

Dear madam/sir,

I have participated in the recent International Medical Assessment Test (IMAT) in Warsaw, Poland on 17 October 2023.

In the chemistry section of this IMAT, question No. 42 – number according to the published solutions by the Ministero dell'Università e della Ricerca (MUR) – we have been witnessing to a question which diverted many of us candidates to mark the “wrong” answer, wrong according to the published solution.

The question was as the following:

“The formulae of the five most abundant substances in air are shown:

N₂

O₂

Ar

CO₂

H₂O

How many of these five substances are elements and how many of these five substances are made of molecules?”

The official answer to this question announced by the MUR is:

“Elements = 3, Molecules = 4”

Which I strongly believe is not correct, and the correct answer must be:

Elements = 1, Molecules = 4

The Rational

- **Background knowledge:**

I have been studying to Master of Science in Biomedicine at the University of Southern Denmark years ago. In my whole academic program and later in my related career, I have never encountered in any academic text including many peer-reviewed scientific journal articles, databases, textbooks, or semi-/webinars that somebody states or names molecular oxygen and molecular nitrogen as “elements”! This is the first time I witness this tagging.

- **Different properties:**

It is true that O₂ and N₂ are made of elements. So do the other molecules CO₂, and H₂O. The difference between the former two and the latter two is, the former consists of the same elements while the latter consists of different elements. Just being made of the same elements, does not make O₂ and N₂ “elements”. Elements have different chemical and physical properties than a combination of the same elements, meaning when elements bond to one another of the same type, they

obtain and demonstrate other chemical and physical properties. This means, O_2 is quite different than the element/elementary O. For example, O as an element can be found in the atmosphere when dioxygen (O_2) is broken down to two elements/atoms of (mono)oxygen (O). Monooxygen or elementary oxygen has different properties than dioxygen. Monooxygen is chemically unstable as all other elements are – except the elements of noble gasses. Elements except those of noble gasses are not found as single atoms since they have tendency to bind either to the same or to other elements, making molecules. There are only 118 elements known to date which are registered in The Periodic Table of the Elements. No other substances are called elements.

- **Wording – Element vs. Elemental:**

In some academic texts we encounter “elemental oxygen”, “elemental nitrogen”, “elemental phosphorus” and so on when regarding to O_2 , N_2 and $P_4/P_5/P_6$ respectively. Let us take the “elemental nitrogen”. Here is the wording extremely important not to misunderstand. The word “elemental” is used because it is as an adjective which describes the context or consistency of N_2 , meaning N_2 is made of the elements N. It does not mean that N_2 is an element itself. This is why Blackman *et al* notes that elemental nitrogen (N) exists as the diatomic molecule N_2 []. They do not note that N_2 is an element. As noted in the latter paragraph, elements differ very much in their properties from their molecular forms, and there are only 118 species named elements, or are elements.

The question in the IMAT must have been written as the following, if the aim was to answer “Elements = 3, Molecules = 4”:

“How many of these five substances are elemental and . . .”

- **Simplicity, Element vs. Elementary Substance:**

I have been educated that “A chemical element is the simplest form of a substance that cannot be broken down to smaller units by chemical non-nuclear reactions”.

As the name “element” – or the related word “elementary” – suggests, it demonstrates “the simplest (chemically unbreakable) single initial building material of one type/species” and for the chemistry’s or physics’ concept “with a unique number of protons in the nucleus of this component in its natural occurring form”.

Now, as we have molecular oxygen and molecular nitrogen, and they CAN be broken down to smaller building units, more correctly elements, by some chemical non-nuclear reactions, they cannot be called or referred to as O_2 and N_2 elements, but O_2 and N_2 molecules or diatomic molecules of oxygen(O) and nitrogen (N), or as dioxygen and dinitrogen. You cannot find in any academic source, naming O_2 and N_2 precisely as “elements”!

Bibliography:

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"One of the basic substances that are made of atoms of only one kind and that cannot be separated by ordinary chemical means into simpler substances."
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"A simple chemical substance that consists of atoms of only one type and cannot be split by chemical means into a simpler substance."
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