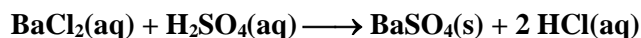
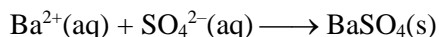


Determination of barium chloride concentration in its aqueous solution

Barium sulphate is a white, practically insoluble substance in water ($K_s = 1,072 \cdot 10^{-10}$). It occurs in nature as the mineral *barite*. Synthetically prepared is used as a white pigment *barite white* in painting. Resists weather, chemicals and light. During precipitation, barium sulphate absorbs many impurities from the solution, which are removed by decantation. It can be prepared by the precipitation reaction of barium chloride with sulphuric acid.



particle notation



Work

Determine the composition of an aqueous solution of barium chloride.

Chemicals

- barium chloride, BaCl_2 , aqueous solution with an unknown concentration
- sulphuric acid, H_2SO_4 , concentrated aqueous solution

Procedure

Density measurement

In order to be able to express the composition of a barium chloride solution, we need information about the density of this solution. We measure it with a densimeter in a sufficiently large measuring cylinder. When reading the density, the densimeter must float freely, it must not touch the walls. After stabilizing the position, we read the density value directly from the densimeter scale.

Precipitation

We measure exactly 20 – 30 cm^3 from the prepared BaCl_2 solution with an unknown concentration into a pre-weighed tall beaker using an automatic burette. We accurately weigh the measured solution and calculate the density of the solution from its volume and weight, which we compare with the densimeter.

Dilute the solution to a volume of approximately 150 cm^3 with distilled water and heat almost to boiling. We measure 3 cm^3 of concentrated sulphuric acid, from which we prepare an aqueous solution, diluted with distilled water in a volume ratio of 1 : 5. When measuring the acid, safety regulations must be observed. When preparing a diluted solution, acid is basically added to water and never the other way around! We also heat the sulphuric acid solution and slowly, with constant stirring, pour using a glass rod into the hot barium chloride solution until we observe the formation of a white precipitate. Hot-precipitated barium sulphate is coarse-grained and quickly settles and filters.

Allow the precipitate to settle and add a few more drops of diluted sulphuric acid to the clear solution above the precipitate. If the white turbidity of barium sulphate no longer forms at the surface, carefully pour off the clear solution or suck it up with a pipette connected to a water pump. We must be careful not to stir the surface and suck out part of the barium sulphate. Add approximately the same volume of distilled water to the beaker with the barium sulphate precipitate and mix the contents intensively. After the precipitate settles again, pour off the clear solution or suck it off. The mentioned method of cleaning the precipitate from unwanted impurities is called *decantation*. We repeat it at least three times.

Filtration

Finally, the barium sulphate precipitate is separated from the solution by filtering through a smooth filter made of special filter paper, which is completely burned without residue during annealing. Pour the barium sulphate onto the filter quantitatively, *i.e.* rinse the beaker with distilled water so that no barium sulphate remains in it. After the end of the filtration, we do not open the filter with the precipitate, but fold it completely so that the precipitate remains closed inside. We reduce the amount of water in the wet filter by drying it on a watch glass in a drying oven, or by carefully pressing it into a layer of filter paper (put about three papers under the wet filter paper and three on top). The filter paper must not dry completely so that it does not crack when it is placed in the crucible.

Annealing

As a first step, we have to anneal the empty crucible. Place it according to fig. 1 above the burner in a triangle, which is placed on an iron ring at such a height that we can use the maximum temperature of the flame (the tip of the inner blue cone of the flame). Turn the crucible occasionally over the flame using preheated crucible tongs. After annealing, let the crucible cool down directly on the triangle. After cooling, place it in a desiccator with tongs, where we let it cool down to room temperature. We determine its weight by weighing it on analytical scales.

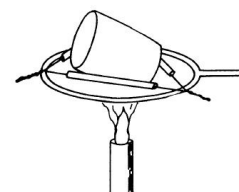


Fig. 1 Annealing



Fig. 2 Handling the paper filter after filtration

- 1 – separation of the precipitate by filtration
- 2 – removing the filter with the precipitate
- 3 – folding the filter
- 4 – inserting the filter into the crucible
- 5 – pressing the filter to the bottom of the crucible

After drying, wrap the filter with the precipitate according to fig. 2 and transfer from the watch glass to a weighed empty crucible, where we carefully press it to the bottom. The crucible with the precipitate is then annealed with filter paper (the filter should not burn with a flame) to a constant weight (approximately 1 hour). After a certain time, white flammable smoke will begin to escape from the crucible due to thermal decomposition or carbonization of the filter paper. If a small flame appears in the crucible, move the heat aside and carefully cover the crucible with a watch glass for a few seconds. When white smoke appears again, we can start annealing again until the filter is completely burned. After annealing, leave the crucible with the precipitate to cool freely in the air. After cooling, transfer it to the desiccator with tongs. After it cools down, we determine the exact weight of the crucible with barium sulphate on the analytical balance. By subtracting the weight of the empty crucible, we get the weight of pure annealed barium sulphate, which we use to calculate the composition of the original aqueous solution of barium chloride.

Task

Express the composition of an aqueous barium chloride solution by mass and mole fraction, mass concentration, molar concentration (molarity) and molality of both components, *i.e.* barium chloride and water.

Each student hands over a filled-in ticket with calculated values to the teacher of the laboratory exercise:

----- ✂ ----- ✂ ----- ✂ ----- ✂ ----- ✂ ----- ✂ ----- ✂ ----- ✂ -----

| Name: | BaCl ₂ | H ₂ O |
|-------------------------|----------------------|----------------------|
| mass fraction | | |
| mole fraction | | |
| mass concentration | g cm ⁻³ | g cm ⁻³ |
| molar concentration | mol dm ⁻³ | mol dm ⁻³ |
| molality | mol kg ⁻¹ | mol kg ⁻¹ |
| density of the solution | | g cm ⁻³ |
| average molar mass | | g mol ⁻¹ |

Calculation of the composition of barium chloride solution

Since the mass m' of the barium chloride solution calculated from its volume V' and the density ρ' determined by the densimeter is not accurate enough, we will use the mass m' obtained by weighing the solution on accurate balance.

To simplify notation, we will use the abbreviation A (*aqua*) \equiv H₂O, B (*barium chloratum*) \equiv BaCl₂, P (*product*) \equiv BaSO₄.

From the weight of barium sulphate obtained, we calculate the weight of barium chloride and water in the original solution.

$$m(\text{B}) = \xi M(\text{B}) |v(\text{B})| = \frac{m(\text{P})}{M(\text{P}) |v(\text{P})|} M(\text{B}) |v(\text{B})| = \frac{m(\text{P}) M(\text{B})}{M(\text{P})} \quad m(\text{A}) = m' - m(\text{B})$$

The quantities describing the composition of the barium chloride solution will be calculated according to their definition relationships.

| | | |
|---------------------|---|---|
| mass fraction | $w(\text{B}) = \frac{m(\text{B})}{m'}$ | $w(\text{A}) = \frac{m(\text{A})}{m'}$ |
| | $w(\text{A}) + w(\text{B}) = \frac{m(\text{A})}{m'} + \frac{m(\text{B})}{m'} = \frac{m'}{m'} = 1$ | |
| mole fraction | $x(\text{B}) = \frac{n(\text{B})}{n(\text{A}) + n(\text{B})} = \frac{\frac{m(\text{B})}{M(\text{B})}}{\frac{m(\text{A})}{M(\text{A})} + \frac{m(\text{B})}{M(\text{B})}}$ | $x(\text{A}) = \frac{n(\text{A})}{n(\text{A}) + n(\text{B})} = \frac{\frac{m(\text{A})}{M(\text{A})}}{\frac{m(\text{A})}{M(\text{A})} + \frac{m(\text{B})}{M(\text{B})}}$ |
| | $x(\text{A}) + x(\text{B}) = \frac{n(\text{A})}{n(\text{A}) + n(\text{B})} + \frac{n(\text{B})}{n(\text{A}) + n(\text{B})} = \frac{n(\text{A}) + n(\text{B})}{n(\text{A}) + n(\text{B})} = 1$ | |
| mass concentration | $\underline{\rho}(\text{B}) = \frac{m(\text{B})}{V'}$ | $\underline{\rho}(\text{A}) = \frac{m(\text{A})}{V'}$ |
| | $\underline{\rho}(\text{A}) + \underline{\rho}(\text{B}) = \frac{m(\text{A})}{V'} + \frac{m(\text{B})}{V'} = \frac{m'}{V'} = \rho'$ | |
| molar concentration | $c(\text{B}) = \frac{n(\text{B})}{V'} = \frac{m(\text{B})}{M(\text{B}) V'}$ | $c(\text{A}) = \frac{n(\text{A})}{V'} = \frac{m(\text{A})}{M(\text{A}) V'}$ |
| molality | $\underline{m}(\text{B}) = \frac{n(\text{B})}{m(\text{A})} = \frac{m(\text{B})}{M(\text{B}) m(\text{A})}$ | $\underline{m}(\text{A}) = \frac{n(\text{A})}{m(\text{A})} = \frac{\cancel{m(\text{A})}}{M(\text{A}) \cancel{m(\text{A})}} = \frac{1}{M(\text{A})}$ |
| average molar mass | $\bar{M} = x(\text{A}) M(\text{A}) + x(\text{B}) M(\text{B})$ | |