



## Writing the Principles - Teacher Answer Key

Below are the 12 principles and changes to connect the lab rewrite to the 12 Principles of Green Chemistry:

1. It is better to prevent waste than to treat or clean up waste after it is formed.

Throwing away the excess milk and other consumables. Using too much of something. Only use the amount you really need so that you do not generate waste.

2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

Throwing away of the filtered out product

3. Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

Not using the bleach wipes therefore not using things that are toxic

4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.

Does the glue still work as well if we change the process?

5. The use of auxiliary substances (e.g. solvents, separation agents, etc.) should be made unnecessary whenever possible and, innocuous when used.

Do we need all of the ingredients like the coke? Could we cut some of the ingredients out and still have it work as well?

6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

Could we test a way to use less energy – how much is optimal? What is the least we need to heat the milk to make it curdle?

7. A raw material feedstock should be renewable rather than depleting whenever technically and economically practical.

Use a glass stirring rod or a wooden spoon instead of a plastic spoon to stir the mixture.

8. Unnecessary derivatization (blocking group protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.

Beets are to change the properties of the glue. If we actually wanted red glue we could add something that is additive such as food coloring in order to prevent waste.

9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

The vinegar is a catalyst. Is it strong enough to reuse once filtered from the Casein?

10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.

Glitter is plastic, a petroleum product. If the glitter is removed, the glue becomes innocuous.

11. Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.

We cut out steps and looked for ways to make the formula simpler. We constantly monitored the heating process in order to note that maybe we could reduce the amount of vinegar used instead of waiting for it to evaporate after we make the glue.

12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

Safety glasses and gloves are worn to diminish any potential for accidents. By limiting the heating steps, we are reducing the potential for accidents, explosions and fires.