Examining the solubility of substances in double replacement reactions essay samp...

Aim:

The aim of this investigation is to perform various double replacement reactions with known substances and record the qualitative observations. Furthermore, writing the equations for the reactions and apply the rules of solubility to see if every color change equals to a precipitate. It is predicted that a solid will form only when there is a change in color.

Plan:

Materials:

* $ZnSO_4$ solution

* $BaCl_2$ solution

* $AgNO_3$ solution

* $Pb(NO_3)_2$ solution

* NaCl solution

* NaBr solution

* $CuSO_4$ solution

* NaI solution

* Na_2SO_3 solution

* Na_2SO_4 solution

* Pipette

* 45 test tubes

* Test tube rack

Procedure:

Mix one drop of each of two solutions in different test tubes and recorded observations.

Safety:

During the experiment a protective coat and goggle must be worn to prevent contact with the chemicals.

Results: This is a table showing the observations while mixing the solutions.

Analysis:

$ZnSO_4$ – $BaCl_2$:

Overall equation: $ZnSO_4(aq) + BaCl_2(aq)$ $ZnCl_2(aq) + BaSO_4(s)$

Net Ionic Equation: $Ba^{2+}(aq) + SO_4^{2-}(aq)$ $BaSO_4(s)$

$ZnSO_4$ – $AgNO_3$:

Overall equation: $ZnSO_4(aq) + 2AgNO_3(aq)$ $Zn(NO_3)_2(aq) + Ag_2SO_4(s)$

Net Ionic Equation: $2Ag^{+}(aq) + SO_4^{2-}(aq)$ $Ag_2SO_4(s)$

$ZnSO_4$ – $Pb(NO_3)_2$:

Overall equation: $ZnSO_4(aq) + Pb(NO_3)_2(aq)$ $Zn(NO_3)_2(aq) + PbSO_4(s)$

Net Ionic Equation: $Pb^{2+}(aq) + SO_4^{2-}(aq)$ $PbSO_4(s)$

$ZnSO_4$ – NaCl :

Overall equation: $ZnSO_4(aq) + 2NaCl(aq)$ $ZnCl_2(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

$ZnSO_4$ – NaBr :

Overall equation: $ZnSO_4(aq) + 2NaBr(aq)$ $ZnBr_2(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

$ZnSO_4$ – $CuSO_4$:

Overall equation: $ZnSO_4(aq) + CuSO_4(aq)$ $ZnSO_4(aq) + CuSO_4(aq)$

Net Ionic Equation: No reaction

$ZnSO_4$ – NaI :

Overall equation: $ZnSO_4(aq) + 2NaI(aq)$ $ZnI_2(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

$ZnSO_4$ – Na_2SO_3 :

Overall equation: $ZnSO_4(aq) + Na_2SO_3(aq)$ $ZnSO_3(s) + Na_2SO_4(aq)$

Net Ionic Equation: $Zn^{2+}(aq) + SO_3^{2-}(aq)$ $ZnSO_3(s)$

This equation shows that a precipitate has formed. However the table shows that no change has occured.

$ZnSO_4$ – Na_2SO_4 :

Overall equation: $ZnSO_4(aq) + Na_2SO_4(aq)$ $ZnSO_4(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

$BaCl_2$ – $AgNO_3$:

Overall equation: $BaCl_2(aq) + 2AgNO_3(aq)$ $Ba(NO_3)_2(aq) + 2AgCl(s)$

Net Ionic Equation: $Ag^+(aq) + Cl^-(aq)$ $AgCl(s)$

$BaCl_2$ – $Pb(NO_3)_2$:

Overall equation: $BaCl_2(aq) + Pb(NO_3)_2(aq)$ $Ba(NO_3)_2(aq) + PbCl_2(s)$

Net Ionic Equation: $Pb^{2+}(aq) + 2Cl^-(aq)$ $PbCl_2(s)$

$BaCl_2$ – NaCl :

Overall equation: $BaCl_2(aq) + NaCl(aq)$ $BaCl_2(aq) + NaCl(aq)$

Net Ionic Equation: No reaction

$BaCl_2$ – NaBr :

Overall equation: $BaCl_2(aq) + 2NaBr(aq)$ $2NaCl(aq) + BaBr_2(aq)$

Net Ionic Equation: No reaction

$BaCl_2$ – $CuSO_4$:

Overall equation: $BaCl_2(aq)$ + $CuSO_4(aq)$ $BaSO_4(s)$ + $CuCl_2(aq)$

Net Ionic Equation: $Ba^{2+}(aq)$ + $SO_4^{2-}(aq)$ $BaSO_4(s)$

$BaCl_2$ – NaI :

Overall equation: $BaCl_2(aq)$ + 2NaI(aq) $BaI_2(aq)$ + 2NaCl(aq)

Net Ionic Equation: No reaction

$BaCl_2$ – Na_2SO_3 :

Overall equation: $BaCl_2(aq)$ + $Na_2SO_3(aq)$ $BaSO_3(s)$ + 2NaCl(aq)

Net Ionic Equation: $Ba^{2+}(aq)$ + $SO_3^{2-}(aq)$ $BaSO_3(s)$

$BaCl_2$ – Na_2SO_4 :

Overall equation: $BaCl_2(aq)$ + $Na_2SO_4(aq)$ $BaSO_4(s)$ + 2NaCl(aq)

Net Ionic Equation: $Ba^{2+}(aq)$ + $SO_4^{2-}(aq)$ $BaSO_4(s)$

$AgNO_3$ – $Pb(NO_3)_2$:

Overall equation: $AgNO_3(aq)$ + $Pb(NO_3)_2(aq)$ $AgNO_3(aq)$ + $Pb(NO_3)_2(aq)$

Net Ionic Equation: No reaction

$AgNO_3$ – NaCl :

Overall equation: $AgNO_3(aq)$ + NaCl(aq) AgCl(s) + $NaNO_3(aq)$

Net Ionic Equation: $Ag^+(aq) + Cl^-(aq)$ $AgCl(s)$

$AgNO_3$ – NaBr :

Overall equation: $AgNO_3(aq) + NaBr(aq)$ $AgBr(s) + NaNO_3(aq)$

Net Ionic Equation: $Ag^+(aq) + Br^-(aq)$ $AgBr(s)$

$AgNO_3$ – $CuSO_4$:

Overall equation: $2AgNO_3(aq) + CuSO_4(aq)$ $Ag_2SO_4(s) + Cu(NO_3)_2(aq)$

Net Ionic Equation: $2Ag^+(aq) + SO_4^{2-}(aq)$ $Ag_2SO_4(s)$

A precipitate has been produced although the table points out that no observation has been made.

$AgNO_3$ – NaI :

Overall equation: $AgNO_3(aq) + NaI(aq)$ $AgI(s) + NaNO_3(aq)$

Net Ionic Equation: $Ag^+(aq) + I^-(aq)$ $AgI(s)$

$AgNO_3$ – Na_2SO_3 :

Overall equation: $2AgNO_3(aq) + Na_2SO_3(aq)$ $Ag_2SO_3(s) + 2NaNO_3(aq)$

Net Ionic Equation: $2Ag^+(aq) + SO_3^{2-}(aq)$ $Ag_2SO_3(s)$

The table and the equation contradict here as well.

$AgNO_3$ – Na_2SO_4 :

Overall equation: 2AgNO3(aq) + Na2SO4(aq) Ag2SO4(s) + 2NaNO3(aq)

Net Ionic Equation: 2Ag+(aq) + SO42-(aq) Ag2SO4(s)

Precipitate form but no change observed.

Pb(NO3)2 – NaCl :

Overall equation: Pb(NO3)2(aq) + 2NaCl(aq) PbCl2(s) + 2NaNO3(aq)

Net Ionic Equation: Pb2+(aq) + 2Cl-(aq) PbCl2(s)

Pb(NO3)2 – NaBr :

Overall equation: Pb(NO3)2(aq) + 2NaBr(aq) PbBr2(s) + 2NaNO3(aq)

Net Ionic Equation: Pb2+(aq) + 2Br-(aq) PbBr2(s)

Pb(NO3)2 – CuSO4 :

Overall equation: Pb(NO3)2(aq) + CuSO4(aq) PbSO4(s) + Cu(NO3)2(aq)

Net Ionic Equation: Pb2+(aq) + SO42-(aq) PbSO4(s)

Pb(NO3)2 – NaI :

Overall equation: Pb(NO3)2(aq) + 2NaI(aq) PbI2(s) + 2NaNO3(aq)

Net Ionic Equation: Pb2+(aq) + 2I-(aq) PbI2(s)

Pb(NO3)2 – Na2SO3 :

Overall equation: Pb(NO3)2(aq) + Na2SO3(aq) PbSO3(s) + 2NaNO3(aq)

Net Ionic Equation: $Pb^{2+}(aq) + SO_3^{2-}(aq)$ $PbSO_3(s)$

$Pb(NO_3)_2$ – Na_2SO_4 :

Overall equation: $Pb(NO_3)_2(aq) + Na_2SO_4(aq)$ $PbSO_4(s) + 2NaNO_3(aq)$

Net Ionic Equation: $Pb^{2+}(aq) + SO_4^{2-}(aq)$ $PbSO_4(s)$

NaCl – NaBr :

Overall equation: NaCl(aq) + NaBr(aq) NaCl(aq) + NaBr(aq)

Net Ionic Equation: No reaction

NaCl – $CuSO_4$:

Overall equation: $2NaCl(aq) + CuSO_4(aq)$ $Na_2SO_4(aq) + CuCl_2(aq)$

Net Ionic Equation: No reaction

NaCl – NaI :

Overall equation: NaCl(aq) + NaI(aq) NaCl(aq) + NaI(aq)

Net Ionic Equation: No reaction

NaCl – Na_2SO_3 :

Overall equation: $NaCl(aq) + Na_2SO_3(aq)$ $NaCl(aq) + Na_2SO_3(aq)$

Net Ionic Equation: No reaction

NaCl – Na_2SO_4 :

Overall equation: $NaCl(aq) + Na_2SO_4(aq)$ $NaCl(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

NaBr – $CuSO_4$:

Overall equation: $2NaBr(aq) + CuSO_4(aq)$ $Na_2SO_4(aq) + CuBr_2(aq)$

Net Ionic Equation: No reaction

NaBr – NaI :

Overall equation: $NaBr(aq) + NaI(aq)$ $NaBr(aq) + NaI(aq)$

Net Ionic Equation: No reaction

NaBr – Na_2SO_3 :

Overall equation: $NaBr(aq) + Na_2SO_3(aq)$ $NaBr(aq) + Na_2SO_3(aq)$

Net Ionic Equation: No reaction

NaBr – Na_2SO_4 :

Overall equation: $NaBr(aq) + Na_2SO_4(aq)$ $NaBr(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

$CuSO_4$ – NaI :

Overall equation: $CuSO_4(aq) + 2NaI(aq)$ $CuI_2(aq) + Na_2SO_4(aq)$

Net Ionic Equation: No reaction

This is a special case: first of all the copper (II) is an unstable ion. On the other hand copper (I) is the most stable form of copper. This is due to the way the electrons are located on the orbitals of the atom. Therefore, at the end of the reaction instead of CuI2(aq), a very insoluble CuI(s) will form giving the solution its brownish color.

The electron arrangement of Cu: 1s2 2s2 2p6 3s2 3p6 4s1 3d10

Lewis Daigram of CuI:

Cu I

CuSO4 – Na2SO3 :

Overall equation: CuSO4(aq) + Na2SO3(aq) CuSO3(s) + Na2SO4(aq)

Net Ionic Equation: Cu2+(aq) + SO32-(aq) CuSO3(s)

CuSO4 – Na2SO4 :

Overall equation: CuSO4(aq) + Na2SO4(aq) CuSO4(aq) + Na2SO4(aq)

Net Ionic Equation: No reaction

NaI – Na2SO3 :

Overall equation: NaI(aq) + Na2SO3(aq) NaI(aq) + Na2SO3(aq)

Net Ionic Equation: No reaction

NaI – Na2SO4 :

Overall equation: NaI(aq) + Na2SO4(aq) NaI(aq) + Na2SO4(aq)

Net Ionic Equation: No reaction

Na2SO3 – Na2SO4 :

Overall equation: Na2SO3(aq) + Na2SO4(aq) Na2SO3(aq) + Na2SO4(aq)

Net Ionic Equation: No reaction

Conclusion:

Based on the results the following conclusion can be made: all salts of sodium (Na) are highly soluble. The same assumption can be made for the other alkali metals considering they have the same chemical properties. All nitrate and chlorate salts are soluble. The sulfate salts of silver (Ag), lead (Pb) and barium (Ba) are white precipitates; on the other hand other sulfate salts are soluble. Chloride, bromide and iodide salts of silver and lead are white solids. Finally all sulfites are insoluble except alkali metals and sulfite compounds.

Accepting that there was no systematic error, the equation of the reactions between ZnSO4 – Na2SO3, AgNO3 – CuSO4, AgNO3 – Na2SO3 and AgNO3 – Na2SO4 show a precipitate forming, however there was no observations recorded. This disproves the prediction of a precipitate forming only with color change. The results show that every color change equals a solid forming but not every solid causes change in color.

The different results show that particular ions show similar outcomes with different ions. Furthermore it is known that all of the ions used in this experiment belong to different groups and periods on the periodic table. This shows that the chemical properties of the ions are the most important factor at determining solubility. The reaction between copper sulfate and sodium iodide is a good example of how the orbits of the electrons play a big role at determining the result.

Evaluation:

There is a risk of systematic error (in this case mainly errors caused by the experimenter) that can’t be determined. First of all there wasn’t enough time in hand to perform all 45 reactions calmly in a well-organized method. It wasn’t possible to put labels on the test tubes indicating the compounds in it; cancelling the change of observing the changes after a longer period of time. Some reactions may perform very slowly only allowing observations of simultaneous changes. The time limit also prevented retests, which would eliminate systematic errors.

Although the lack of time and crowded working station no obscure results were obtained. However, for the fairness of the experiment at least two more retests are needed. Also the solutions in each test tube should be observed one more time after a few minutes considering the chance of a slow reaction. Therefore a good method and time is very important in experiments like these where many combinations of reactions must be performed.