

SUPPLEMENTARY MATERIAL TO
**The effects of E-learning units on 13–14-year-old students’
misconceptions regarding some elementary chemical concepts**

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TABLE S-I. Students’ misconceptions on the structure and states of matter

No.	Misconception	Group	SSM ₁			SSM ₂		
			<i>f</i> /%	χ^2	<i>p</i>	<i>f</i> /%	χ^2	<i>p</i>
M1	Particles in solids are equally distributed and do not move	CG	62.5			60.4		
		EG1	50.0	1.972	0.373	75.0	7.418	0.035
		EG2	48.8			41.5		
M2	The size of a plant cell is on the nano (1–100 nm) level	CG	43.8			52.1		
		EG1	45.8	0.031	0.984	29.2	6.065	0.048
		EG2	43.9			29.3		
M3	Water molecules stop moving if the water freezes	CG	45.8			41.7		
		EG1	41.7	3.557	0.169	45.8	2.224	0.329
		EG2	26.8			29.3		
M4	The size of the particles in table salt is on the micro (1–100 μm) level	CG	45.8			47.9		
		EG1	41.7	3.557	0.169	33.3	5.409	0.067
		EG2	26.8			24.4		
M5	The volume of a substance in the liquid state can easily change	CG	22.9			20.8		
		EG1	41.7	3.125	0.210	37.5	3.404	0.182
		EG2	24.4			36.6		
M6	Particles in water vapour are smaller than the particles in ice	CG	33.3			31.3		
		EG1	33.3	2.458	0.293	8.3	7.531	0.023
		EG2	19.5			12.2		
M7	The size of the particles in ice is on the micro (1–100 μm) level	CG	25.0			22.9		
		EG1	33.3	0.570	0.752	20.8	1.268	0.530
		EG2	26.8			31.7		
M8	Condensation affects the size of a molecule	CG	16.7			14.6		
		EG1	29.2	5.431	0.066	8.3	–*	
		EG2	7.3			9.8		
M9	Different states of the same substance contain different particles	CG	16.7			20.8		
		EG1	25.0	3.875	0.144	12.5	4.906	0.086
		EG2	7.3			4.9		
M10	Freezing affects the size of a molecule	CG	18.8			22.9		
		EG1	8.3	– ^a		25.0	6.604	0.037
		EG2	4.9			4.9		

^aPearson χ^2 analysis was not performed since the threshold of 20 % of answers was not reached in any of the groups

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The p values lower than .05 that indicated the statistically significant difference in the proportion of students who had and who did not have the misconceptions, are in bold.

TABLE S-II. Students' misconceptions on pure substances and mixtures; The p values lower than .05 that indicated the statistically significant difference in the proportion of students who had and who did not have the misconceptions, are in bold

No.	Misconception	Group	SSM ₁			SSM ₂		
			f(%)	χ^2	p	f(%)	χ^2	p
M1	Particles in solids are equally distributed and do not move.	CG	62.5			60.4		
		EG1	50.0	1.972	.373	75.0	7.418	.035
		EG2	48.8			41.5		
M2	The size of a plant cell is on the nano (1–100 nm) level.	CG	43.8			52.1		
		EG1	45.8	.031	.984	29.2	6.065	.048
		EG2	43.9			29.3		
M3	Water molecules stop moving if the water freezes.	CG	45.8			41.7		
		EG1	41.7	3.557	.169	45.8	2.224	.329
		EG2	26.8			29.3		
M4	The size of the particles in table salt is on the micro (1–100 μm) level.	CG	45.8			47.9		
		EG1	41.7	3.557	.169	33.3	5.409	.067
		EG2	26.8			24.4		
M5	The volume of a substance in the liquid state can easily change.	CG	22.9			20.8		
		EG1	41.7	3.125	.210	37.5	3.404	.182
		EG2	24.4			36.6		
M6	Particles in water vapour are smaller than the particles in ice.	CG	33.3			31.3		
		EG1	33.3	2.458	.293	8.3	7.531	.023
		EG2	19.5			12.2		
M7	The size of the particles in ice is on the micro (1-100 μm) level.	CG	25.0			22.9		
		EG1	33.3	.570	.752	20.8	1.268	.530
		EG2	26.8			31.7		
M8	Condensation affects the size of a molecule.	CG	16.7			14.6		
		EG1	29.2	5.431	.066	8.3	-*	
		EG2	7.3			9.8		
M9	Different states of the same substance contain different particles	CG	16.7			20.8		
		EG1	25.0	3.875	.144	12.5	4.906	.086
		EG2	7.3			4.9		
M10	Freezing affects the size of a molecule.	CG	18.8			22.9		
		EG1	8.3	-Error!		25.0	6.604	.037
		EG2	4.9	Bookmark not defined.		4.9		

*Pearson chi-square analysis was not performed since the threshold of 20% of answers was not reached in any of the groups.

Examples of multiple-choice test items

(Correct answers are marked in bold)

A. Pretest**Item 2**

You accidentally spill some water to the floor, but you do not have time to wipe it off. A few hours later, the amount of spilled water decreased. What happened to the water?

- A. The amount of water decreased and now takes up less space.
- B. Water turned into gas and went into the air.**
- C. Water broke down to hydrogen and oxygen atoms, which are now in the air.

Item 3

What kind of particles is present in the water?

- A. Water molecules.**
- B. Water atoms.
- C. Atoms of hydrogen and oxygen.
- D. Molecules of hydrogen and oxygen.

Item 4

If you take a bottle of juice from the fridge and put it on the table in the warm room, on the outer side of the bottle appear drops. What are they?

- A. Juice drops from the bottle.
- B. Water drops from the steam from air.**
- C. Drops of water and juice from the bottle.
- D. Drops of water from the bottle.

B) SSM₁ / SSM₂**Item 1**

Which statement about water is **correct**?

- A. Water molecules will stop moving if the water freezes.
- B. Water molecules will stop moving if the water evaporates.
- C. Water molecules will stop moving if a glass with liquid water is not disturbed.
- D. Water molecules will not stop moving.**

Item 2

Which procedure can be used to **increase** the water molecule?

- A. Freezing.
- B. Melting.
- C. Evaporation.
- D. Condensation.
- E. None of the above.**

Item 3

Encircle the **correct** statements:

- a. Liquid substance can easily change its volume.
- b. The shape of the liquid depends on the container.**

- c. **Gases do not have a determined shape.**
- d. A substance cannot change its state from solid to gas.
- e. **The same substance can be found in several states of matter.**

C) PSM₁ / PSM₂

Item 1

Which of the following statements are **correct**?

- a. Milk is a pure substance.
- b. **Sugar is a pure substance.**
- c. **Blood is a mixture.**
- d. Air is a pure substance.

Item 2

Which of the following statements about air is **correct**?

- A. **Air is raw material for gases that air is composed of.**
- B. The major constituent of air is oxygen.
- C. Oxygen in air and pure oxygen have different properties.
- D. Nitrogen in the air is produced by photosynthesis.

Item 3

Which of the following statements are **correct**?

- a. **All particles in pure substances are equal.**
- b. Different parts of a pure substance have different properties.
- c. **Pure substances can be found in different states of matter, depending on a temperature.**
- d. Substances in nature are mostly found in pure form.
- e. **Properties of pure substances are the same in one gram and in 10 grams of those substances.**

- Tvari se sastoje iz čestica
- Isparavanje broma
- Agregatna stanja tvari
- Agregatna stanja vode
- Sažetak
- Zadaci
- Zadaci


Zadaci
naloge

4. Koja tvrdnja je tačna za tvari u različitim agregatnim stanjima?


- U istim tvarima u različitim agregatnim stanjima nalaze se različite čestice.
- U čvrstim tvarima čestice se slobodno kreću.
- Čestice u plinovima su više udaljene jedna od druge nego u tekućinama.
- Brzina kretanja čestica iste tvari u svim agregatnim stanjima je jednaka.

5. Dopuni tekst.

Prikazane su sheme rasporeda čestica u vodi pri prijelazu među agregatnim stanjima. Koja shema prikazuje promjene pri topljenju leda, a koja pri isparavanju vode?



Raspored čestica na slici prikazuje _____ vode.





Raspored čestica na slici prikazuje _____ leda.


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
6. Dopuni tekst.


Prikazani su rasporedi čestica u različitim agregatnim stanjima. Kod svakog prikaza upiši broj agregatnog stanja, koje raspored predstavlja.



1


2


3


4


5


6

plin; tekućina; čvrsta tvar;
 plin i tekućina;
 čvrsta tvar i tekućina;
 plin i čvrsta tvar

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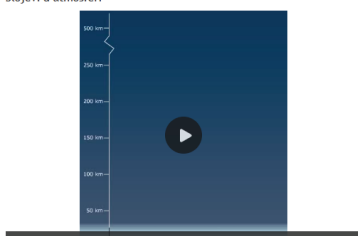
Fig. S-1. Illustration of one slide from the e-learning unit Structure and states of matter

Čiste tvari i smjese
Smjese
Zrak je smjesa plinova
Plinovi u zraku
Čiste tvari
Čiste tvari
Sažetak
Zadaci
Zadaci

Zrak je smjesa plinova

Oko Zemlje se nalazi atmosfera, koja predstavlja 1500 km deo stoji sloj plinova. Što se više udaljavamo od površine Zemlje, atmosfera je sve rjeđa.

Stojevi u atmosferi



Oko 80 % mase svih plinova u atmosferi je u najnižem sloju troposferi. To možemo osjetiti ako se penjemo na visoku planinu. Što se više penjemo, osjećamo se više umorno, jer je u zraku manje kisika nego na moru. U višim predjelima jednim udisajem dobitimo manje kisika nego u nižim i zato teže dišemo.

Zrak je smjesa plinova. Čestice plina u zraku.



Legenda

- dušik
- kisik
- argon
- ogljikov dioksid

Fig. S-2. Illustration of one slide from the e-learning unit Pure substances and mixtures.