Module 1: The Chemical Earth

Some comments

1. Revision

At first sight Module 1 in *C.C.* appears very long (94 pages compared with an average of 77 per module in the Preliminary Course). This is mainly because the book revises a lot of material that the syllabus takes as assumed knowledge, namely

- mixtures, compounds and elements
- atoms and molecules
- some relationships between elements in the Periodic Table
- particle theory of matter
- atomic structure (nucleus, electron cloud, protons, neutrons)
- word equations and qualitative descriptions of reactants and products in decomposition reactions
- common names and formulae for common compounds

This material is all treated in *Conquering Chemistry* so that if teachers feel the need to revise it, it is easily accessible, and if students need to look up the meaning of a basic terms or concepts, they can use this text.

2. Biosphere

There may be a problem with the word *biosphere*. All standard texts – biological, geological, chemical – define it as *the portion of the Earth inhabited by or used by living matter* (and so it is the hydrosphere, atmosphere and part of the lithosphere). See page 10. However from the contexts in which the word is used in the syllabus, the meaning appears to be *living matter*. It is perhaps necessary to treat both the proper biosphere and living matter (that is what *C.C.* does on pages 27 to 30).

3. How many naturally occurring elements?

Page 7 claims that there are 'about 90 naturally occurring elements'. Can't we be more precise than this? Some sources say that there are 89 – atomic numbers 1 to 92, but excluding technetium (At No 43), promethium (61) and astatine (210). Uranium (atomic number 92) is widely considered to be the last of the naturally occurring elements. However the *CRC Handbook of Physics and Chemistry* claims that there are 91 naturally occurring elements – atomic numbers 1 to 94 less technetium and promethium (and presumably another one). That source claims that both neptunium (At No 93) and plutonium (94) have been found in trace amounts in certain uranium-containing rocks. They are believed to have been formed by reaction of neutrons with uranium in natural transmutation processes.

Actually there are several other elements such as francium and astatine which have not strictly been found in nature, but which are conceptually present on Earth. These are elements with only short-lived isotopes that are formed in the radioactive decay series of various naturally-occurring uranium and thorium isotopes. Because the U and Th isotopes are naturally present, and because in the laboratory we have identified their decay products, we must conclude that these decay products are present on Earth, even if in extremely small quantities.

This question of how many naturally occurring elements raises an important point about the methods of scientific discovery. Because we have not found technetium and promethium, does this **prove** that they are not present on Earth? Because you cannot find the needle in the haystack, does that prove it is not there? Of course the short half lives of all the known isotopes of promethium (less than 18 years) is added evidence for its non-occurrence on Earth; however technetium does have a couple of quite long-lived isotopes (10^6 years). On balance the evidence for the non-occurrence of Tc and Pm on Earth is strong, but not absolute.