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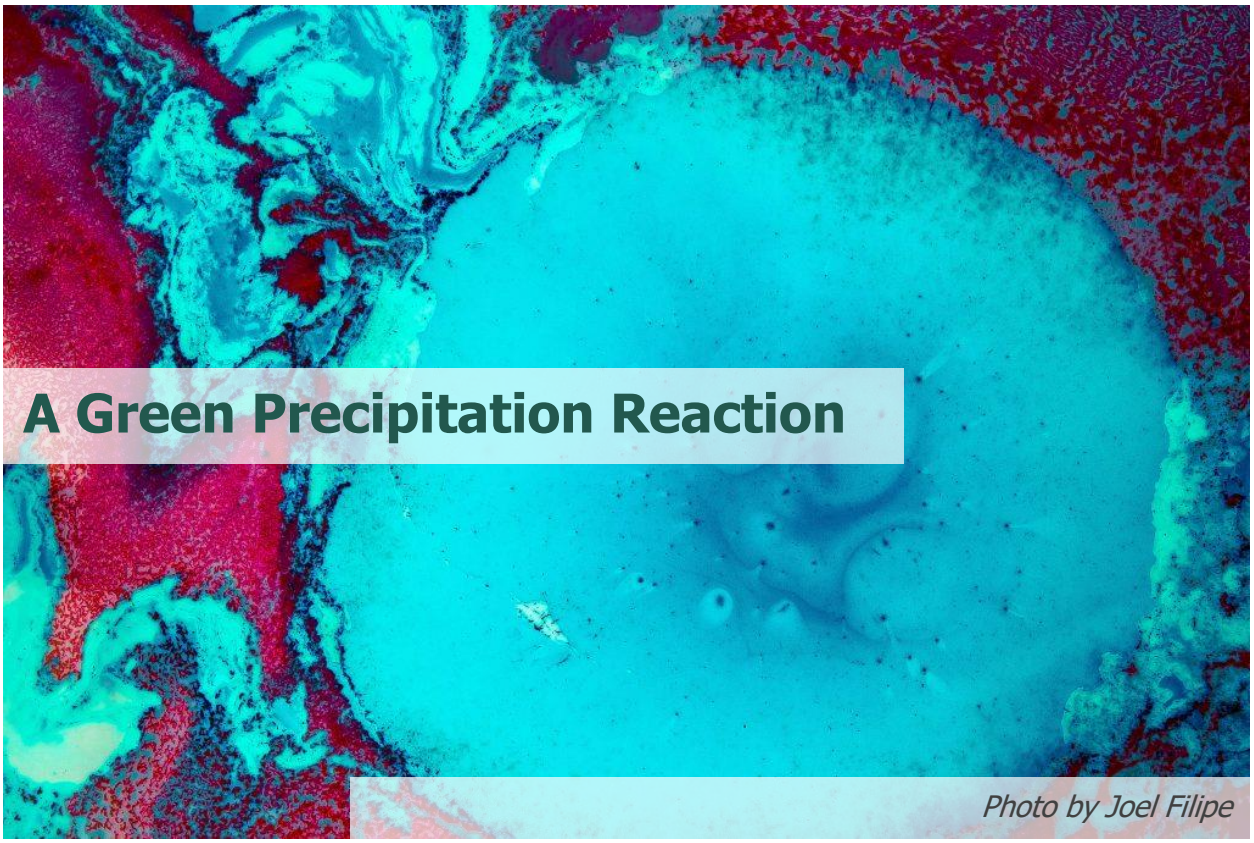
Natural Science INSTITUTE



A Green Precipitation Reaction

Photo by Joel Filipe

The Foundation for Change

- *Increased awareness of the concept of designing safer chemicals*
- *Establishing the scientific, technical and economic credibility of the concept*
- *Effecting a sharper focus on chemicals of concern*
- *Greater emphasis on mechanistic and SAR research in toxicology*
- *Revision in the concepts and practices in chemical education*
- *Major participation by the chemical industry*

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Objectives

- Understand common chemistry concepts such as the limiting reactant, percent yield, and percent composition.
- Understand data quantitatively and qualitatively
- Use data to understand limiting reactants and the percent yield

Background

This lesson plan is intended to replace a lab where students determine the percent composition of sulfate in alum by precipitation with excess barium nitrate. In addition, they will be able to determine the percent composition of zinc acetate by precipitation of zinc carbonate. Students will learn how to calculate common chemistry problems. Students will also learn about the concepts of Green Chemistry.

Standards Met: *NGSS*

- *HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties*
- *HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.*

Introduction to Green Chemistry

Students should first learn that this lesson replaces the determination of the percent composition of sulfate in alum by precipitation with excess barium nitrate. Students will learn about the basics of Green Chemistry through the quiz. Let students write down their answers based on prior knowledge and then provide them with right answers.

The Benefits of Green Chemistry:

1) Green chemistry aims to?
   a) Design chemical products and processes that maximize profits
   b) Design safer chemical products and processes that reduce or eliminate the use and generation of hazardous substances
   c) Design chemical products and processes that work most efficiently
   d) Utilize non-renewable energy

2) Green chemistry can reduce all but which of the following?
   a) Cost
   b) Risk and Hazard
   c) Awareness
   d) Waste

3) Business benefits of green chemistry include?
   a) Reduced costs associated with waste treatment and disposal
   b) Innovating "greener" products to entice customers
   c) Greater compliance with environmental legislation
   d) All of the above

4) Environmental benefits of green chemistry include?
   a) Fewer raw materials and natural resources used
   b) Cleaner production technologies and reduced emissions
   c) Smaller quantities of hazardous waste to be treated and disposed of
   d) All of the above

5) The term used to measure a product or person's environmental impact is?
   a) Handprint
   b) CO_2 print
   c) Footprint
   d) Hazardous print

6) _____ is fulfilling the needs of the present generation without compromising the ability of future generations to meet their needs?
   a) Sustainability
   b) Green chemistry
   c) Life cycle assessment

7) The definition of green chemistry is the same as the definition of sustainability?
   a) True
   b) False

8) Since 1996, Presidential Green Chemistry Challenge Award winning technologies have helped save or eliminate at least 1.3 billion pounds of hazardous chemicals and solvents?
   a) True
   b) False

12 Principles of Green Chemistry:
9)
10) Which of the following are among the 12 Principles of Green Chemistry
   a) Design commercially viable products
   b) Use only new solvents
   c) Use catalysts, not stoichiometric reagents
   d) Re-use waste
   e)
11) Bio-polymers exemplify Green Chemistry Principle # 10, which is?
   a) Catalysis
   b) Prevent waste
   c) Benign solvents and auxiliaries
   d) Design for degradation

12) Biodiesel is an example of which of the 12 Principles of Green Chemistry?
   a) #1 Waste prevention
   b) #7 - Use of renewable feedstocks
   c) #9 - Use of catalysis
   d) #5 - Safer solvents

13) The use of solar power is covered within Green Chemistry Principle #6, which is?
   a) Atom economy
   b) Design for energy efficiency
   c) Design benign chemicals
   d) Less hazardous synthesis

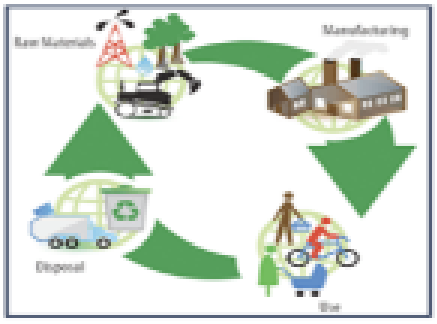
14) An example of chemical toxics prevention is?
   a) Removing water from industrial reactions
   b) Eliminating the formation of chlorinated organics in paper
   c) Utilizing ammonia instead of vinegar
   d) Monitoring BPA (Bisphenol A) in plastic bottles

15) Bio-catalysis has become very useful in green chemistry manufacturing?
   a) True
   b) False

16) An example of green chemistry is?
   a) Recycled carpet

b) A product made on Earth Day
c) A sublimation reaction
d) Bio-plastics

17) This word is synonymous with green chemistry and also means harmless or gentle and not life threatening
a) Sustainable
b) Benign
c) User friendly
d) Greenness



18) The figure above shows a process that is often used as part of which "green" product design system?
a) Market flow analysis
b) Customer Market Flow Analysis
c) Life Cycle Assessment
d) Product Life Analysis

19) Soybean is used to replace traditional inks in printer cartridges, highlighting which of the green chemistry principles?
a) Atom economy
b) **Use of Renewable Feedstock's**
c) Reduce derivatives
d) Prevent waste

"Green" versus Hazardous Chemicals:

20) Green chemists reduce risk by
a) Reducing the hazard inherent in a chemical product or process
b) Minimizing the use of all chemicals
c) Inventing technologies that will clean up toxic sites
d) Developing recycled products

21) The term missing in Risk = Hazard X _____ is?
a) Exposure
b) Cancer
c) Benign
d) Reactivity

22) Used to indicate the level of contaminants present, the term, "PPM" means?
a) Parts-per-micron
b) Parts-per-million
c) Parts-per-mass
d) Parts-per-molecule

23)Which of the following is the greenest solvent
a) Formaldehyde
b) Benzene
c) Ethanol
d) Water

24)This "green" chemical is used in household cleaners to remove stains and is also a favorite dressing on salads?
a) Acetic acid (vinegar)
b) Citric acid
c) Hydrochloric acid (HCl)
d) Water

25)_____is an excellent "green" solvent, as well as a greenhouse gas?
a) Methanol
b) CFCs
c) Carbon monoxide
d) Carbon dioxide

26)A chemical process with an E-Factor of 1 creates LESS waste than an E-Factor of 25? (E-Factor is defined as the total waste divided by the total product)
a) True
b) False

27)TRI is used by the EPA to track pollution prevention. TRI stands for?
a) Total Reporting Inventory
b) Total Release Impact
c) Toxic Release Inventory
d) Toxic Release Impact

28)_____ , or VOCs have been replaced and were banned in some paints?
a) Versatile Organic Chemicals
b) Volatile Organic Compounds
c) Volatile Organic Components
d) Versatile Odorless Components

29)_____interferewith hormone systems in animals and humans and are abbreviated EDC's?
a) Endocrine destructive components
b) Energy Disrupting Chemicals
c) Endocrine Disrupting Chemicals
d) Enzyme Destructive Components

30) In the late 1960's the Cuyahoga River in Ohio overloaded with chemical pollutants and _____ ?
   a) Killed fish
   b) Polluted surrounding soil
   c) Caused foaming
   d) Caught fire

31) Shortly after midnight in 1984, a reaction caused poisonous methyl isocyanate gas to leak from a factory in the city of Bhopal in India causing how many deaths?
   a) 37
   b) 370
   c) 3700
   d) 37,000

Answers

1. B
2. C
3. D
4. D
5. C
6. A
7. B
8. A
9. C
10. D
11. B
12. B
13. B
14. A
15. D
16. B
17. C
18. B
19. A
20. A
21. B
22. D
23. A
24. D
25. A
26. C
27. C
28. C
29. D
30. C

Experimental part

Materials

- 1.0 g of sodium carbonate
- 15 mL of 1 M zinc acetate
- 25 mL graduated cylinder
- 50 mL beaker
- 50 mL Erlenmeyer Flask
- Funnel
- Balance
- Weigh paper
- Filter paper

Teacher Preparation

15 mL of 1 M zinc acetate per reaction
For a class of 20-30 (10 groups of 2-3 students): In a volumetric flask prepare 150 mL of stock solution of 1 M zinc acetate. Weigh out 27.5 grams of zinc acetate and place in a flask. Add water to the 150 mL line. Swirl around the flask to ensure that all ingredients dissolve and place in a container that has easy access for student use.

Disposal Information: *Zinc acetate, Sodium carbonate and Sodium acetate may be poured down the drain and flushed with water. The dry zinc carbonate as a product on filter paper, should be disposed of in the trash.*

Theory

- Write the formula for zinc acetate ($Zn(CH_3COO)_2$ and sodium carbonate (Na_2CO_3) on the board.

- Have students predict the products of the reaction and balance the equation in their lab book.

  Answer $Na_2CO_3 + Zn(CH_3COO)_2 \rightarrow 2\ Na(CH_3COO) + ZnCO_3$

- Have students solve: What is the minimum volume of 1.0 M $Zn(CH_3COO)_2$ you would need to react fully given 1.0 g Na_2CO_3?

  Answer Calculations (Abbreviation Ac = acetate (CH_3COO):

  $n(Na_2CO_3)=n(\underline{Zn(Ac)_2})=m(Na_2CO_3)/M(Na_2CO_3)=1.0\ g/105.99\ g/mol=0.0094\ mol$

  $c(\underline{Zn(Ac)_2})= 1\ mol/L$
  Need=0.0094 mol
  $V(\underline{Zn(Ac)_2})=0.0094\ mol/1\ (mol/L) = 0.0094\ L=9.4\ mL$*

** Students are asked on their hand-out sheets to multiply this amount by 1.5 to ensure the addition of an excess amount of the reagent and to ensure a complete reaction.*

Student Lab Procedure

1. Weigh out 1.0 g of sodium carbonate into a 50 mL beaker. Record the weight _____.
2. Add 15 mL water to the 50 mL beaker to dissolve the solid to make an aqueous solution of sodium carbonate.
3. Calculate: Given 1.0 g of sodium carbonate, how many grams of zinc acetate will be needed to complete this reaction?
4. _____
5. What is the minimum volume of 1.0 M zinc acetate that you will need to react completely given the grams you calculated above?
6. Calculate the volume you determined above by 1.5. The excess volume of 1.0 M zinc acetate is _____.

7. Measure the calculated amount of 1.0 M zinc acetate to solution to the sodium carbonate solution.
8. Record Observations.

Qualitative Procedure

Write your names on a piece of filter paper and weigh the paper. Record on data table. Filter products to get the precipitate. Let this dry overnight.

The next day, weigh the precipitate on filter paper. Record the weight in the data table.

Data Table

Object	Mass (g)
Sodium carbonate sample	
Filter paper	
Filter paper + zinc carbonate	
Zinc carbonate	

Questions

- Calculate the percent composition of carbonate in sodium carbonate. How do these results compare to the known formula?
- Identify the limiting reactant for the reaction.

- What is the percent yield of zinc carbonate for the reaction?

Lesson adopted from:

1. http://www.dec.ny.gov/docs/materials_minerals_pdf/precipitation1.pdf
2. https://pubs.acs.org/doi/abs/10.1021/bk-1996-0640.ch001
3. https://www.acs.org/content/dam/acsorg/greenchemistry/education/resources/