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SUPPLEMENTARY MATERIAL TO
**Teaching chemical reactions to upper secondary school students:
A laboratory approach**

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CHEMICALS AND LABORATORY EQUIPMENT FOR THE FIFTH TEACHING
SESSION

- a) 8 dropper vials of the solutions $\text{Pb}(\text{NO}_3)_2$, AgNO_3 , KI , Na_2CO_3 , NaCl , FeCl_3 , NaOH $C=1$ mol/L, HCl $C=1$ mol/L), 2 Cu wires, 1 Fe fastener
- b) 2 test tube racks with 10 test tubes, protective goggles and gloves

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TABLE S-I. First worksheet, guided inquiry

	Chemical reaction	Observations
SIMPLE REPLACEMENT		
1	1 mL $\text{CuSO}_4(\text{aq}) + \text{Fe}(\text{s}) \rightarrow$	
2	1 mL $\text{AgNO}_3(\text{aq}) + \text{Cu}(\text{s}) \rightarrow$	
3	1 mL $\text{HCl}(\text{aq}) + \text{Cu}(\text{s}) \rightarrow$	
4	1 mL $\text{HCl}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow$	
DOUBLE REPLACEMENT		
5	1 mL $\text{NaCl}(\text{aq}) + 10\text{-}15 \text{ drops } \text{AgNO}_3(\text{aq}) \rightarrow$	
6	1 mL $\text{KI}(\text{aq}) + 10\text{-}15 \text{ drops } \text{AgNO}_3(\text{aq}) \rightarrow$	
7	1 mL $\text{KI}(\text{aq}) + 10\text{-}15 \text{ drops } \text{Pb}(\text{NO}_3)_2(\text{aq}) \rightarrow$	
8	1 mL $\text{FeCl}_3(\text{aq}) + 10\text{-}15 \text{ drops } \text{NaOH}(\text{aq}) \rightarrow$	
9	1 mL $\text{Na}_2\text{CO}_3(\text{aq}) + 10\text{-}15 \text{ drops } \text{HCl}(\text{aq}) \rightarrow$	
NEUTRALIZATION		
10	[1 mL $\text{NaOH}(\text{aq}) + 2\text{-}3 \text{ drops of phenolphthalein}$] (solution color:.....) + + $\text{HCl}(\text{aq})$, carefully, until the indicator changes color (color of solution.....)	

EXERCISES:

- Write, in the table above (next to the dots), the chemical equations of the reactions that "take place", showing the precipitate or gas, where it is produced.
- Write the colours of the following precipitates:
 - AgCl , b) AgI ,
 - PbI_2 , d) $\text{Fe}(\text{OH})_3$
- Based on the experiments you did, rank the elements Cu, Zn, H, Ag, in increasing order of activity, justifying your answer
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CHEMICALS AND LABORATORY EQUIPMENT FOR THE SEVENTH TEACHING SESSION

- 4 dropper vials of known solutions $\text{Pb}(\text{NO}_3)_2$, KI, Na_2CO_3 , HCl, 3 dropper vials of the unknown solutions (X_1 : Na_2CO_3 , X_2 : HCl, X_3 : KI)
- 2 test tube holders with 12 test tubes, protective goggles and gloves

TABLE S-II. Second worksheet, open inquiry

1. Research Question: Design an experiment to detect the anions present in each of the "unknown" solutions X1, X2, X3. Write down the steps/procedure you will follow, justifying your choices. List the instruments and substances you will use in each step.
2. Carry out the experiment you designed. Write the experimental results you used to find the contents of each vial.
3. Write the chemical equations of the reactions that took place.
4. Complete the table:

Solution	X1	X2	X3
Anion which it contains			

INDICATIVE ANSWERS TO THE OPEN-ENDED QUESTION

Public school:

1. The experiments in the school laboratory left me with positive feelings, because in addition to being easier to understand, they were also more fun.
2. It was really nice, and I would like to do it again in the future.
3. It was an enjoyable way to learn Chemistry and do experiments, resulting in better remembering of what we were taught.
4. It was a nice experience, because it was the first time, I entered a workshop, and I even participated.
5. When some reactions changed colour, I was surprised, and it was really cool.
6. I had quite a good time in the laboratory, we did experiments and learned new things.
7. It was very good; it helped me understand Chemistry much more and to be able to have a hands-on experience.
8. I thought it would be somewhat difficult because it was the first time I entered a laboratory, but in general the teacher's instructions and the cooperation with the group made things easier.
9. At first, I had my usual anxiety but nothing out of the ordinary. Then it became very easy, although a bit boring because I was the one who wrote all the reactions.
10. It was something new for me and I was quite wary but, in the end, it wasn't too difficult, and I really enjoyed it.
11. The experience was even better because we did the tasks in groups, so if someone was "stuck" or didn't know something, they helped the other and when we completed the experiments correctly, we felt satisfaction.
12. It was undoubtedly an unforgettable experience. If I had the chance, I would do it again without hesitation. I was able to understand the course better and was given the opportunity to interact with my classmates.

13. The experience was unique. Many schools do not offer such things. What we all experienced was fantastic.
14. I found it quite a good experience both with my group and with the teacher who helped us understand. We spent our time pleasantly and creatively.
15. It was a good experience that I have never experienced before, and I enjoyed it. I learned more about chemical reactions.
16. It has helped me understand chemical reactions more and I am now more interested in them as a subject.
17. When I entered the laboratory, I also felt like one of those who work in a laboratory. I really liked it, and I would also like to do a job like that.
18. I really liked it. And it was a very nice experience, since I also understood the reactions.
19. I would also like to enter the laboratory again next year and do experiments again and have teachers doing a demonstration again.
20. It was very nice. It helped us understand the reactions and we also had fun at the same time.
21. It's amazing to do experiments. I was very happy to be able to do them with the other girls.
22. It was perfect. It was the first time we did a lesson in a lab, and it will be unforgettable. Experiments helped me understand Chemistry better.

Private school:

1. I really liked it, and I would like to go to the labs more often, since it helps our understanding.
2. Exciting, as we were given the opportunity to do various experiments with lab equipment.
3. It was a very nice experience, since I did things that I probably won't do again.
4. Very positive experience, much more interesting, experiments with evidence, practical study. They helped me learn more about the reactions.
5. Nice experience with unexpected results.
6. It was an interesting way to learn about chemical reactions.
7. Pleasant and interactive, nice cooperation with classmates.
8. It was a pleasant and interesting teaching session that I believe gave us knowledge that will stay with us.
9. Nice experience, impressive reactions, organized.