Recent Topics in Advanced Materials Science

Recent Topics in Advanced Materials Science:

Element by Element

By

Akio Makishima

Cambridge
Scholars
Publishing

Recent Topics in Advanced Materials Science: Element by Element

By Akio Makishima

This book first published 2019

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-4029-4
ISBN (13): 978-1-5275-4029-3

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

In this book, topics of organic chemistry are not separated from those of inorganic chemistry. This has not been done before. Most organic chemistry topics appear from section twelve (Zr, Hf, and Ta) to section sixteen (Pd and Pt), because these elements form new complexes and work as catalysts for reactions in organic chemistry.

Part Four discusses specific topics not included in Parts One, Two, and Three. These topics include catalysts for cars (section nineteen), anti-Markovnikov reactions (twenty), zeolites and luminescence (twenty-one), Perovskites materials (twenty-two), MOF materials (twenty-three), water harvesting and purification (twenty-four), functional polymers (twenty-five), artistic molecules (twenty-six), molecular machines (twenty-seven), and ecological topics (twenty-eight).

You will notice that this book discusses materials science in terms of industrial, inorganic, and organic chemistry, but contains only a few mentions of biochemistry or life-related-sciences, which form a large proportion of this field today. Of course, this can be inferred from the title, and the author intentionally removed such topics because these topics have been summarized in another of the author's books, *Biochemistry in Materials Science: Catalysts, Complexes and Proteins* (Makishima, 2018). The books, therefore, act as a companion to each other.

Index of periodic tables.

A. Part One, Two and Three (Sections from One to Eighteen)

$H^{1}_{8,12}$																He^{2}
$Li^{3}_{4,8,10}$	Be^{4}	ELEMENT$^{Main}_{Sub}$Section number									$B^{4}_{5,7,10,13,18}$	$C_{1,4,5}{}^{6}_{8\text{-}12,16,18}$	$N_{4,5}{}^{8}_{9\text{-}11,13\text{-}16}$	$O_{8}{}^{9}_{10\text{-}14,16,18}$	$F_{4\text{-}9}{}^{10}_{11,14,16,18}$	Ne^{2}
$Na_{2}{}^{5}_{8}$	$Mg_{4,8,10}$										$Al_{1}{}^{4}_{8,10,11,15}$	$Si_{3,4}{}^{7}_{8,9,14,18}$	$P_{3,6,7}{}^{8}_{10,11,14,16}$	$S_{6,8}{}^{9}_{10\text{-}14,16,17}$	$Cl_{3,5,7,9}{}^{10}_{16,17}$	Ar
$K_{3,4,}{}^{5}_{10,16\text{-}18}$	$Ca^{5}_{10,14}$	Sc_{14}	$Ti_{1,4}{}^{11}$	$V_{4}{}^{11}$	$Cr_{8}{}^{11}$	$Mn_{3,7}{}^{11}_{14}$	$Fe_{3,8}{}^{11}_{17}$	$Co_{3,8,10}{}^{11}$	$Ni_{3,8,9}{}^{11}$	$Cu_{5,8,9}{}^{11}_{15,16}$	$Zn_{3,7\text{-}10}{}^{11}_{12,14,17}$	$Ga^{4}_{6,8}$	Ge^{7}_{8}	As^{8}	$Se_{8}{}^{9}_{13}$	$Br_{16,17}$	Kr
Rb^{5}	Sr	Y^{18}	$Zr_{4,8}{}^{12}_{18}$	Nb_{10}	$Mo_{8,11}{}^{13}$	Tc	$Ru_{9}{}^{14}$	$Rh_{10}{}^{15}$	$Pd_{6,8,10,13}{}^{16}$	$Ag_{3,13,16,17}$	$Cd_{9,11}$	In^{4}_{6}	$Sn_{4,5,8}$	$Sb_{5,6}{}^{8}_{16\text{-}18}$	$Te_{8,9}$	$I_{9}{}^{10}_{14,16}$	Xe^{10}
Cs^{5}_{6}	Ba	L	$Hf_{4}{}^{12}$	$Ta_{10}{}^{12}$	$W_{4,8}{}^{13}$	Re	Os^{14}	$Ir_{9,11}{}^{15}$	$Pt^{16}_{17,18}$	$Au_{9,16}{}^{17}$	Hg^{17}	Tl_{8}	$Pb_{1,2,5,8,17}$	$Bi_{5}{}^{8}$	Po	At	Rn
Fr	Ra	A	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

L	La^{18}	$Ce_{5}{}^{18}$	Pr^{18}	Nd^{18}	Pm	Sm	$Eu_{1}{}^{18}$	$Gd_{1,4}{}^{18}$	$Tb_{1}{}^{18}$	Dy^{18}	Ho^{18}	Er^{18}	Tm	Yb	Lu^{18}
A	Ac	$Th_{5}{}^{18}$	Pa_{5}	$U_{5,11}{}^{18}$	Np^{18}	Pu^{18}	Am	Cm^{18}	Bk^{18}	Cf	Es	Fm	Md	No	Lr

B. Part Four (Sections from Nineteen to Twenty-eight)

H^{24}_{28}																He
Li	Be	ELEMENT$^{Main}_{Sub}$Section number									$B^{25}_{26\text{-}28}$	$C^{19\text{-}22}_{23}{}^{25,26}_{27,28}$	$N^{19\text{-}25}_{27,28}$	$O^{19\text{-}21}_{23}{}^{24,25}_{27,28}$	$F^{24}_{25,26,28}$	Ne
$Na_{25,28}$	$Mg_{25}{}^{28}$										Al^{21}	$Si^{21,24}_{25}{}^{28}$	$P_{21}{}^{25,26,28}$	$S^{19,20}_{21,22,25}{}^{26}_{28}$	$Cl^{20}_{22,28}$	Ar
K^{26}_{28}	Ca	Sc	Ti	V	Cr_{24}	Mn	Fe^{26}	Co^{24}	$Ni_{24,27}$	$Cu^{21,23}_{24}{}^{28}$	Zn^{23}	Ga	Ge	As^{28}	Se	$Br^{20,22}_{25\text{-}27}$	Kr
Rb	Sr^{21}	Y	$Zr_{19}{}^{24}$	Nb	Mo	Tc	$Ru^{19,20,26}$	Rh^{19}	$Pd^{19,20,26,27}$	Ag^{21}_{23}	Cd^{24}	In	Sn^{26}	Sb	Te	$I^{22,26}$	Xe
Cs	Ba	L	Hf	Ta	W^{24}	Re	Os	Ir	$Pt^{19,20}$	Au^{21}	Hg^{24}	Tl	Pb^{22}_{24}	Bi	Po	At	Rn
Fr	Ra	A	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

L	La	Ce^{19}	Pr^{19}	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
A	Ac	Th	Pa	$U^{23,28}$	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

The author was once a pure materials-scientist in a company. Then he became an analytical geochemist in the Institute for Study of the Earth's Interior (ISEI), Okayama University at Misasa, which has been recently renovated into the Institute for Planetary Materials (IPM). He achieved his professorship in 2006 in ISEI, and he has published over 60 scientific papers. He had to give up research activities at 55 years old because of his health problems, and so he became an author of modern sciences. He has already published three books: *Thermal Ionization Mass Spectrometry (TIMS): Silicate Digestion, Separation and Measurement* (Makishima 2016); *Origins of the Earth, Moon, and Life: An Interdisciplinary Approach* (Makishima 2017); and *Biochemistry in Materials Science: Catalysts, Complexes and Proteins* (Makishima 2018). This is his fourth book. These books represent his wide interests in science. The author is very much fascinated by the beauty of inorganic materials, as well as biochemical materials, especially the chemical formulae of inorganic complexes as described in section twenty-six of this book.

References

Makishima, Akio. 2016. *Thermal ionization mass spectrometry (TIMS). Silicate digestion, Separation, Measurement.* Weinheim: Wiley-VCH Verlag GmbH & Co. KGaA.

Makishima, Akio. 2017. *Origins of the Earth, Moon and Life: a Multidisciplinary Approach.* Amsterdam: Elsevier.

Makishima, Akio. 2018. *Biochemistry in Materials Science: Catalysts, complexes and proteins.* Amsterdam: Elsevier.

PART ONE:

TOPICS FOR TYPICAL ELEMENTS

SECTION ONE

PHYSICAL CONSTANTS AND HYDROGEN RELATED TOPICS

Chapter 1.1. The new proton's atomic mass

Heiße et al. (2017) reported the precise measurement of a single proton's atomic mass with a purpose-built Penning-trap system. A comparison with the previous data is shown in Fig. 1-1.

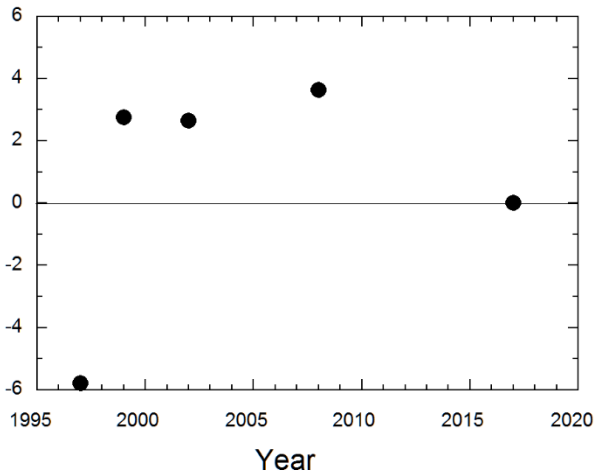

Fig. 1-1.