

## Resource Letter OE-1 on Origin of the Elements\*

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This is one of a series of Resource Letters on different topics, intended to guide college physicists to some of the literature and other teaching aids that may help them to improve course contents in specified fields of physics. No Resource Letter is meant to be exhaustive and complete; in time there may be more than one letter on some of the main subjects of interest. Comments and suggestions concerning the content and arrangement of letters as well as suggestions for future topics will be welcomed. Please send such communications to Professor Joel E. Gordon, Resource Letter Committee, Department of Physics, Amherst College, Amherst, Massachusetts 01002.

*Notation:* The letter E after an item number indicates elementary level, useful principally for high school and introductory college use; the letter I indicates intermediate (junior, senior) level; and the letter A indicates advanced material, principally suited for senior, graduate study. An asterisk (\*) indicates items particularly recommended for introductory study.

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### I. INTRODUCTION

#### 1. Prologue

SECOND in intrinsic interest only to the origin of the universe, and much more susceptible to investigation, is the age old puzzle of the origin of the chemical elements and isotopes of which the material world is constituted. The problem is indeed a very old one and the early Greek atomists anticipated in some ways the general nature of currently accepted ideas as illustrated in the comments by Simplicius, 6th Century A.D. on the work of Leucippus, 5th Century B.C.:

They [the atoms] move in the void and catching each other up and jostle together, and some recoil in any direction that may chance, and others become entangled with one another in various degrees according to the symmetry of their shapes and sizes and positions and order, and they re-

main together and thus the coming into being of composite things is effected.

The very active theoretical and experimental attack on the problem at the present time is an interdisciplinary inquiry involving astronomy, geology, chemistry, and physics. Physics students interested in the field are well-advised to take courses in astrophysics, geophysics, and physical and nuclear chemistry. In this connection it must be emphasized that the authors of this letter are nuclear physicists, and consequently have concentrated their attention on the nuclear rather than the astronomical or geological aspects of the synthesis of elements.

#### 2. History

It is currently believed that the origin of the elements involves nucleosynthesis and thus energy generation in stars. Early speculations on the source of stellar energy by von Helmholtz, Kelvin, Lockyer, and others culminated in the recognition by Henry Norris Russell of the need for an "unknown" source of energy other than electromagnetic, chemical, or gravitational. Nuclear processes were suggested by Rutherford,

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