Test Course

The Mole Concept: Chemical Formula of a Hydrate

Final Report - Answer Guide

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Session	Test Course
Course	Test Course
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Test Your Knowledge

Arrange each chemical in order of mass, from smallest mass to largest mass.

≡ 1.0 moles $PbCl_2$

1 **Correct answer:** 5.0 moles H_2

≡ 1.5 moles Na

2 **Correct answer:** 1.5 moles Na

≡ 2.0 moles N_2

3 **Correct answer:** 2.0 moles N_2

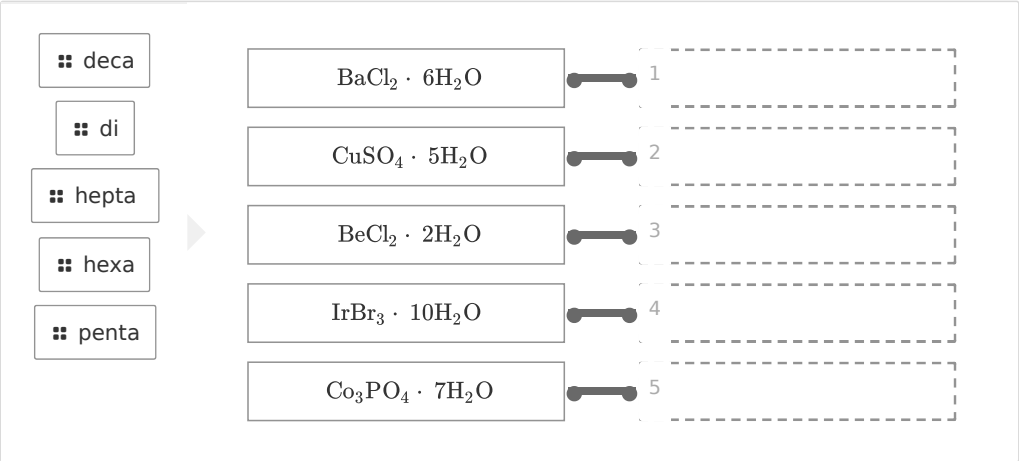
≡ 3.0 moles CH_3CH_2OH

4 **Correct answer:** 3.0 moles CH_3CH_2OH

≡ 5.0 moles H_2

5 **Correct answer:** 1.0 moles $PbCl_2$

Match each prefix to the appropriate hydrate it would be used to name.



Correct answers:

1 hexa 2 penta 3 di 4 deca 5 hepta

Exploration

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

- True
- False ✔

In 85.2 g of $FeCl_2$ there are _____ moles of $FeCl_2$.

- 1.52
- 2.00
- 0.672 ✔
- 0.933

In 85.2 g of $FeCl_2$ there are _____ moles of chlorine.

- 1.34 ✔
- 0.672
- 2.00
- 2.69

Water is released from a hydrate by _____.

- heating the hydrate ✔
- cooling the hydrate
- adding water to the hydrate
- None of the above

Exercise 1

Calculate the moles of anhydrous (dry) $KAl(SO_4)_2$ that were present in the sample. Show all work including units.

0.90 g $KAl(SO_4)_2$ x 1 mol $KAl(SO_4)_2$ / 258.2 g = 0.0035 mols $KAl(SO_4)_2$

Calculate the ratio of moles of H_2O to moles of anhydrous $KAl(SO_4)_2$. Show all work including units.

Note: Report the ratio to the closest whole number.

Ratio = 0.061 mols H_2O/0.0035 mols $KAl(SO_4)_2$
Ratio = 17

Write the empirical formula for the hydrated $KAl(SO_4)_2$, based on your experimental results and answer to Question 2. Show all work including units.

Hint: if the ratio of moles of H_2O to moles of anhydrous $KAl(SO_4)_2$ was 4, then the empirical formula would be: $KAl(SO_4)_2 \cdot 4H_2O$.

The empirical formula, using the calculated data is: $KAl(SO_4)_2 \cdot 17H_2O$

Describe any visual differences between the hydrated sample and the dried, anhydrous form.

The hydrated sample appears to be small, circular, damp particles. They move well in the aluminum cup and have a shiny, metallic appearance. The dried, anhydrous form looks very dried out, it is clumped together and is unable to move in as small particles. It looks like molten lava.

How would the following errors affect the empirical formula for the compound? That is, will these errors cause the calculated number of moles of water in the hydrate to be artificially high or low?

a. The student ran out of time and did not do the second heating. Explain how this error will affect the calculation for the number of moles of water in the hydrate? Will the final answer be artificially high or low?

b. The student recorded the mass of the cup + sample incorrectly and started with 2.20 g of hydrated compound but used 2.00 g in the calculations. Explain how this error will affect the calculation for the number of moles of water in the hydrate? Will the final answer be artificially high or low? How do you know?

a. Not all of the water would have been released, resulting in a hydrate calculation that has too few moles of water.
b. The sample would have “released” more water, resulting in a hydrate calculation that included more moles of water than were actually present.

Data Table 1: Alum Data

(SAMPLE ANSWER BELOW)

Object	Mass (g)
Aluminum Cup (Empty)	2.50
Aluminum Cup + 2.0 grams of Alum	4.50
Aluminum Cup + Alum After 1st Heating	3.40
Aluminum Cup + Alum After 2nd Heating	3.40
Mass of Released H_2O	1.10
Molar mass of H_2O	18.015
Moles of Released H_2O	0.0611

Competency Review

There are _____ atoms in 12 grams of pure carbon (^{12}C).

- 12.022 x 10^{23}
- 6.022 x 10^{23} ✔
- 4.023 x 10^{23}
- 1.00 x 10^{23}

One mole of a compound has the mass that is equal to the molecular mass.

- True ✔
- False

The element oxygen has a molar mass of 15.999 grams, thus one mole of oxygen is equal to _____ g/mol.

- 31.998
- 15.999 x 10^{23}
- 15.999 ✔
- 31.998 x 10^{23}

A hydrate is a compound in which water molecules are a part of the crystalline structure.

- True ✔
- False

When copper sulfate heptahydrate is heated, ___ moles of water are available to be released.

- 1
- 4
- 7 ✔
- 9

The second step in converting between the mass of a compound and moles of a compound is to use the molar mass to convert grams to moles.

- True ✔
- False

There are ___ moles of anhydrous $CuSO_4$ present in a sample with 0.5 g $CuSO_4$ at a molar mass of 159.61 g/mol.

- 0.00313 ✔
- 0.00853
- 0.00710
- 0.00626

If there were 0.00708 moles of $CuSO_4$ and 0.085 moles of released H_2O, the ratio of moles of H_2O to moles of anhydrous $CuSO_4$ is _____.

- 10
- 27
- 5
- 12 ✔

After heating a sample of hydrated $CuSO_4$, the mass of released H_2O was found to be 2.0 g. The number of moles of H_2O released is _____ if the molar mass of H_2O is 18.016 g/mol.

- 0.111 ✔
- 0.004
- 9.031
- 0.222

If for every mole of copper sulfate there were 8 moles of water released, the empirical formula for hydrated copper sulfate is ____.

- 8 $CuSO_4$ ● H_2O
- 8 $CuSO_4$ ● 8 H_2O
- $CuSO_8$ ● H_8O
- $CuSO_4$ ● 8 H_2O ✔

Extension Questions

Cu (II) sulfate exists as a hydrate. It has many practical uses including use as a fungicide and pesticide. When mixed with chromium and arsenic it forms the wood preservative called CCA. CCA was used in pressure treated wood to protect wood from rotting due to insects and microbial agents. Because CCA treated wood contains toxic heavy metals, its use has been discontinued for home use and children's play sets.

A chemist is given a sample of the $CuSO_4$ hydrate and asked to determine the empirical formula of it. The original sample weighed 42.75 g. After heating to remove the waters of hydration, the sample weighed 27.38 g. Determine the formula for this hydrate. Show your work.

(SAMPLE ANSWER BELOW)

Mass of water removed = 42.75 g – 27.38 g = 15.37 g Moles of water removed = 15.37 g x 1 mol/18.0 g = 0.854 mols Mass of anhydrous copper sulfate = 27.38 g Moles of anhydrous copper sulfate = 27.38 g x 1 mol/159.55 g = 0.172 mols Moles H_2O/mols $CuSO_4$ = 0.854/0.172 = 4.96 = 5 (rounded to whole number) Formula = $CuSO_4 \cdot 5H_2O$