

Test Course

Stoichiometry of a Precipitation Reaction

Final Report - Answer Guide

Institution	SI Curriculum Development University
Session	Test Course
Course	Test Course
Instructor	Corinne Brown

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 95.94	37 IIIB 43 Tc Technetium 98.906	38 IIIB 44 Ru Ruthenium 101.07	39 IIIB 45 Rh Rhodium 101.07	40 IIIB 46 Pd Palladium 106.32	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 118.710	45 IIIB 51 Sb Antimony 121.757	46 IIIB 52 Te Tellurium 127.6	47 IIIB 53 I Iodine 126.905	48 IIIB 54 Xe Xenon 131.29	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 140.116	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 289	112 IIIB 118 Og Oganesson 294	113 IIIB 119 Uu Ununennium 288	114 IIIB 120 Uub Unbibium 286	115 IIIB 121 Uut Untrium 284	116 IIIB 122 Uuq Unquadrium 289	117 IIIB 123 Uuh Unhexium 285	118 IIIB 124 Uuq Unquadrium 289	119 IIIB 125 Uuh Unhexium 285	120 IIIB 126 Uuq Unquadrium 289	121 IIIB 127 Uuh Unhexium 285	122 IIIB 128 Uuq Unquadrium 289	123 IIIB 129 Uuh Unhexium 285	124 IIIB 130 Uuq Unquadrium 289	125 IIIB 131 Uuh Unhexium 285	126 IIIB 132 Uuq Unquadrium 289	127 IIIB 133 Uuh Unhexium 285	128 IIIB 134 Uuq Unquadrium 289	129 IIIB 135 Uuh Unhexium 285	130 IIIB 136 Uuq Unquadrium 289	131 IIIB 137 Uuh Unhexium 285	132 IIIB 138 Uuq Unquadrium 289	133 IIIB 139 Uuh Unhexium 285	134 IIIB 140 Uuq Unquadrium 289	135 IIIB 141 Uuh Unhexium 285	136 IIIB 142 Uuq Unquadrium 289	137 IIIB 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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.

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

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

A perfect percent yield would be 100%. Based on your results, describe your success in recovery of the calcium carbonate and suggest possible sources of error.

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 1.0 g of the calcium chloride dihydrate may contain a higher percentage of water than suggested, lowering the amount of pure calcium chloride in the 1.0 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.

$$X \text{ g} / 120.37 \text{ g/mol } \text{MgSO}_4 = 2.4 \text{ g} / 246.48 \text{ g/mol } \text{MgSO}_4 \cdot 7\text{H}_2\text{O}$$
$$X = 1.2 \text{ g } \text{MgSO}_4$$

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 CaCO₃ would be compared to the combined starting mass of CaCl₂ and Na₂CO₃.

Data Table 1: Stoichiometry Values
(SAMPLE ANSWER BELOW)

Initial: CaCl ₂ •2H ₂ O (g)	1.50
Initial: CaCl ₂ •2H ₂ O (mol)	0.0102
Initial: CaCl ₂ (mol)	0.0102
Initial: Na ₂ CO ₃ (mol)	0.0103
Initial: Na ₂ CO 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 products, and the chemicals produced from the reaction are called reactants.

- ☐ True
☒ False



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
- ☐ a ratio

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

- ☒ True ✓
- ☐ False

There are ____ moles of water 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 ____.

- ☐ 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. To measure the actual yield of the solid, one must ____.

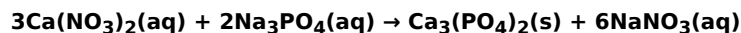
- ☐ calculate the maximum potential yield, and apply the final value in the appropriate equation
- ☒ use filter paper to isolate and dry the precipitate, and then determine the mass of the solid ✓
- ☐ find the cumulative mass of the precipitate and solid, then extrapolate the molecular mass
- ☐ All of the above

Reasons that the actual yield of a precipitation reaction might not equal the theoretical yield include ____.

- ☐ environmental conditions causing variations in the water content of the hydrate
- ☐ the reaction not going to completion
- ☐ the precipitate not being 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. $(2.9 \text{ g} / 3.1 \text{ g}) \times 100\% = 93.5 \% \text{ yield}$