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Education Faculty Students' Ideas about Fundamental Characteristic of Atoms and Molecules

Eğitim Fakültesi Öğrencilerinin Atom ve Moleküllerin Temel Özellikleri Hakkındaki Düşünceleri

Adnan KÜÇÜKÖNDER
Kahramanmaraş Sütçü İmam University, Faculty of Arts and Sciences, Department of Physics 46100 Kahramanmaraş-TURKEY.

Ömer SÖĞÜT
Kahramanmaraş Sütçü İmam University, Faculty of Arts and Sciences, Department of Physics 46100 Kahramanmaraş-TURKEY.

Erdoğan BÜYÜKKASAP
Atatürk University, Education Faculty, Department of Physics Education, 25240 Erzurum, TURKEY

ÖZET

Atom ve molekül kavramları kimya öğrenimi açısından temel kavramlar olup fizik ve biyolojinin bir çok alanı açısından da önemlidir.Bu çalışmada Türkiye'deki Eğitim Fakültelerinde okuyan Kimya, Fizik, Biyoloji ve Fen Bilgisi Eğitimi son sınıfında okuyan öğrencilerin mülakat yöntemiyle atom ve molekül hakkındaki kavramları ve yanlış kavramları belirlenmiştir.

Anahtar kelimeler: Atom, molekül, yanlış kavramlar, mülakat yöntemi.

ABSTRACT

An understanding of the concepts of atoms and molecules is fundamental to chemistry and some subjects in physics and biology. Students (year, that is last year) of chemistry. physics. biology and science education departments of education faculties in Turkey were interviewed to determine their ideas about fundamental characteristics of atoms and molecules. These are reported in this paper.

Key words: Atom, molecule, misconceptions, interwiev method.

1. Introduction

Many ideas, which the students have prior to instruction or develop during instruction, have been well documented in physics content areas such as heat, motion, the particulate nature of matter, light, atoms and molecules. If the students ideas conflict with scientifically accepted ideas, they are labeled as misconceptions, preconceptions or alternative frame works depending upon the researcher's view of the nature of knowledge. İn the present paper the term "misconception" will be used as defined by Cho, Kahle and Nordland (1985) as "any conceptual idea whose meaning deviates from the one commonly accepted by scientific consensus".

Students' misconceptions are often strongly held, resistant to change and can hinder further learning. Learned school science may have little effect upon students' misconceptions and students may receive instruction in particular topics in science, perform reasonably well in a test on that subject, yet not undergo any meaningful change in their beliefs regarding the phenomena being investigated. Various workers (Gardener, 1986; Anderson and Karrquist, 1983; Fethersthaugh, 1990; Duit, 1983; Shipstone, 1984; Wandersee, 1983; Griffiths and Preston, 1992; Anderson, 1986; Novick and Nussbaum, 1981) which used interviews and/or questionnaires to find out whether students used concepts systematical the particular situation determines the conception which is relevant, and many students conceptions were actually misconceptions which were difficult to change through regular instruction. There are various studies about the structure of atoms and misconceptions (Schmidt H.J., 1997; Harrison A.G. and Treagust D.F., 2000; Niaz M., et al. 2002; Özmen, H., et al. 2002; Toomey R., et al. 2001)

According to science educators, understanding the concepts of atom and molecule is fundamental in the learning of chemistry and some subjects of physics and biology. Such understanding is essential to the learning of other concepts such as chemical bonding, states of matter, spectroscopy, and genetics. The present study focuses upon chemistry, physics, biology and science education students' understanding of the nature of atoms and molecules.

2. Method

We used the interview guide produced by Griffiths and Preston (1992). In addition to this, we followed their procedure, systematic of analysis and representation of the data and techniques of reliability and validity. The interview guide consisted of two major groups of questions, one relating to molecules and the other to atoms. Interview guide is shown in appendix. The sample consisted of final year students (year) of chemistry, physics, biology and science education department of education faculty of Atatürk University in Turkey.

3. Results and Discussion

Results were obtained by a gradual reduction of the total information relating it specifically to the original research questions. Frequency of misconceptions was identified for students of chemistry, physics, biology, and sciences education departments. The content areas relating to molecules are discussed first, followed by the content areas relating to atoms.

Table 1. *Frequencies of misconceptions identified for students of Chemistry, Physics, Biology and Science Education Departments.*

	Frequency of occurrence			
	A n=30	B n=30	C n=30	D n=40
MISCONCEPTION				
THE STRUCTURE OF MOLECULES				
1.1 A water molecule resembles a closed figure with no definite shape.	8	6	5	7
1.2 A water molecule is spherical with particles spread throughout.	-	4	2	4
1.3 A water molecules are composed of two or more solid spheres.	2	8	4	15
THE COMPOSITION OF THE MOLECULE				
2.1 Water molecules contain components other than oxygen and hydrogen.	1	1	-	-
2.2 Water molecules are not all composed of the same atoms.	-	-	-	-
2.3 Water molecules contain more than three atoms.	-	1	-	-
2.4 Water molecules contain less than three atoms.	-	-	-	-
2.5 Water molecules contain different numbers of atoms.	3	-	3	3

A=Chemistry Education, **B**= Physics Education, **C**=Biology Education, **D**= Science Education
- represents a frequency of zero

Table 1. *Frequencies of misconceptions identified for students of Chemistry, Physics, Biology and Science Education Departments.* (Devamı)

	Frequency of occurrence			
	A n=30	**B n=30**	**C n=30**	**D n=40**
THE SIZE OF MOLECULES				
3.1 A water molecule is "macro" in size.	3	3	2	1
3.2 A water molecule is the smallest indivisible entity.	2	3	1	
3.3 Water molecules within a phase may have different sizes.	7	8	13	12
3.4 Water molecules in solid phase (ice) are the largest.	4	3	10	2
3.5 Water molecules in solid phase (ice) are the smallest.	-	4	-	-
3.6 Water molecules in gaseous phase (steam) are the largest.	1	-	-	1
3.7 Water molecules in gaseous phase (steam) are the smallest.	1	-	-	-
3.8 The size of a water molecules depends on its temperature.	-	-	4	2
THE SHAPE OF MOLECULES				
4.1 Water molecules are flat.	4	3	5	4
4.2 Water molecules have different shapes depending on what phase they are in.	7	1	7	13
4.3 Water molecules in a certain phase may have different shapes.	1	3	2	
4.4 Temperature may affect the shape of molecule.	1	2	4	3
4.5 The shape of a container will affect the shape of molecules.	-	-	-	-
4.6 Pressure may affect the shape of a molecule.	2	3	2	2
THE WEIGHT OF MOLECULES				
5.1 A water molecule is heavy enough to be physically weighed.	2	1	3	-
5.2 Water molecules in a certain phase may weigh differently.	3	7	6	3
5.3 Water molecules in solid phase (ice) are the heaviest.	3	7	15	13
5.4 Water molecules in gaseous phase (steam) are the lightest.	4	7	17	13
5.5 The size of a water molecule affects its weight.	-	-	-	-
THE BONDING OF MOLECULES				
6.1 Water molecules in ice touch each other continuously leaving no space.	-	-	-	1
6.2 Water molecules in ice are not bonded in any pattern.	-	1	-	-
6.3 Water molecules are held together by an outside power.	1	-	-	-
6.4 Heat causes molecules to expand leading to separation of molecules during melting.	-	1	8	-

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Table 1. *Frequencies of misconceptions identified for students of Chemistry, Physics, Biology and Science Education Departments.* (Devamı)

	Frequency of occurrence			
	A n=30	B n=30	C n=30	D n=40
THE ENERGY OF MOLECULES				
7.1 Water molecules within each phase move at the same speed.	-	-	-	-
7.2 The speed of a molecule is determined by its size.	1	2	3	3
7.3 The more space a molecule has the faster it will move.	-	-	-	-
7.4 Heat causes molecules to expand.	-	-	2	-
7.5 Heat cause water molecules to break down.	-	-	5	3
THE STRUCTURE/SHAPE OF ATOMS				
8.1 An atom resembles a sphere with components inside.	2	6	3	14
8.2 An atom resembles a solid sphere.	5	7	5	4
8.3 An atom looks like several dots/circles.	-	9	3	3
8.4 Atoms are flat.	-	-	1	2
8.5 Electrons move in orbits.	-	-	-	-
8.6 Matter exists between atoms.	-	-	-	-
THE SIZE OF ATOMS				
9.1 Atoms arc large enough to be seen under a microscope.	2	2	3	3
9.2 Atoms are larger than molecules.	-	-	-	-
9.3 Atoms are the same size.	-	-	-	2
9.4 The size of an atom is determined primarily by the number of protons.	1	-	-	-
9.5 Heat may result in a change of atom size.	-	1	-	-
9.6 Collisions may result in a change of atomic size.	1	1	-	-
THE SİZE OF ATOMS				
10.1 All atoms have the same weight.	-	1	-	1
THE ANIMISM OF ATOMS				
11.1 All atoms are alive.	4	5	4	4
11.2 Only some atoms are alive.	1	-	4	7
11.3 Atoms are alive because they move.	1	2	2	1

A=Chemistry Education, B= Physics Education, C=Biology Education, D= Science Education
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About 20% of students of all departments held Misconceptions 1.1 and 1.3, that "a water molecule resembles a closed figure with no definite shape" and "a water molecule are composed of two or more solid spheres". Others believed that a water molecule is spherical with particles spread throughout (Misconception 1.2). Frequency of Misconceptions 1.3 for students of science education department is higher than that of other departments.

Percentages of misconceptions about the composition of the molecules are lower. Only, about 9% of students of all departments held misconception 2.5, that "water molecules contain different numbers of atoms".

About 31% of students all departments believed that "water molecules within a phase may have different size". About 15% of students held Misconception 3.4 that "water molecules in solid phase (ice) are the largest. The most typical explanation for this idea was "when water freezes it expands".

About 12% of all students believed that "water molecules are flat". About 22% of all students held Misconception 4.2 that "water molecules have different shapes depending on the phase they are in".

About 29% of all students believed that "water molecules in solid phase (ice) are the heaviest". About 32%of all students had Misconception 5.4 that "water molecules in gaseous phase (steam) are the lightest. The most typical explanation was that "water molecules in steam are the lightest, because they can fly".

Percentages of misconception about the bonding and the energy of molecules are low. Eight students of biology education department believed that "heat causes molecules to expand leading to separation of molecules during melting".

About 19% of all students held Misconception 8.6, that "an atom resembles a sphere with components in side". 16% all of students claimed that "an atom resembles a solid sphere". Percentage of students who believed that "an atom looks like several dots/circles" is 12%.

About 12% of all students thought that "atoms are large enough to be seen under a microscope". About 13% all students held Misconception 11.1, that "all atoms are alive". About 9% of ali students believed that "only some atoms alive".

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Appendix

Interview Guide*

Molecules

(A) Structure

1. If you were to take one water molecule from an ice cube and look at it under a microscope so powerful that you could see all the details of a molecule, what would you see?
2. What do you call the part of the molecule that you have drawn? (For example, if a student draws a circle with some dots in it you would ask what the dots mean.)
3. If you were to take one water molecule from some tap waterand look at it undera microscope so powerful that you could see all the details of a molecule, what would you see?
4. What do you call the part of the molecule that you have drawn?
5. If you were to take one water molecule from steam and look at it under a microscope so powerful that you could see all the details of a molecule, what would you see?
6. What do you call the part of the molecule that you have drawn?

(B) Composition

7. What are water molecules made up of
8. Are all the water molecules, that is, those from ice, liquid, and steam made up of the same parts?
9. Do all the molecules from the ice have the same parts?
10. Do all the molecules from the tap have the same parts?
11. Do all the molecules from steam have the same parts?
12. Are there atoms in molecules? Do all molecules have atoms?
13. How many atoms would you find in a molecule of water?
14. Would all water molecules have the same number and kind of atoms? How would they differ?

(C) Size

15. How big do you think a molecule of water is? Try to compare it with something.
16. Do you think that is anything smaller than a molecule? What is it?
17. Are all the molecule in the ice the same size?
18. Are all the molecules in the water the same size?
19. Are all the molecules in the steam the same size?
20. Are all the molecules in ice, water and steam the same size?
21. How are the sizes different? Why does the size change? If the size doesn't change, why not?

(D) Shape

22. Are the molecules that you have draw flat or are they three dimension?
23. Are all the molecules of water in the ice the same shape as the one that you have drawn ?
24. Are all the molecules of water in the liquid the same shape as the one that you have drawn ?
25. Are all the molecules of water in the steam the same shape as the one that you have drawn ?
26. Is there anything which might cause the shape of the molecule to change?

(E) Weight

27. How heavy do you think a molecule of water in ice is? Try to compare it with something.
28. Do all water molecules from ice weigh the same? Why might some be heavier than others?
29. How heavy do you think a molecule of water in a liquid is? Try to compare it with something.
30. Do all water molecules from a liquid weigh the same? Why might some be heavier than others?

31. How heavy do youthink a molecule ofwater in liquid is? Try to compare it with something.
32. Do all water molecules from steam weigh the same? Why might some be heavier than others?
33. From which phase are the molecules the heaviest? From which phase are the molecules the lightest? Why might some water molecules be heavier than others?

(F) Bonding

34. Ifyou could takea halfdozen molecules from ice and look atthemunder a microscope so powerful that you could see all the details of a molecule, what would you see?
35. How are the molecules held together?
36. Is there anything between the molecules? What is it?
37. Are all the molecules the same distance from each other?
38. Why do molecules separate farther apart when going from ice to liquid to steam?

(G) Energy

39. Do molecules move?
40. In which phase do the molecules move the fastest?
41. In which phase do the molecules move the slowest?
42. Do molecules move at different speeds within solids, liquids and gases?
43. Why do some molecules move faster than others?
44. If you were to add heat an ice cube, what do you think would happen to the molecules? Would anything physical be added or removed?

Atoms

(A) Structure/Shape

45. If you were to take one atom and look at it under a microscope so powerful that you could see all the details of a molecule, what would you see? (Get the students to draw a picture)
46. Are there smaller parts which make up atoms? What are they?
47. Do you think that all atoms would look the same? How would they be different ?
48. Are atoms flat or do they have more than two dimensions? Are they all like this?
49. Is there anything between atoms? What is it?

(B) Size

50. How big are atoms? Try to compare them with something.
51. Hoe would the size of the atom compare with the size of a molecule?
52. Are all atoms the same size? Why would they be different?
53. Can the size of atom change? If so, when would a change occur?

(C) Weight

54. Do all atoms weigh the same? How would you explain the difference in weight between atoms?
55. How heavy do you think an atom is? Try to compare it with something.

(D) Animism

56. Do you think atoms are alive?
57. Atoms in a pencil appear not to be alive, and atoms in your body appear to be alive. How do you explain the differences?

* Griffiths and Preston (1992).