

SI Chemistry - Full Discipline Demo

Stoichiometry of a Precipitation Reaction

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

Chemical equation	The chemical compounds that are present before a reaction occurs	1
Hydrate	The compounds produced from the reaction	2
Mole	Unit of measure, containing Avogadro's number	3
Precipitation reaction	The quantitative proportion of reactants to products	4
Products	Two solutions are mixed and an insoluble substance forms	5
Reactants	An illustration of the reaction that occurs between two or more chemical compounds	6
Stoichiometry	A solid compound that contains water molecules	7

Correct answers:

- 1 Reactants 2 Products 3 Mole 4 Stoichiometry
5 Precipitation reaction 6 Chemical equation 7 Hydrate

Match each compound with its correct molar mass.

**HANDS-ON
LABS**
SCIENCE
DELIVERED

PERIODIC TABLE OF ELEMENTS

1 IA 1 H Hydrogen 1.008	2 IIA 3 Li Lithium 6.941	4 IIA 4 Be Beryllium 9.012	5 IIIB 11 Na Sodium 22.990	6 IIIB 12 Mg Magnesium 24.305	7 IIIB 13 Al Aluminum 26.982	8 IIIB 14 Si Silicon 28.086	9 IIIB 15 P Phosphorus 30.974	10 IIIB 16 S Sulfur 32.06	11 IIIB 17 Cl Chlorine 35.453	12 IIIB 18 Ar Argon 39.948	13 IIIB 19 K Potassium 39.098	14 IIIB 20 Ca Calcium 40.078	15 IIIB 21 Sc Scandium 44.956	16 IIIB 22 Ti Titanium 47.867	17 IIIB 23 V Vanadium 50.942	18 IIIB 24 Cr Chromium 51.996	19 IIIB 25 Mn Manganese 54.938	20 IIIB 26 Fe Iron 55.845	21 IIIB 27 Co Cobalt 58.933	22 IIIB 28 Ni Nickel 58.693	23 IIIB 29 Cu Copper 63.546	24 IIIB 30 Zn Zinc 65.38	25 IIIB 31 Ga Gallium 69.723	26 IIIB 32 Ge Germanium 72.631	27 IIIB 33 As Arsenic 74.922	28 IIIB 34 Se Selenium 78.972	29 IIIB 35 Br Bromine 79.904	30 IIIB 36 Kr Krypton 84.798	31 IIIB 37 Rb Rubidium 85.468	32 IIIB 38 Sr Strontium 87.62	33 IIIB 39 Y Yttrium 88.906	34 IIIB 40 Zr Zirconium 91.224	35 IIIB 41 Nb Niobium 92.906	36 IIIB 42 Mo Molybdenum 95.95	37 IIIB 43 Tc Technetium 98.907	38 IIIB 44 Ru Ruthenium 101.07	39 IIIB 45 Rh Rhodium 102.906	40 IIIB 46 Pd Palladium 106.42	41 IIIB 47 Ag Silver 107.868	42 IIIB 48 Cd Cadmium 112.411	43 IIIB 49 In Indium 114.818	44 IIIB 50 Sn Tin 118.711	45 IIIB 51 Sb Antimony 121.760	46 IIIB 52 Te Tellurium 127.6	47 IIIB 53 I Iodine 126.905	48 IIIB 54 Xe Xenon 131.294	49 IIIB 55 Cs Cesium 132.905	50 IIIB 56 Ba Barium 137.327	51 IIIB 57 La Lanthanum 138.905	52 IIIB 58 Ce Cerium 140.12	53 IIIB 59 Pr Praseodymium 140.908	54 IIIB 60 Nd Neodymium 144.242	55 IIIB 61 Pm Promethium 144.913	56 IIIB 62 Sm Samarium 150.36	57 IIIB 63 Eu Europium 151.964	58 IIIB 64 Gd Gadolinium 157.25	59 IIIB 65 Tb Terbium 158.925	60 IIIB 66 Dy Dysprosium 162.500	61 IIIB 67 Ho Holmium 164.930	62 IIIB 68 Er Erbium 167.259	63 IIIB 69 Tm Thulium 168.934	64 IIIB 70 Yb Ytterbium 173.055	65 IIIB 71 Lu Lutetium 174.967	66 IIIB 72 Hf Hafnium 178.49	67 IIIB 73 Ta Tantalum 180.948	68 IIIB 74 W Tungsten 183.84	69 IIIB 75 Re Rhenium 186.207	70 IIIB 76 Os Osmium 190.23	71 IIIB 77 Ir Iridium 192.22	72 IIIB 78 Pt Platinum 195.084	73 IIIB 79 Au Gold 196.967	74 IIIB 80 Hg Mercury 200.592	75 IIIB 81 Tl Thallium 204.383	76 IIIB 82 Pb Lead 207.2	77 IIIB 83 Bi Bismuth 208.980	78 IIIB 84 Po Polonium (209)	79 IIIB 85 At Astatine (210)	80 IIIB 86 Rn Radon (222)	81 IIIB 87 Fr Francium (223)	82 IIIB 88 Ra Radium (226)	83 IIIB 89 Ac Actinium (227)	84 IIIB 90 Th Thorium (232)	85 IIIB 91 Pa Protactinium (231)	86 IIIB 92 U Uranium (238)	87 IIIB 93 Np Neptunium (237)	88 IIIB 94 Pu Plutonium (244)	89 IIIB 95 Am Americium (243)	90 IIIB 96 Cm Curium (247)	91 IIIB 97 Bk Berkelium (247)	92 IIIB 98 Cf Californium (251)	93 IIIB 99 Es Einsteinium (252)	94 IIIB 100 Fm Fermium (257)	95 IIIB 101 Md Mendelevium (258)	96 IIIB 102 No Nobelium (259)	97 IIIB 103 Lr Lawrencium (262)	98 IIIB 104 Rf Rutherfordium (261)	99 IIIB 105 Db Dubnium (262)	100 IIIB 106 Sg Seaborgium (266)	101 IIIB 107 Bh Bohrium (264)	102 IIIB 108 Hs Hassium (277)	103 IIIB 109 Mt Meitnerium (268)	104 IIIB 110 Ds Darmstadtium (271)	105 IIIB 111 Rg Roentgenium (272)	106 IIIB 112 Cn Copernicium (285)	107 IIIB 113 Nh Nihonium (284)	108 IIIB 114 Fl Flerovium (289)	109 IIIB 115 Mc Moscovium (288)	110 IIIB 116 Lv Livermorium (293)	111 IIIB 117 Ts Tennessine (294)	112 IIIB 118 Og Oganesson (294)	113 IIIB 119 Nh Nihonium (284)	114 IIIB 120 Fl Flerovium (289)	115 IIIB 121 Mc Moscovium (288)	116 IIIB 122 Lv Livermorium (293)	117 IIIB 123 Ts Tennessine (294)	118 IIIB 124 Og Oganesson (294)
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74
g/mol

H₂SO₄

1

98
g/mol

Ca(OH)₂

2

212
g/mol

CuSO₄ • 5H₂O

3

250
g/mol

K₃PO₄

4

Correct answers:

1 98 g/mol 2 74 g/mol 3 250 g/mol 4 212 g/mol

Match each hydrate formula with the correct chemical name.

$\text{MgSO}_4 \cdot \text{H}_2\text{O}$	Magnesium sulfate dihydrate	1
$\text{MgSO}_4 \cdot 2\text{H}_2\text{O}$	Magnesium sulfate monohydrate	2
$\text{MgSO}_4 \cdot 3\text{H}_2\text{O}$	Magnesium sulfate heptahydrate	3
$\text{MgSO}_4 \cdot 5\text{H}_2\text{O}$	Magnesium sulfate hexahydrate	4
$\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$	Magnesium sulfate trihydrate	5
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	Magnesium sulfate pentahydrate	6

Correct answers:

- 1 $\text{MgSO}_4 \cdot 2\text{H}_2\text{O}$ 2 $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ 3 $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 4 $\text{MgSO}_4 \cdot 6\text{H}_2\text{O}$
5 $\text{MgSO}_4 \cdot 3\text{H}_2\text{O}$ 6 $\text{MgSO}_4 \cdot 5\text{H}_2\text{O}$

Exploration

A chemical equation is a written representation of the process that occurs in a chemical reaction.

☒ True

☐ False



The term for a reaction where two solutions are mixed and an insoluble substance forms is called a ____ reaction.

- ☐ chemical
- ☐ soluble
- ☒ precipitation ✓
- ☐ stoichiometry
- ☐ balanced

A mole is a unit of measure, describing the amount of a chemical substance that contains as many atoms, ions, or molecules as there are in exactly 12 grams of pure Nickel.

- ☐ True
- ☒ False ✓

Stoichiometric quantities can be used to maximize the amount of product produced from a chemical reaction.

- ☒ True ✓
- ☐ False

A ____ is a solid compound that contains ____ molecules.

- ☒ hydrate; water ✓
- ☐ water molecule; hydrated
- ☐ hydrate; solid
- ☐ hydrate; hydrated

Exercise 1

Given that a theoretical yield for isolating Calcium Carbonate in this experiment would be 100%. From that information and based on the results you obtained in this experiment, describe your success in the recovery of calcium carbonate and suggest two possible sources of error that would have caused you to not obtain 100% yield.

The answers to the question of percent yield will differ by student; the answer obtained during testing at HOL was 88.2%. However, the suggested possible sources of error are the same, whether or not the yield was above or below 100%. Possible sources of error in calculating the percent yield include: scale inaccuracies, salt sticking to the filter paper, incorrect math and calculations, impurities in the chemicals, etc. However, students should note that the calcium chloride dihydrate may contain more water than it suggests in the empirical formula (as a result of humidity, etc.) and thus the 1.00 g of the calcium chloride dihydrate may contain a higher percentage of water than suggested, lowering the amount of pure calcium chloride in the 1.00 gram.

What impact would adding twice as much Na_2CO_3 than required for stoichiometric quantities have on the quantity of product produced?

As long as the minimum amount of Na_2CO_3 , required to reach stoichiometric quantities is added to the reaction, the addition of more Na_2CO_3 would not impact the quantity of product produced. The CaCl_2 is the limiting reactant, thus in this experiment it is the addition of the calcium chloride that is determinant of the quantity of precipitated product produced.

Determine the quantity (g) of pure CaCl_2 in 7.5 g of $\text{CaCl}_2 \cdot 9\text{H}_2\text{O}$. Show your work.

$$X \text{ g} / 110.98 \text{ g/mol } \text{CaCl}_2 = 7.5 \text{ g} / 273.12 \text{ g/mol } \text{CaCl}_2 \cdot 9\text{H}_2\text{O}$$
$$X = 3.0 \text{ g } \text{CaCl}_2$$

There are 3.0 g of pure CaCl_2 in 7.5 g of $\text{CaCl}_2 \cdot 9\text{H}_2\text{O}$.

Determine the quantity (g) of pure MgSO_4 in 2.4 g of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$. Show your work.

$$X \text{ g} / 120.37 \text{ g/mol MgSO}_4 = 2.4 \text{ g} / 246.48 \text{ g/mol MgSO}_4 \cdot 7\text{H}_2\text{O}$$

$$X = 1.2 \text{ g MgSO}_4$$

There are 1.2 g of pure MgSO_4 in 2.4 g of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$.

Conservation of mass was discussed in the background. Describe how conservation of mass (actual, not theoretical) could be checked in the experiment performed.

To check the conservation of mass in the reaction performed in the exercise, the mass of sodium chloride produced from the reaction would need to be isolated from solution, measured, and added to the mass of precipitate formed. Next, the mass of the NaCl and CaCO_3 would be compared to the combined starting mass of CaCl_2 and Na_2CO_3 .

Data Table 1: Stoichiometry Values
(SAMPLE ANSWER BELOW)

Initial: $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (g)	1.50
Initial: $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (mol)	0.0102
Initial: CaCl_2 (mol)	0.0102
Initial: Na_2CO_3 (mol)	0.0103
Initial: Na_2CO_3 (g)	1.09
Theoretical: CaCO_3 (g)	1.02
Mass of Filter paper (g)	1.09
Mass of Filter Paper + CaCO_3 (g)	2.12
Actual: CaCO_3 (g)	1.03
% Yield:	101%

Competency Review

The chemicals that are present before a reaction occurs are called ____, and the chemicals produced from the reaction are called ____.

- ☐ products; reactants
- ☒ reactants; products

✓

A precipitation reaction produces insoluble substances that can be removed from the solution.

- ☒ True
- ☐ False

✓

The quantitative proportion of reactants to products in a chemical reaction is known as ____.

- ☐ the Law of Conservation of Mass
- ☒ stoichiometry
- ☐ the precipitation coefficient

✓

The molar mass of H_2O is approximately 18 grams; thus, one mole of H_2O weighs approximately 18 grams.

- ☒ True
- ☐ False

✓

How many moles of water are in the compound copper sulfate pentahydrate?

- ☐ 3
- ☒ 5
- ☐ 6
- ☐ 7

✓

In order to calculate the theoretical maximum amount of product produced in a precipitation reaction, you must ____.

- ☐ convert grams of reactants to moles
- ☐ determine how many moles of reactants are necessary to reach stoichiometric quantities
- ☐ determine moles of product from the reaction
- ☐ convert moles of product to grams
- ☒ All of the above

✓

A reaction is performed in a lab whereby two solutions are mixed together. The products are a liquid and a solid precipitate. What procedures would facilitate measurement of actual yield of the solid?

- ☐ Calculate the maximum potential yield, and apply the final value in the appropriate equation.
- ☒ Use filter paper to isolate and dry the precipitate, and then determining mass of the solid.
- ☐ Find the cumulative mass of the precipitate and solid, and extrapolate the molecular mass.
- ☐ All of the above

✓

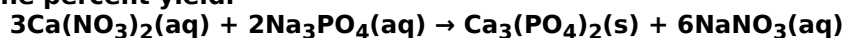
Why might the actual yield of a precipitation reaction not equal the theoretical yield?

- ☐ Environmental conditions may cause variations in the water content of the hydrate.
- ☐ The reaction did not go to completion.
- ☐ The precipitate was not properly isolated.
- ☒ All of the above

✓

Extension Questions

A student carries out the precipitation reaction shown below, starting with 0.030 moles of calcium nitrate. The final mass of the precipitate is 2.9 g. Answer the questions below to determine the percent yield.



- a. Which product is the precipitate?**
- b. How many moles of the precipitate would one expect to be produced from 0.030 moles of calcium nitrate?**
- c. How many grams of solid do you expect to be produced?**
- d. What is the percent yield?**

(SAMPLE ANSWER BELOW)

- a. The precipitate is $\text{Ca}_3(\text{PO}_4)_2$.
- b. $0.030 \text{ moles} \times (1 \text{ mole } \text{Ca}_3(\text{PO}_4)_2 / 3 \text{ moles } \text{Ca}(\text{NO}_3)_2) = 0.010 \text{ moles } \text{Ca}_3(\text{PO}_4)_2$
- c. $0.010 \text{ mol} \times 310.177 \text{ g/mol} = 3.1 \text{ g } \text{Ca}_3(\text{PO}_4)_2 \text{ (s)}$
- d. $(2.9 \text{ g} / 3.1 \text{ g}) \times 100\% = 93.5 \text{ \% yield}$