729 to get a further idea of a typical examination question.
- Do “Review and check for section 16.2” on p 730 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).
- Answer questions 1, 3 and 5 on p 748 of **KT&T** (answers can be found in “Appendix R”, p A113 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**, pp 730-733.

OUTCOMES

On completion of this study section, you should be able to:

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

- Study interactive example 16.3 on pp 731 and 732 to get an idea of a typical examination question.
- Study example 16.4 on pp 732 and 733 to get a further idea of a typical examination question.
- Do “Review and check for section 16.3” on p 733 of **KT&T** (answers can be found in “Appendix P”, p A68 in the back of the textbook).
- Answer questions 7 and 9 on p 748 of **KT&T** (answers can be found in “Appendix R”, p A113 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**, pp 733-737.

OUTCOMES

On 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 interactive example 16.5 on pp 733 and 734 to get an idea of a typical examination question.
- Study "Problem Solving Tip 16.1" on p 736. 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-2 to A-5 there is a good explanation of how to use logarhithms and how to solve a quadratic equation. Study this if you do not know how to do it.**
- Study interactive example 16.6 on pp 736 and 737 to get an idea of a typical examination question.
- Do "Review and check for section 16.4" on p 737 of **KT&T** (answers can be found in "Appendix P", p A68 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**, pp 738-740.

OUTCOMES

On completion of this study section, you should be able to:

- Know how the equilibrium constant, K, changes when other stoichiometric coefficients 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 "Problem Solving Tip 16.2" on p 739. This will provide you with valuable ideas about how the equilibrium constant, K, changes when other stoichiometric coefficients 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.
- Study example 16.7 on pp 739 and 740 to get an idea of a typical examination question.
- Do "Review and check for section 16.5" on p 740 of **KT&T** (answers can be found in "Appendix P", p A69 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 7.6) 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**, pp 740-745.

OUTCOMES

On completion of this study section, you should be able 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) by making use of Le Chatelier's principle.

- Study interactive example 16.8 on pp 742 and 743 to get an idea of a typical examination question.
- Do "Review and check for section 16.6" on p 745 of **KT&T** (answers can be found in "Appendix P", p A69 in the back of the textbook).

PRINCIPLES OF CHEMICAL REACTIVITY: THE 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 17**, pp 756-804.

OUTCOMES

On 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.

CONTENTS OF STUDY UNIT 8

ACIDS AND BASES: A SURVEY

The time scheduled for this study section is an estimated 1 hour.

This study section is based on **KT&T**, pp 757-758.

OUTCOMES

On completion of this study section, you should be able to:

- Define and use the Brønsted concept of acids and bases.

- Do “Review and check for section 17.1” on p 758 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).

THE EXTENDED 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**, pp 758-760.

OUTCOMES

On completion of this study section, you should be able to:

- Define and use the Brønsted concept of acids and bases;
- recognise monoprotic and polyprotic acids and bases and write down balanced reaction equations for their ionisation 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 17.2” on p 760 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 1, 3, 5 and 7 on p 797 of **KT&T** (answers can be found in “Appendix R”, p A114 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**, pp 760-763.

OUTCOMES

On completion of this study section, you should be able to:

- Describe what is meant by the auto-ionisation of water;
- define and be able to use the ionisation 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 17.1 on p 762 to get an idea of a typical examination question.
- Do “Review and check for section 17.3” on p 763 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 9, 11 and 13 on p 797 of **KT&T** (answers can be found in “Appendix R”, p A114 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**, pp 764-769.

OUTCOMES

On completion of this study section, you should be 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 17.1” on p 765. This will give you valuable information as to when an acid or a base is strong or weak.
- Do “Review and check for section 17.4” on p 769 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 15, 17, 19 and 21 on p 798 of **KT&T** (answers can be found in “Appendix R”, p A115 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**, pp 769-771.

OUTCOMES

On completion of this study section, you should be able to:

- Predict, with the help of Table 17.4 on p 770, whether salts in solution will be neutral, acidic or base in nature.

- Study interactive example 17.2 on pp 770 and 771 to get an idea of a typical examination question.
- Study "Problem Solving Tip 17.2" on p 771. 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 17.5" on p 771 of **KT&T** (answers can be found in "Appendix P", p A69 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**, pp 771-774.

OUTCOMES

On 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 17.3 on p 773 to get an idea of a typical examination question.
- Do “Review and check for section 17.6” on p 774 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 33 and 35 on p 798 of **KT&T** (answers can be found in “Appendix R”, p A115 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**, pp 774-775.

OUTCOMES

On completion of this study section, you should be able to:

- Understand and to know what the results of the following types of acid-base reactions will be:
  - 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 ”eview and check for section 17.7” on p 775 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).

CALCULATIONS WITH EQUILIBRIUM CONSTANTS

The time scheduled for this study section is an estimated 5 hours.

This study section is based on **KT&T**, pp 776-785.

OUTCOMES

On 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 interactive example 17.4 on pp 776 and 777 to get an idea of a typical examination question.
- Study interactive example 17.5 on pp 778 and 779 to get further ideas of a typical examination question.
- Study example 17.6 on pp 779 and 780 to get further ideas of a typical examination question.
- Also study interactive examples 17.7 and 17.8 on pp 781 tot 783 to get an idea of a typical examination question.
- Study “Problem Solving Tip 17.3” on p 783. 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 17.8” on pp 784 and 785 of **KT&T** (answers can be found in “Appendix P”, p A69 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**, pp 785-786.

OUTCOMES

On completion of this study section, you should be able to:

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

- Study example 17.9 on pp 785 and 786 to get an idea of a typical examination question.
- Do “Review and check for section 17.9” on p 786 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 65 and 67 on p 800 of **KT&T** (answers can be found in “Appendix R”, p A115 in the back of the textbook).

MOLECULAR STRUCTURE, BINDING AND ACID-BASE ACTION

The time scheduled for this study section is an estimated 1½ hours.

This study section (Study Section 8.10) 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**, pp 787-791.

OUTCOMES

On completion of this study section, you should be able to:

- Indicate the relationship that exists between the structure of a compound and its acid-base characteristics.

- Do “Review and check for section 17.10” on p 791 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).

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**, pp 791-795.

OUTCOMES

On 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 17.11” on p 795 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 73 and 75 on p 800 of **KT&T** (answers can be found in “Appendix R”, p A115 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 18**, pp 806-856.

OUTCOMES

On 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 solution 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.

CONTENT OF STUDY UNIT 9

THE COMMON ION EFFECT

The time scheduled for this study section is an estimated 4 hours.

This study section is based on **KT&T**, pp 807-810.

OUTCOMES

On completion of this study section, you should be 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 interactive example 18.1 on pp 809 and 810 to get an idea of a typical examination question.
- Do “Review and check for section 18.1” on p 810 of **KT&T** (answers can be found in “Appendix P”, p A69 in the back of the textbook).
- Answer questions 1, 3 and 5 on p 848 of **KT&T** (answers can be found in “Appendix R”, p A116 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**, pp 810-818.

OUTCOMES

On completion of this study section, you should be able to:

- Describe the function of a buffer solution;
- use the Henderson-Hasselbach equation (equation 18.2 on p 813) to 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 interactive example 18.2 on pp 812 to get an idea of a typical examination question.
- Study examples 18.3 and 18.4 on pp 813 to 815 to get more of an idea of a typical examination question.
- Study "Problem Solving Tip 18.1" on p 816. This will provide you with a valuable summary of the most important aspect of buffer solutions.
- Study example 18.5 on pp 816 and 817 to get more of an idea of a typical examination question.
- Do "Review and check for section 18.2" on pp 817 and 818 of **KT&T** (answers can be found in "Appendix P", p A69 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**, pp 818-828.

OUTCOMES

On 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 interactive example 18.6 on pp 822 and 823 to get an idea of a typical examination question.
- Study example 18.7 on pp 825 and 826 to get more of an idea of a typical examination question.
- Study "Problem-solving Tip 18.2" on p 826. 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 18.3" on p 828 of **KT&T** (answers can be found in "Appendix P", p A69 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**, pp 828-838.

OUTCOMES

On 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 interactive examples 18.8 and 18.9 on pp 830 to 832 to get an idea of typical examination questions.
- Study example 18.10 on pp 832 and 833 to get more of an idea of a typical examination question.
- Study examples 18.11 and 18.2 on pp 835 and 836 to get more of an idea of a typical examination question.
- Do “Review and check for section 18.4” on p 838 of **KT&T** (answers can be found in “Appendix P”, p A69 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**, pp 839-843.

OUTCOMES

On 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 interactive examples 18.13 and 18.14 on pp 840 to 842 to get an idea of typical examination questions.
- Study examples 18.15 on pp 842 and 843 to get more of an idea of a typical examination question.
- Do “Review and check for section 18.5” on p 843 of **KT&T** (answers can be found in “Appendix P”, p A70 in the back of the textbook).

THE EQUILIBRIUMS OF COMPLEX IONS

The time scheduled for this study section is an estimated 1 hour.

This study section (Study Section 9.6) 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**, pp 843-844.

OUTCOMES

On completion of this study section, you should be able to:

- Understand that the formation of a complex ion can increase the solubility of an insoluble salt.

- Study example 18.16 on p 844 to get an idea of a typical examination question.
- Do “Review and check for section 18.6” on p 844 of **KT&T** (answers can be found in “Appendix P”, p A70 in the back of the textbook).

THE SOLUBILITY OF COMPLEX IONS

The time scheduled for this study section is an estimated 1 hour.

This study section (Study Section 9.7) 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**, pp 844-846.

OUTCOMES

On completion of this study section, you should be able to:

- Understand that the formation of complex ions can lead to an increase in the solubility of an insoluble salt.

- Study example 18.17 on p 846 to get an idea of a typical examination question.
- Do “Review and check for section 18.7” on p 846 of **KT&T** (answers can be found in “Appendix P”, p A70 in the back of the textbook).

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																	18
Hydrogen 1 H 1.01 2.1	2											13	14	15	16	17	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		3	4	5	6	7	8	9	10	11	12	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^-	dihydrogen phosphate	$H_2PO_4^-$	oxalate	$C_2O_4^{2-}$
arsenate	AsO_4^{3-}	hydrogen carbonate	HCO_3^-	perchlorate	ClO_4^-
arsenite	AsO_3^{3-}	hydrogen oxalate	$HC_2O_4^-$	periodate	IO_4^-
benzoate	$C_6H_5COO^-$	hydrogen sulfate	HSO_4^-	permanganate	MnO_4^-
borate	BO_3^{3-}	hydrogen sulfide	HS^-	peroxide	O_2^{2-}
bromate	BrO_3^-	hydrogen sulfite	HSO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	hydroxide	OH^-	pyrophosphate	$P_2O_7^{4-}$
chlorate	ClO_3^-	hypochlorite	ClO^-	sulfate	SO_4^{2-}
chloride	Cl^-	iodate	IO_3^-	sulfite	SO_3^{2-}
chlorite	ClO_2^-	monohydrogen phosphate	HPO_4^{2-}	thiocyanate	SCN^-
chromate	CrO_4^{2-}	nitrate	NO_3^-	thiosulfate	$S_2O_3^{2-}$
cyanate	CNO^-	nitrite	NO_2^-	**POSITIVE POLYATOMIC IONS**	
cyanide	CN^-	orthosilicate	SiO_4^{4-}	ammonium	NH_4^+
dichromate	$Cr_2O_7^{2-}$			hydronium	H_3O^+

PERIODIC TABLE OF IONS

KEY: atomic number → 26 Fe^{3+} iron (III) ← ion charge; symbol → Fe^{2+} iron (II) ← ion name (IUPAC)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H^+ hydrogen																1 H^- hydride	2 He helium
3 Li^+ lithium	4 Be^{2+} beryllium											5 B boron	6 C carbon	7 N^{3-} nitride	8 O^{2-} oxide	9 F^- fluoride	10 Ne neon
11 Na^+ sodium	12 Mg^{2+} magnesium											13 Al^{3+} aluminum	14 Si silicon	15 P^{3-} phosphide	16 S^{2-} sulfiide	17 Cl^- chloride	18 Ar argon
19 K^+ potassium	20 Ca^{2+} calcium	21 Sc^{3+} scandium	22 Ti^{4+} titanium (IV); Ti^{3+} titanium (III)	23 V^{3+} vanadium(III); V^{5+} vanadium (V)	24 Cr^{3+} chromium (III); Cr^{2+} chromium (II)	25 Mn^{2+} manganese(II); Mn^{4+} manganese(IV)	26 Fe^{3+} iron (III); Fe^{2+} iron (II)	27 Co^{2+} cobalt (II); Co^{3+} cobalt (III)	28 Ni^{2+} nickel (II); Ni^{3+} nickel (III)	29 Cu^{2+} copper (II); Cu^+ copper (I)	30 Zn^{2+} zinc	31 Ga^{3+} gallium	32 Ge^{4+} germanium	33 As^{3-} arsenide	34 Se^{2-} selenide	35 Br^- bromide	36 Kr krypton
37 Rb^+ rubidium	38 Sr^{2+} strontium	39 Y^{3+} yttrium	40 Zr^{4+} zirconium	41 Nb^{5+} niobium (V); Nb^{3+} niobium(III)	42 Mo^{6+} molybdenum	43 Tc^{7+} technetium	44 Ru^{3+} ruthenium(III); Ru^{4+} ruthenium(IV)	45 Rh^{3+} rhodium	46 Pd^{2+} paladium(II); Pd^{4+} paladium(IV)	47 Ag^+ silver	48 Cd^{2+} cadmium	49 In^{3+} indium	50 Sn^{4+} tin (IV); Sn^{2+} tin (II)	51 Sb^{3+} antimony(III); Sb^{5+} antimony(V)	52 Te^{2-} telluride	53 I^- iodide	54 Xe xenon
55 Cs^+ cesium	56 Ba^{2+} barium	57 La^{3+} lanthanum	72 Hf^{4+} hafnium	73 Ta^{5+} tantalum	74 W^{6+} tungsten	75 Re^{7+} rhenium	76 Os^{4+} osmium	77 Ir^{4+} iridium	78 Pt^{4+} platinum(IV); Pt^{2+} platinum(II)	79 Au^{3+} gold (III); Au^+ gold (I)	80 Hg^{2+} mercury (II); Hg^+ mercury (I)	81 Tl^+ thallium (I); Tl^{3+} thallium(III)	82 Pb^{2+} lead (II); Pb^{4+} lead (IV)	83 Bi^{3+} bismuth(III); Bi^{5+} bismuth(V)	84 Po^{2+} polonium(II); Po^{4+} polonium(IV)	85 At^- astatide	86 Rn radon
87 Fr^+ francium	88 Ra^{2+} radium	89 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

TABLE 1: GUIDELINES TO PREDICT THE SOLUBILITY OF IONIC COMPOUNDS (Figure 3.10, p 122 of KT&T)

SOLUBLE COMPOUNDS	
Almost all salts of Na^+, K^+, NH_4^+ **Salts of:** nitrate, NO_3^- chlorate, ClO_3^- perchlorate, ClO_4^- acetate, $CH_3CO_2^-$	**EXCEPTIONS**
Almost all salts of Cl^-, Br^-, I^-	Halides of Ag^+, Hg_2^{2+}, Pb^{2+}
Salts containing F^-	Fluorides of Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
Salts of sulfate, SO_4^{2-}	Sulfates of Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Ag^+

INSOLUBLE COMPOUNDS	
	EXCEPTIONS
Most salts of: Carbonate, CO_3^{2-} Phosphate, PO_4^{3-} Oxalate, $C_2O_4^{2-}$ Chromate, CrO_4^{2-} Sulfide, S^{2-}	Salts of NH_4^+ and the alkali metal cations
Most metal hydroxides and oxides	Alkali metal hydroxides and $Ba(OH)_2$ and $Sr(OH)_2$