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LANGE'S HANDBOOK OF CHEMISTRY

Editor: JOHN A. DEAN

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University of Tennessee (Knoxville)*

*Formerly Compiled and Edited by
NORBERT ADOLPH LANGE, Ph.D.*

ELEVENTH EDITION

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**LANGE'S
HANDBOOK OF
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The editors for this book were Harold B. Crawford and Ross J. Kepler, and its production was supervised by Teresa F. Leaden. It was set in Fototronic Bodoni by York Graphic Services, Inc.

It was printed and bound by The Colonial Press Inc.

PERIODIC TABLE

| | | Groups | | | | | | | |
|---------|-------------------|----------------------|------------------------------|--------------------------|-------------------|--------------------|---------------------|---------------------|--------------------|
| | | Ia | IIa | IIIb | IVb | Vb | VIb | VIIb | VIII |
| Periods | | <i>Alkali metals</i> | <i>Alkaline earth metals</i> | | | | | | |
| | 1 | 1 H 1.0079 | | | | | | | |
| | 2 | 3 Li 6.941 | 4 Be 9.0122 | | | | | | |
| | 3 | 11 Na 22.9898 | 12 Mg 24.305 | <i>Transition Metals</i> | | | | | |
| | 4 | 19 K 39.098 | 20 Ca 40.08 | 21 Sc 44.956 | 22 Ti 47.90 | 23 V 50.941 | 24 Cr 51.996 | 25 Mn 54.9380 | 26 Fe 55.847 |
| | 5 | 37 Rb 85.468 | 38 Sr 87.62 | 39 Y 88.906 | 40 Zr 91.22 | 41 Nb 92.906 | 42 Mo | 43 Tc 98.906 | 44 Ru 101.07 |
| | 6 | 55 Cs 132.9054 | 56 Ba 137.34 | 57 La 138.905 | 58 to 71 | 72 Hf 178.49 | 73 Ta 180.948 | 74 W 183.85 | 75 Re 186.2 |
| 7 | 87 Fr (223) | 88 Ra 226.025 | 89 Ac (227) | 90 to 103 | 104 (Rf)(Ku) | 105 Ha | | | |

| | | <i>Inner-transition metals</i> | | | | | |
|---|------------------|--------------------------------|--------------------|---------------------|---------------------|--------------------|---------------------|
| | | 6 | <i>Lanthanides</i> | | | 58 Ce 140.12 | 59 Pr 140.908 |
| 7 | <i>Actinides</i> | | | 90 Th 232.038 | 91 Pa 231.036 | 92 U 238.029 | 93 Np 237.048 |

| Groups | | | | | | | | | |
|--------------------------|-------------------|---------------------|--------------------|--|--------------------|----------------------|--------------------|---------------------|--------------------|
| VIII | Ib | IIb | IIIa | IVa | Va | VIa | VIIa | O | |
| | | | | | | | | | <i>Noble gases</i> |
| | | | | | | | | | 2 He 4.0026 |
| | | | | <i>Representative elements (nonmetals)</i> | | | | | |
| | | | | 5 B 10.81 | 6 C 12.011 | 7 N 14.0067 | 8 O 15.9994 | 9 F 18.9984 | 10 Ne 20.179 |
| | | | | 13 Al 26.9815 | 14 Si 28.086 | 15 P 30.9738 | 16 S 32.06 | 17 Cl 35.453 | 18 Ar 39.948 |
| <i>Transition Metals</i> | | | | 31 Ga 69.72 | 32 Ge 72.59 | 33 As 74.9216 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.80 |
| 27 Co 58.9332 | 28 Ni 58.71 | 29 Cu 63.546 | 30 Zn 65.38 | 49 In 114.82 | 50 Sn 118.69 | 51 Sb 121.75 | 52 Te 127.60 | 53 I 126.9045 | 54 Xe 131.30 |
| 45 Rh 102.905 | 46 Pd 106.4 | 47 Ag 107.868 | 48 Cd 112.40 | 81 Tl 204.37 | 82 Pb 207.2 | 83 Bi 208.9804 | 84 Po (210) | 85 At (210) | 86 Rn (222) |
| | | | | <i>Representative elements (metals)</i> | | | | | |

OF THE ELEMENTS

(1971 values for atomic weights)

| <i>Inner-transition metals</i> | | | | | | | | | |
|--------------------------------|--------------------|--------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|--------------------|
| 62 Sm 150.4 | 63 Eu 151.96 | 64 Gd 157.25 | 65 Tb 158.925 | 66 Dy 162.50 | 67 Ho 164.930 | 68 Er 167.26 | 69 Tm 168.934 | 70 Yb 173.04 | 71 Lu 174.97 |
| 94 Pu (242) | 95 Am (243) | 96 Cm (247) | 97 Bk (247) | 98 Cf (249) | 99 Es (254) | 100 Fm (253) | 101 Md (256) | 102 No (254) | 103 Lr (257) |

To those workers in science who through their labors determined the values recorded herein, this compilation is dedicated. Their devotion to the search for the constants of nature and the dissemination of this knowledge are the foundations upon which rest the achievements of applied science.

PREFACE TO THE FIRST EDITION

This book is the result of a number of years' experience in the compiling and editing of data useful to chemists. In it an effort has been made to select material to meet the needs of chemists who cannot command the unlimited time available to the research specialist, or who lack the facilities of a large technical library which so often is not conveniently located at many manufacturing centers. If the information contained herein serves this purpose, the compiler will feel that he has accomplished a worthy task. Even the worker with the facilities of a comprehensive library may find this volume of value as a time-saver because of the many tables of numerical data which have been especially computed for this purpose.

Every effort has been made to select the most reliable information and to record it with accuracy. Many years of occupation with this type of work bring a realization of the opportunities for the occurrence of errors, and while every endeavor has been made to prevent them, yet it would be remarkable if the attempts towards this end had always been successful. In this connection it is desired to express appreciation to those who in the past have called attention to errors and it will be appreciated if this be done again with the present compilation for the publishers have given their assurance that no expense will be spared in making the necessary changes in subsequent printings.

It has been aimed to produce a compilation complete within the limits set by the economy of available space. One difficulty always at hand to the compiler of such a book is that he must decide what data are to be excluded in order to keep the volume from becoming unwieldy because of its size. He can hardly be expected to have an expert's knowledge of all branches of the science nor the intuition necessary to decide in all cases which particular value to record especially when many differing values are given in the literature for the same constant. If the expert in a particular field will judge the usefulness of this book

by the data which it supplies to him from fields other than his specialty and not by the lack of highly specialized information in which only he and his co-workers are interested (and with which he is familiar and for which he would never have occasion to consult this compilation), then an estimate of its value to him will be apparent. However, if such specialists will call attention to missing data with which they are familiar and which they believe others less specialized will also need, then works of this type can be improved in succeeding editions.

Many of the gaps in this volume are caused by the lack of such information in the literature. It is hoped that to one of the most important classes of workers in chemistry, namely the teachers, the book will be of value not only as an aid in answering the most varied questions with which they are confronted by interested students, but also as an inspiration through what it suggests by the gaps and inconsistencies, challenging as they do the incentive to engage in the creative and experimental work necessary to supply the missing information.

While the principal value of the book is for the professional chemist or student of chemistry, it should also be of value to many people not especially educated as chemists. Workers in the natural sciences—physicists, mineralogists, biologists, pharmacists, engineers, patent attorneys, and librarians—are often called upon to solve problems dealing with the properties of chemical products or materials of construction. For such needs this compilation supplies helpful information and will serve not only as an economical substitute for the costly accumulation of a large library of monographs on specialized subjects, but also as a means of conserving the time required to search for information so widely scattered throughout the literature. For this reason especial care has been taken in compiling a comprehensive index and in furnishing cross references with many of the tables.

It is hoped that this book will be of the same usefulness to the worker in science as is the dictionary to the worker in literature, and that its resting place will be on the desk rather than on the book shelf.

N. A. Lange

Cleveland, Ohio
May 2, 1934

PREFACE

TO THE ELEVENTH EDITION

The new editor has assumed the task of data compilation from the late Dr. Lange, the man who initiated the *Handbook of Chemistry* almost four decades ago. It seems only fitting that his name should be embodied within the new title in recognition for his efforts on the ten preceding editions of this handbook.

Perhaps it would be simplest to begin by stating the ways in which this new edition has not been changed. It remains the one-volume source of factual information for chemists, both professionals and students—the first place in which to “look it up” on the spot. The aim is to provide sufficient data to satisfy all one’s general needs.

The changes, however, are both numerous and significant. First of all, there is a basic change in organization. The handbook is now divided into sections—mathematics, general information and conversion tables, atomic and molecular structure, inorganic chemistry, analytical chemistry, electrochemistry, organic chemistry, spectroscopy, thermodynamic properties, physical properties, miscellaneous—and within these sections related groups of factual data are presented. This arrangement, plus the new sectional tables of contents, which provide a complete listing of items within each section, backed up by a thorough and extensively cross-indexed subject index, makes it possible to find the information quickly.

The following subject matter is offered for the first time:

Emission and absorption lines for arc, spark, and flame and atomic absorption—with sensitivities and/or detection limits

Formation constants of metal complexes with organic and inorganic ligands

Mass absorption coefficients of X-ray emission lines commonly used in X-ray absorption work, with coefficients for all elements

Statistical tables

Atomic electron affinities

Electronegativities of the elements

Spatial orientation of common hybrid bonds
Hammett and Taft substituent constants
Selectivity coefficients for ion-exchange resins
Cross contamination and separation factors in separation methods

Also new are self-instructional sections developed for certain areas: measurement of pH, use of statistics, separation methods, and X-ray methods.

Expanded coverage is provided in such important areas as:

Solubility products
Proton transfer reactions (acid dissociation constants) with 1200 entries for organic compounds and 150 for inorganic compounds
Electrode potentials of elements and their compounds listed by element
Bond energies and radii of atoms and ions
Reference electrodes
Reference pH buffers for water, deuterium oxide, and aqueous-organic systems
Approved symbols and abbreviations

Updating has increased the usefulness of such valuable tabulations as:

Physical properties of 4000 inorganic compounds
Nomenclature of inorganic compounds
Heats and free energies of formation, entropies, and heat capacities—incorporating the latest recommended values of the National Bureau of Standards
X-ray emission spectra and X-ray K and L absorption edges, given both as wavelengths and as energies in keV
Critical properties
Limiting equivalent ionic conductances in aqueous solution
Table of nuclides, now 100 pages extending through element 105
Ionization potentials of the elements

Finally, the mathematical section has been expanded from its rather restricted size in recent editions so as to include mathematical information commonly needed by an upper-division or graduate student, or professional, without recourse to other reference sources.

It is hoped that users of this and previous editions will continue to offer friendly criticism and suggestions, and call attention to errors.

John A. Dean

Knoxville, Tennessee

ACKNOWLEDGMENT

Grateful acknowledgment is hereby made of an indebtedness to those who have contributed to former editions and whose compilations continue in use in this edition. In particular, acknowledgment is made of the contribution of Dr. Joseph R. Peterson, who prepared the expanded Table of Nuclides; also that of Mr. Theodore C. Rains who supplied many of the atomic absorption sensitivities.

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For the detailed contents of any section, consult the title page of that section. See also the alphabetical index in the back of this handbook.

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Section 1

MATHEMATICS

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MATHEMATICAL TABLES

Table 1.1
SQUARES OF NUMBERS

From *Baumeister and Marks, Standard Handbook for Mechanical Engineers*,
7th ed., 1967, McGraw-Hill Book Company; by permission

| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Avg diff |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
| 1.00 | 1.000 | 1.002 | 1.004 | 1.006 | 1.008 | 1.010 | 1.012 | 1.014 | 1.016 | 1.018 | 2 |
| 1 | 1.020 | 1.022 | 1.024 | 1.026 | 1.028 | 1.030 | 1.032 | 1.034 | 1.036 | 1.038 | |
| 2 | 1.040 | 1.042 | 1.044 | 1.047 | 1.049 | 1.051 | 1.053 | 1.055 | 1.057 | 1.059 | |
| 3 | 1.061 | 1.063 | 1.065 | 1.067 | 1.069 | 1.071 | 1.073 | 1.075 | 1.077 | 1.080 | |
| 4 | 1.082 | 1.084 | 1.086 | 1.088 | 1.090 | 1.092 | 1.094 | 1.096 | 1.098 | 1.100 | |
| 1.05 | 1.102 | 1.105 | 1.107 | 1.109 | 1.111 | 1.113 | 1.115 | 1.117 | 1.119 | 1.121 | |
| 6 | 1.124 | 1.126 | 1.128 | 1.130 | 1.132 | 1.134 | 1.136 | 1.138 | 1.141 | 1.143 | |
| 7 | 1.145 | 1.147 | 1.149 | 1.151 | 1.153 | 1.156 | 1.158 | 1.160 | 1.162 | 1.164 | |
| 8 | 1.166 | 1.169 | 1.171 | 1.173 | 1.175 | 1.177 | 1.179 | 1.182 | 1.184 | 1.186 | |
| 9 | 1.188 | 1.190 | 1.192 | 1.195 | 1.197 | 1.199 | 1.201 | 1.203 | 1.206 | 1.208 | |
| 1.10 | 1.210 | 1.212 | 1.214 | 1.217 | 1.219 | 1.221 | 1.223 | 1.225 | 1.228 | 1.230 | |
| 1 | 1.232 | 1.234 | 1.237 | 1.239 | 1.241 | 1.243 | 1.245 | 1.248 | 1.250 | 1.252 | |
| 2 | 1.254 | 1.257 | 1.259 | 1.261 | 1.263 | 1.266 | 1.268 | 1.270 | 1.272 | 1.275 | |
| 3 | 1.277 | 1.279 | 1.281 | 1.284 | 1.286 | 1.288 | 1.290 | 1.293 | 1.295 | 1.297 | |
| 4 | 1.300 | 1.302 | 1.304 | 1.306 | 1.309 | 1.311 | 1.313 | 1.316 | 1.318 | 1.320 | |
| 1.15 | 1.322 | 1.325 | 1.327 | 1.329 | 1.332 | 1.334 | 1.336 | 1.339 | 1.341 | 1.343 | |
| 6 | 1.346 | 1.348 | 1.350 | 1.353 | 1.355 | 1.357 | 1.360 | 1.362 | 1.364 | 1.367 | |
| 7 | 1.369 | 1.371 | 1.374 | 1.376 | 1.378 | 1.381 | 1.383 | 1.385 | 1.388 | 1.390 | |
| 8 | 1.392 | 1.395 | 1.397 | 1.399 | 1.402 | 1.404 | 1.407 | 1.409 | 1.411 | 1.414 | |
| 9 | 1.416 | 1.418 | 1.421 | 1.423 | 1.426 | 1.428 | 1.430 | 1.433 | 1.435 | 1.438 | |
| 1.20 | 1.440 | 1.442 | 1.445 | 1.447 | 1.450 | 1.452 | 1.454 | 1.457 | 1.459 | 1.462 | |
| 1 | 1.464 | 1.467 | 1.469 | 1.471 | 1.474 | 1.476 | 1.479 | 1.481 | 1.484 | 1.486 | |
| 2 | 1.488 | 1.491 | 1.493 | 1.496 | 1.498 | 1.501 | 1.503 | 1.506 | 1.508 | 1.510 | |
| 3 | 1.513 | 1.515 | 1.518 | 1.520 | 1.523 | 1.525 | 1.528 | 1.530 | 1.533 | 1.535 | |
| 4 | 1.538 | 1.540 | 1.543 | 1.545 | 1.548 | 1.550 | 1.553 | 1.555 | 1.558 | 1.560 | |
| 1.25 | 1.562 | 1.565 | 1.568 | 1.570 | 1.573 | 1.575 | 1.578 | 1.580 | 1.583 | 1.585 | 3 |
| 6 | 1.588 | 1.590 | 1.593 | 1.595 | 1.598 | 1.600 | 1.603 | 1.605 | 1.608 | 1.610 | |
| 7 | 1.613 | 1.615 | 1.618 | 1.621 | 1.623 | 1.626 | 1.628 | 1.631 | 1.633 | 1.636 | |
| 8 | 1.638 | 1.641 | 1.644 | 1.646 | 1.649 | 1.651 | 1.654 | 1.656 | 1.659 | 1.662 | |
| 9 | 1.664 | 1.667 | 1.669 | 1.672 | 1.674 | 1.677 | 1.680 | 1.682 | 1.685 | 1.687 | |
| 1.30 | 1.690 | 1.693 | 1.695 | 1.698 | 1.700 | 1.703 | 1.706 | 1.708 | 1.711 | 1.713 | |
| 1 | 1.716 | 1.719 | 1.721 | 1.724 | 1.727 | 1.729 | 1.732 | 1.734 | 1.737 | 1.740 | |
| 2 | 1.742 | 1.745 | 1.748 | 1.750 | 1.753 | 1.756 | 1.758 | 1.761 | 1.764 | 1.766 | |
| 3 | 1.769 | 1.772 | 1.774 | 1.777 | 1.780 | 1.782 | 1.785 | 1.788 | 1.790 | 1.793 | |
| 4 | 1.796 | 1.798 | 1.801 | 1.804 | 1.806 | 1.809 | 1.812 | 1.814 | 1.817 | 1.820 | |
| 1.35 | 1.822 | 1.825 | 1.828 | 1.831 | 1.833 | 1.836 | 1.839 | 1.841 | 1.844 | 1.847 | |
| 6 | 1.850 | 1.852 | 1.855 | 1.857 | 1.860 | 1.863 | 1.866 | 1.869 | 1.871 | 1.874 | |
| 7 | 1.877 | 1.880 | 1.882 | 1.885 | 1.888 | 1.891 | 1.893 | 1.896 | 1.899 | 1.902 | |
| 8 | 1.904 | 1.907 | 1.910 | 1.913 | 1.915 | 1.918 | 1.921 | 1.924 | 1.927 | 1.929 | |
| 9 | 1.932 | 1.935 | 1.938 | 1.940 | 1.943 | 1.946 | 1.949 | 1.952 | 1.954 | 1.957 | |
| 1.40 | 1.960 | 1.963 | 1.966 | 1.968 | 1.971 | 1.974 | 1.977 | 1.980 | 1.982 | 1.985 | |
| 1 | 1.988 | 1.991 | 1.994 | 1.997 | 1.999 | 2.002 | 2.005 | 2.008 | 2.011 | 2.014 | |
| 2 | 2.016 | 2.019 | 2.022 | 2.025 | 2.028 | 2.031 | 2.033 | 2.036 | 2.039 | 2.042 | |
| 3 | 2.045 | 2.048 | 2.051 | 2.053 | 2.056 | 2.059 | 2.062 | 2.065 | 2.068 | 2.071 | |
| 4 | 2.074 | 2.076 | 2.079 | 2.082 | 2.085 | 2.088 | 2.091 | 2.094 | 2.097 | 2.100 | |
| 1.45 | 2.102 | 2.105 | 2.108 | 2.111 | 2.114 | 2.117 | 2.120 | 2.123 | 2.126 | 2.129 | |
| 6 | 2.132 | 2.135 | 2.137 | 2.140 | 2.143 | 2.146 | 2.149 | 2.152 | 2.155 | 2.158 | |
| 7 | 2.161 | 2.164 | 2.167 | 2.170 | 2.173 | 2.176 | 2.179 | 2.182 | 2.184 | 2.187 | |
| 8 | 2.190 | 2.193 | 2.196 | 2.199 | 2.202 | 2.205 | 2.208 | 2.211 | 2.214 | 2.217 | |
| 9 | 2.220 | 2.223 | 2.226 | 2.229 | 2.232 | 2.235 | 2.238 | 2.241 | 2.244 | 2.247 | |

Moving the decimal point ONE place in *N* requires moving it TWO places in body of table (see p. 1-6).

MATHEMATICS

Table 1-1 (Continued)
SQUARES OF NUMBERS

| <i>N</i> | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Avg diff |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
| 1.50 | 2.250 | 2.253 | 2.256 | 2.259 | 2.262 | 2.265 | 2.268 | 2.271 | 2.274 | 2.277 | 3 |
| 1 | 2.280 | 2.283 | 2.286 | 2.289 | 2.292 | 2.295 | 2.298 | 2.301 | 2.304 | 2.307 | |
| 2 | 2.310 | 2.313 | 2.316 | 2.320 | 2.323 | 2.326 | 2.329 | 2.332 | 2.335 | 2.338 | |
| 3 | 2.341 | 2.344 | 2.347 | 2.350 | 2.353 | 2.356 | 2.359 | 2.362 | 2.365 | 2.369 | |
| 4 | 2.372 | 2.375 | 2.378 | 2.381 | 2.384 | 2.387 | 2.390 | 2.393 | 2.396 | 2.399 | |
| 1.55 | 2.402 | 2.406 | 2.409 | 2.412 | 2.415 | 2.418 | 2.421 | 2.424 | 2.427 | 2.430 | |
| 6 | 2.434 | 2.437 | 2.440 | 2.443 | 2.446 | 2.449 | 2.452 | 2.455 | 2.459 | 2.462 | |
| 7 | 2.465 | 2.468 | 2.471 | 2.474 | 2.477 | 2.481 | 2.484 | 2.487 | 2.490 | 2.493 | |
| 8 | 2.496 | 2.500 | 2.503 | 2.506 | 2.509 | 2.512 | 2.515 | 2.519 | 2.522 | 2.525 | |
| 9 | 2.528 | 2.531 | 2.534 | 2.538 | 2.541 | 2.544 | 2.547 | 2.550 | 2.554 | 2.557 | |
| 1.60 | 2.560 | 2.563 | 2.566 | 2.570 | 2.573 | 2.576 | 2.579 | 2.582 | 2.586 | 2.589 | |
| 1 | 2.592 | 2.595 | 2.599 | 2.602 | 2.605 | 2.608 | 2.611 | 2.615 | 2.618 | 2.621 | |
| 2 | 2.624 | 2.628 | 2.631 | 2.634 | 2.637 | 2.641 | 2.644 | 2.647 | 2.650 | 2.654 | |
| 3 | 2.657 | 2.660 | 2.663 | 2.667 | 2.670 | 2.673 | 2.676 | 2.680 | 2.683 | 2.686 | |
| 4 | 2.690 | 2.693 | 2.696 | 2.699 | 2.703 | 2.706 | 2.709 | 2.713 | 2.716 | 2.719 | |
| 1.65 | 2.722 | 2.726 | 2.729 | 2.732 | 2.736 | 2.739 | 2.742 | 2.746 | 2.749 | 2.752 | |
| 6 | 2.756 | 2.759 | 2.762 | 2.766 | 2.769 | 2.772 | 2.776 | 2.779 | 2.782 | 2.786 | |
| 7 | 2.789 | 2.792 | 2.796 | 2.799 | 2.802 | 2.806 | 2.809 | 2.812 | 2.816 | 2.819 | |
| 8 | 2.822 | 2.826 | 2.829 | 2.832 | 2.836 | 2.839 | 2.843 | 2.846 | 2.849 | 2.853 | |
| 9 | 2.856 | 2.859 | 2.863 | 2.866 | 2.870 | 2.873 | 2.876 | 2.880 | 2.883 | 2.887 | |
| 1.70 | 2.890 | 2.893 | 2.897 | 2.900 | 2.904 | 2.907 | 2.910 | 2.914 | 2.917 | 2.921 | |
| 1 | 2.924 | 2.928 | 2.931 | 2.934 | 2.938 | 2.941 | 2.945 | 2.948 | 2.952 | 2.955 | |
| 2 | 2.958 | 2.962 | 2.965 | 2.969 | 2.972 | 2.976 | 2.979 | 2.983 | 2.986 | 2.989 | |
| 3 | 2.993 | 2.996 | 3.000 | 3.003 | 3.007 | 3.010 | 3.014 | 3.017 | 3.021 | 3.024 | |
| 4 | 3.028 | 3.031 | 3.035 | 3.038 | 3.042 | 3.045 | 3.049 | 3.052 | 3.056 | 3.059 | |
| 1.75 | 3.062 | 3.066 | 3.070 | 3.073 | 3.077 | 3.080 | 3.084 | 3.087 | 3.091 | 3.094 | 4 |
| 6 | 3.098 | 3.101 | 3.105 | 3.108 | 3.112 | 3.115 | 3.119 | 3.122 | 3.126 | 3.129 | |
| 7 | 3.133 | 3.136 | 3.140 | 3.144 | 3.147 | 3.151 | 3.154 | 3.158 | 3.161 | 3.165 | |
| 8 | 3.168 | 3.172 | 3.176 | 3.179 | 3.183 | 3.186 | 3.190 | 3.193 | 3.197 | 3.201 | |
| 9 | 3.204 | 3.208 | 3.211 | 3.215 | 3.218 | 3.222 | 3.226 | 3.229 | 3.233 | 3.236 | |
| 1.80 | 3.240 | 3.244 | 3.247 | 3.251 | 3.254 | 3.258 | 3.262 | 3.265 | 3.269 | 3.272 | |
| 1 | 3.276 | 3.280 | 3.283 | 3.287 | 3.291 | 3.294 | 3.298 | 3.301 | 3.305 | 3.309 | |
| 2 | 3.312 | 3.316 | 3.320 | 3.323 | 3.327 | 3.331 | 3.334 | 3.338 | 3.342 | 3.345 | |
| 3 | 3.349 | 3.353 | 3.356 | 3.360 | 3.364 | 3.367 | 3.371 | 3.375 | 3.378 | 3.382 | |
| 4 | 3.386 | 3.389 | 3.393 | 3.397 | 3.400 | 3.404 | 3.408 | 3.411 | 3.415 | 3.419 | |
| 1.85 | 3.422 | 3.426 | 3.430 | 3.434 | 3.437 | 3.441 | 3.445 | 3.448 | 3.452 | 3.456 | |
| 6 | 3.460 | 3.463 | 3.467 | 3.471 | 3.474 | 3.478 | 3.482 | 3.486 | 3.489 | 3.493 | |
| 7 | 3.497 | 3.501 | 3.504 | 3.508 | 3.512 | 3.516 | 3.519 | 3.523 | 3.527 | 3.531 | |
| 8 | 3.534 | 3.538 | 3.542 | 3.546 | 3.549 | 3.553 | 3.557 | 3.561 | 3.565 | 3.568 | |
| 9 | 3.572 | 3.576 | 3.580 | 3.583 | 3.587 | 3.591 | 3.595 | 3.599 | 3.602 | 3.606 | |
| 1.90 | 3.610 | 3.614 | 3.618 | 3.621 | 3.625 | 3.629 | 3.633 | 3.637 | 3.640 | 3.644 | |
| 1 | 3.648 | 3.652 | 3.656 | 3.660 | 3.663 | 3.667 | 3.671 | 3.675 | 3.679 | 3.683 | |
| 2 | 3.686 | 3.690 | 3.694 | 3.698 | 3.702 | 3.706 | 3.709 | 3.713 | 3.717 | 3.721 | |
| 3 | 3.725 | 3.729 | 3.733 | 3.736 | 3.740 | 3.744 | 3.748 | 3.752 | 3.756 | 3.760 | |
| 4 | 3.764 | 3.767 | 3.771 | 3.775 | 3.779 | 3.783 | 3.787 | 3.791 | 3.795 | 3.799 | |
| 1.95 | 3.802 | 3.806 | 3.810 | 3.814 | 3.818 | 3.822 | 3.826 | 3.830 | 3.834 | 3.838 | |
| 6 | 3.842 | 3.846 | 3.849 | 3.853 | 3.857 | 3.861 | 3.865 | 3.869 | 3.873 | 3.877 | |
| 7 | 3.881 | 3.885 | 3.889 | 3.893 | 3.897 | 3.901 | 3.905 | 3.909 | 3.912 | 3.916 | |
| 8 | 3.920 | 3.924 | 3.928 | 3.932 | 3.936 | 3.940 | 3.944 | 3.948 | 3.952 | 3.956 | |
| 9 | 3.960 | 3.964 | 3.968 | 3.972 | 3.976 | 3.980 | 3.984 | 3.988 | 3.992 | 3.996 | |

$\pi^2 = 9.86960$ $1/\pi^2 = 0.101321$ $e^2 = 7.38906$

Table 1-1 (Continued)
SQUARES OF NUMBERS

| <i>N</i> | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Avg diff |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|
| 2.00 | 4.000 | 4.004 | 4.008 | 4.012 | 4.016 | 4.020 | 4.024 | 4.028 | 4.032 | 4.036 | 4 |
| 1 | 4.040 | 4.044 | 4.048 | 4.052 | 4.056 | 4.060 | 4.064 | 4.068 | 4.072 | 4.076 | |
| 2 | 4.080 | 4.084 | 4.088 | 4.093 | 4.097 | 4.101 | 4.105 | 4.109 | 4.113 | 4.117 | |
| 3 | 4.121 | 4.125 | 4.129 | 4.133 | 4.137 | 4.141 | 4.145 | 4.149 | 4.153 | 4.158 | |
| 4 | 4.162 | 4.166 | 4.170 | 4.174 | 4.178 | 4.182 | 4.186 | 4.190 | 4.194 | 4.198 | |
| 2.05 | 4.202 | 4.207 | 4.211 | 4.215 | 4.219 | 4.223 | 4.227 | 4.231 | 4.235 | 4.239 | |
| 6 | 4.244 | 4.248 | 4.252 | 4.256 | 4.260 | 4.264 | 4.268 | 4.272 | 4.277 | 4.281 | |
| 7 | 4.285 | 4.289 | 4.293 | 4.297 | 4.301 | 4.306 | 4.310 | 4.314 | 4.318 | 4.322 | |
| 8 | 4.326 | 4.331 | 4.335 | 4.339 | 4.343 | 4.347 | 4.351 | 4.356 | 4.360 | 4.364 | |
| 9 | 4.368 | 4.372 | 4.376 | 4.381 | 4.385 | 4.389 | 4.393 | 4.397 | 4.402 | 4.406 | |
| 2.10 | 4.410 | 4.414 | 4.418 | 4.423 | 4.427 | 4.431 | 4.435 | 4.439 | 4.444 | 4.448 | |
| 1 | 4.452 | 4.456 | 4.461 | 4.465 | 4.469 | 4.473 | 4.477 | 4.482 | 4.486 | 4.490 | |
| 2 | 4.494 | 4.499 | 4.503 | 4.507 | 4.511 | 4.516 | 4.520 | 4.524 | 4.528 | 4.533 | |
| 3 | 4.537 | 4.541 | 4.545 | 4.550 | 4.554 | 4.558 | 4.562 | 4.567 | 4.571 | 4.575 | |
| 4 | 4.580 | 4.584 | 4.588 | 4.592 | 4.597 | 4.601 | 4.605 | 4.610 | 4.614 | 4.618 | |
| 2.15 | 4.622 | 4.627 | 4.631 | 4.635 | 4.640 | 4.644 | 4.648 | 4.653 | 4.657 | 4.661 | |
| 6 | 4.666 | 4.670 | 4.674 | 4.679 | 4.683 | 4.687 | 4.692 | 4.696 | 4.700 | 4.705 | |
| 7 | 4.709 | 4.713 | 4.718 | 4.722 | 4.726 | 4.731 | 4.735 | 4.739 | 4.744 | 4.748 | |
| 8 | 4.752 | 4.757 | 4.761 | 4.765 | 4.770 | 4.774 | 4.779 | 4.783 | 4.787 | 4.792 | |
| 9 | 4.796 | 4.800 | 4.805 | 4.809 | 4.814 | 4.818 | 4.822 | 4.827 | 4.831 | 4.836 | |
| 2.20 | 4.840 | 4.844 | 4.849 | 4.853 | 4.858 | 4.862 | 4.866 | 4.871 | 4.875 | 4.880 | |
| 1 | 4.884 | 4.889 | 4.893 | 4.897 | 4.902 | 4.906 | 4.911 | 4.915 | 4.920 | 4.924 | |
| 2 | 4.928 | 4.933 | 4.937 | 4.942 | 4.946 | 4.951 | 4.955 | 4.960 | 4.964 | 4.968 | |
| 3 | 4.973 | 4.977 | 4.982 | 4.986 | 4.991 | 4.995 | 5.000 | 5.004 | 5.009 | 5.013 | |
| 4 | 5.018 | 5.022 | 5.027 | 5.031 | 5.036 | 5.040 | 5.045 | 5.049 | 5.054 | 5.058 | |
| 2.25 | 5.062 | 5.067 | 5.072 | 5.076 | 5.081 | 5.085 | 5.090 | 5.094 | 5.099 | 5.103 | 5 |
| 6 | 5.108 | 5.112 | 5.117 | 5.121 | 5.126 | 5.130 | 5.135 | 5.139 | 5.144 | 5.148 | |
| 7 | 5.153 | 5.157 | 5.162 | 5.167 | 5.171 | 5.176 | 5.180 | 5.185 | 5.189 | 5.194 | |
| 8 | 5.198 | 5.203 | 5.208 | 5.212 | 5.217 | 5.221 | 5.226 | 5.230 | 5.235 | 5.240 | |
| 9 | 5.244 | 5.249 | 5.253 | 5.258 | 5.262 | 5.267 | 5.272 | 5.276 | 5.281 | 5.285 | |
| 2.30 | 5.290 | 5.295 | 5.299 | 5.304 | 5.308 | 5.313 | 5.318 | 5.322 | 5.327 | 5.331 | |
| 1 | 5.336 | 5.341 | 5.345 | 5.350 | 5.355 | 5.359 | 5.364 | 5.368 | 5.373 | 5.378 | |
| 2 | 5.382 | 5.387 | 5.392 | 5.396 | 5.401 | 5.406 | 5.410 | 5.415 | 5.420 | 5.424 | |
| 3 | 5.429 | 5.434 | 5.438 | 5.443 | 5.448 | 5.452 | 5.457 | 5.462 | 5.466 | 5.471 | |
| 4 | 5.476 | 5.480 | 5.485 | 5.490 | 5.494 | 5.499 | 5.504 | 5.508 | 5.513 | 5.518 | |
| 2.35 | 5.522 | 5.527 | 5.532 | 5.537 | 5.541 | 5.546 | 5.551 | 5.555 | 5.560 | 5.565 | |
| 6 | 5.570 | 5.574 | 5.579 | 5.584 | 5.588 | 5.593 | 5.598 | 5.603 | 5.607 | 5.612 | |
| 7 | 5.617 | 5.622 | 5.626 | 5.631 | 5.636 | 5.641 | 5.645 | 5.650 | 5.655 | 5.660 | |
| 8 | 5.664 | 5.669 | 5.674 | 5.679 | 5.683 | 5.688 | 5.693 | 5.698 | 5.703 | 5.707 | |
| 9 | 5.712 | 5.717 | 5.722 | 5.726 | 5.731 | 5.736 | 5.741 | 5.746 | 5.750 | 5.755 | |
| 2.40 | 5.760 | 5.765 | 5.770 | 5.774 | 5.779 | 5.784 | 5.789 | 5.794 | 5.798 | 5.803 | |
| 1 | 5.808 | 5.813 | 5.818 | 5.823 | 5.827 | 5.832 | 5.837 | 5.842 | 5.847 | 5.852 | |
| 2 | 5.856 | 5.861 | 5.866 | 5.871 | 5.876 | 5.881 | 5.885 | 5.890 | 5.895 | 5.900 | |
| 3 | 5.905 | 5.910 | 5.915 | 5.919 | 5.924 | 5.929 | 5.934 | 5.939 | 5.944 | 5.949 | |
| 4 | 5.954 | 5.958 | 5.963 | 5.968 | 5.973 | 5.978 | 5.983 | 5.988 | 5.993 | 5.998 | |
| 2.45 | 6.002 | 6.007 | 6.012 | 6.017 | 6.022 | 6.027 | 6.032 | 6.037 | 6.042 | 6.047 | |
| 6 | 6.052 | 6.057 | 6.061 | 6.066 | 6.071 | 6.076 | 6.081 | 6.086 | 6.091 | 6.096 | |
| 7 | 6.101 | 6.106 | 6.111 | 6.116 | 6.121 | 6.126 | 6.131 | 6.136 | 6.140 | 6.145 | |
| 8 | 6.150 | 6.155 | 6.160 | 6.165 | 6.170 | 6.175 | 6.180 | 6.185 | 6.190 | 6.195 | |
| 9 | 6.200 | 6.205 | 6.210 | 6.215 | 6.220 | 6.225 | 6.230 | 6.235 | 6.240 | 6.245 | |

Moving the decimal point ONE place in *N* requires moving it TWO places in body of table (see p. 1-6).

Table 1-1 (Continued)
SQUARES OF NUMBERS

| <i>N</i> | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Avg diff |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| 2.50 | 6.250 | 6.255 | 6.260 | 6.265 | 6.270 | 6.275 | 6.280 | 6.285 | 6.290 | 6.295 | 5 |
| 1 | 6.300 | 6.305 | 6.310 | 6.315 | 6.320 | 6.325 | 6.330 | 6.335 | 6.340 | 6.345 | |
| 2 | 6.350 | 6.355 | 6.360 | 6.366 | 6.371 | 6.376 | 6.381 | 6.386 | 6.391 | 6.396 | |
| 3 | 6.401 | 6.406 | 6.411 | 6.416 | 6.421 | 6.426 | 6.431 | 6.436 | 6.441 | 6.447 | |
| 4 | 6.452 | 6.457 | 6.462 | 6.467 | 6.472 | 6.477 | 6.482 | 6.487 | 6.492 | 6.497 | |
| 2.55 | 6.502 | 6.508 | 6.513 | 6.518 | 6.523 | 6.528 | 6.533 | 6.538 | 6.543 | 6.548 | |
| 6 | 6.554 | 6.559 | 6.564 | 6.569 | 6.574 | 6.579 | 6.584 | 6.589 | 6.595 | 6.600 | |
| 7 | 6.605 | 6.610 | 6.615 | 6.620 | 6.625 | 6.631 | 6.636 | 6.641 | 6.646 | 6.651 | |
| 8 | 6.656 | 6.662 | 6.667 | 6.672 | 6.677 | 6.682 | 6.687 | 6.693 | 6.698 | 6.703 | |
| 9 | 6.708 | 6.713 | 6.718 | 6.724 | 6.729 | 6.734 | 6.739 | 6.744 | 6.750 | 6.755 | |
| 2.60 | 6.760 | 6.765 | 6.770 | 6.776 | 6.781 | 6.786 | 6.791 | 6.796 | 6.802 | 6.807 | |
| 1 | 6.812 | 6.817 | 6.823 | 6.828 | 6.833 | 6.838 | 6.843 | 6.849 | 6.854 | 6.859 | |
| 2 | 6.864 | 6.870 | 6.875 | 6.880 | 6.885 | 6.891 | 6.896 | 6.901 | 6.906 | 6.912 | |
| 3 | 6.917 | 6.922 | 6.927 | 6.933 | 6.938 | 6.943 | 6.948 | 6.954 | 6.959 | 6.964 | |
| 4 | 6.970 | 6.975 | 6.980 | 6.985 | 6.991 | 6.996 | 7.001 | 7.007 | 7.012 | 7.017 | |
| 2.65 | 7.022 | 7.028 | 7.033 | 7.038 | 7.044 | 7.049 | 7.054 | 7.060 | 7.065 | 7.070 | |
| 6 | 7.076 | 7.081 | 7.086 | 7.092 | 7.097 | 7.102 | 7.108 | 7.113 | 7.118 | 7.124 | |
| 7 | 7.129 | 7.134 | 7.140 | 7.145 | 7.150 | 7.156 | 7.161 | 7.166 | 7.172 | 7.177 | |
| 8 | 7.182 | 7.188 | 7.193 | 7.198 | 7.204 | 7.209 | 7.215 | 7.220 | 7.225 | 7.231 | |
| 9 | 7.236 | 7.241 | 7.247 | 7.252 | 7.258 | 7.263 | 7.268 | 7.274 | 7.279 | 7.285 | |
| 2.70 | 7.290 | 7.295 | 7.301 | 7.306 | 7.312 | 7.317 | 7.322 | 7.328 | 7.333 | 7.339 | |
| 1 | 7.344 | 7.350 | 7.355 | 7.360 | 7.366 | 7.371 | 7.377 | 7.382 | 7.388 | 7.393 | |
| 2 | 7.398 | 7.404 | 7.409 | 7.415 | 7.420 | 7.426 | 7.431 | 7.437 | 7.442 | 7.447 | |
| 3 | 7.453 | 7.458 | 7.464 | 7.469 | 7.475 | 7.480 | 7.486 | 7.491 | 7.497 | 7.502 | |
| 4 | 7.508 | 7.513 | 7.519 | 7.524 | 7.530 | 7.535 | 7.541 | 7.546 | 7.552 | 7.557 | |
| 2.75 | 7.562 | 7.568 | 7.574 | 7.579 | 7.585 | 7.590 | 7.596 | 7.601 | 7.607 | 7.612 | 6 |
| 6 | 7.618 | 7.623 | 7.629 | 7.634 | 7.640 | 7.645 | 7.651 | 7.656 | 7.662 | 7.667 | |
| 7 | 7.673 | 7.678 | 7.684 | 7.690 | 7.695 | 7.701 | 7.706 | 7.712 | 7.717 | 7.723 | |
| 8 | 7.728 | 7.734 | 7.740 | 7.745 | 7.751 | 7.756 | 7.762 | 7.767 | 7.773 | 7.779 | |
| 9 | 7.784 | 7.790 | 7.795 | 7.801 | 7.806 | 7.812 | 7.818 | 7.823 | 7.829 | 7.834 | |
| 2.80 | 7.840 | 7.846 | 7.851 | 7.857 | 7.862 | 7.868 | 7.874 | 7.879 | 7.885 | 7.890 | |
| 1 | 7.896 | 7.902 | 7.907 | 7.913 | 7.919 | 7.924 | 7.930 | 7.935 | 7.941 | 7.947 | |
| 2 | 7.952 | 7.958 | 7.964 | 7.969 | 7.975 | 7.981 | 7.986 | 7.992 | 7.998 | 8.003 | |
| 3 | 8.009 | 8.015 | 8.020 | 8.026 | 8.032 | 8.037 | 8.043 | 8.049 | 8.054 | 8.060 | |
| 4 | 8.066 | 8.071 | 8.077 | 8.083 | 8.088 | 8.094 | 8.100 | 8.105 | 8.111 | 8.117 | |
| 2.85 | 8.122 | 8.128 | 8.134 | 8.140 | 8.145 | 8.151 | 8.157 | 8.162 | 8.168 | 8.174 | |
| 6 | 8.180 | 8.185 | 8.191 | 8.197 | 8.202 | 8.208 | 8.214 | 8.220 | 8.225 | 8.231 | |
| 7 | 8.237 | 8.243 | 8.248 | 8.254 | 8.260 | 8.266 | 8.271 | 8.277 | 8.283 | 8.289 | |
| 8 | 8.294 | 8.300 | 8.306 | 8.312 | 8.317 | 8.323 | 8.329 | 8.335 | 8.341 | 8.346 | |
| 9 | 8.352 | 8.358 | 8.364 | 8.369 | 8.375 | 8.381 | 8.387 | 8.393 | 8.398 | 8.404 | |
| 2.90 | 8.410 | 8.416 | 8.422 | 8.427 | 8.433 | 8.439 | 8.445 | 8.451 | 8.456 | 8.462 | |
| 1 | 8.468 | 8.474 | 8.480 | 8.486 | 8.491 | 8.497 | 8.503 | 8.509 | 8.515 | 8.521 | |
| 2 | 8.526 | 8.532 | 8.538 | 8.544 | 8.550 | 8.556 | 8.561 | 8.567 | 8.573 | 8.579 | |
| 3 | 8.585 | 8.591 | 8.597 | 8.602 | 8.608 | 8.614 | 8.620 | 8.626 | 8.632 | 8.638 | |
| 4 | 8.644 | 8.649 | 8.655 | 8.661 | 8.667 | 8.673 | 8.679 | 8.685 | 8.691 | 8.697 | |
| 2.95 | 8.702 | 8.708 | 8.714 | 8.720 | 8.726 | 8.732 | 8.738 | 8.744 | 8.750 | 8.756 | |
| 6 | 8.762 | 8.768 | 8.773 | 8.779 | 8.785 | 8.791 | 8.797 | 8.803 | 8.809 | 8.815 | |
| 7 | 8.821 | 8.827 | 8.833 | 8.839 | 8.845 | 8.851 | 8.857 | 8.863 | 8.868 | 8.874 | |
| 8 | 8.880 | 8.886 | 8.892 | 8.898 | 8.904 | 8.910 | 8.916 | 8.922 | 8.928 | 8.934 | |
| 9 | 8.940 | 8.946 | 8.952 | 8.958 | 8.964 | 8.970 | 8.976 | 8.982 | 8.988 | 8.994 | |

$\pi^2 = 9.8696$ $1/\pi^2 = 0.101321$ $e^2 = 7.38906$