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| UNIT 8**SOLUBILITY AND PRECIPITATION REACTIONS**Answers |

***Lesson 1 – What is solubility and what are saturated solutions?***

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| **Summary Activity 1.1: What is a solution?** |
| * Solution: mixture of two components, evenly distributed and in the same phase (usually liquid), solute = minor component of a solution; solvent = major component of a solution
* Water; aqueous solutions
* Sea water, brine, limewater
* Moles of solute per cubic decimetre of solution
* A substance which can form free ions in solution; strong electrolytes completely dissociate into ions in solution, weak electrolytes only partially dissociate
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| Image result for test icon**Test your knowledge 1.2: Understanding Solubility and Saturated Solutions** |
| 1. 13.6 moldm-3
2. 61.2 g
3. Yes, because the molarity would be 12.5 moldm-3 which is less than a saturated solution
4. By heating the solution until some of the water evaporates, or by cooling the solution
5. Ca(OH)2(s) 🡪 Ca2+(aq) + 2OH-(aq)
6. 0.37 g
7. No, because the molarity would be 0.27 moldm-3 which is greater than the solubility of Ca(OH)2
8. Glucose is more soluble because its saturated solution has a higher molarity than a saturated solution of calcium hydroxide
9. Calcium hydroxide is an electrolyte because when it dissolves it dissociates into its ions; glucose it not an electrolyte because it remains as molecules when it dissolves
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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 1.3: Determining the solubility of calcium hydroxide in water by titration** |
| **Equipment needed per group: spatula, weighing boat, funnel, filter paper, 250 cm3 volumetric flask, 250 cm3 beaker, 25.0 cm3 pipette with pipette filler, 50 cm3 burette, clamp, stand, boss, access to mass balance, access to distilled water, access to Ca(OH)2 (1 – 2 g per group), access to phenolphthalein (1 cm3 per group), access to 0.05 moldm-3 HCl (100 cm3 per group)*** **Ca(OH)2 + 2HCl 🡪 CaCl2 + 2H2O**
* **The solubility of Ca(OH) in water is 0.011 moldm-3; around 22 cm3 of HCl should be needed**
* **Using 22 cm3, moles of HCl = 22/1000 x 0.05 = 0.0011, so moles of Ca(OH)2 = 5.5 x 10-4, so molarity of solution = 2.2 x 10-4/0.05 = 0.011 moldm-3; this is the solubility of Ca(OH)2**
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# *Lesson 2 – What is crystallisation and what are solubility curves?*

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| **Summary Activity 2.1: Preparing salts** |
| * We heated the salt solution gently until most of the water had evaporated off
* Some of the salt crystallises out during heating because the concentration of the solution increases as the water is removed
* Most of the salt crystallises out during cooling; the water continues to evaporate so the concentration increases, and the solubility decreases as the solution cools down
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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 2.2: Purify a sample of copper sulphate by recrystallisation** |
| **Equipment needed per group: 15 g of hydrated copper sulphate, spatula, 50 cm3 measuring cylinder; stirring rod, 250 cm3 beaker, 3 pieces of filter paper, funnel, evaporating dish, tripod, gauze and Bunsen burner OR sand bath, access to distilled water, access to fridge*** **The insoluble impurities are removed when the solid is filtered**
* **The soluble impurities are removed when the solid is decanted**
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| Image result for test icon**Test your knowledge 2.3: Using solubility curves** |
| 1. Approx 9 moldm-3
2. Approx 2.5 moldm-3
3. Solubility = approx. 4 moldm-3 so n = 4 x 0.05 = 0.2 so m = 20 g
4. Solubility = approx. 14 moldm-3, n = 20/101 = 0.2 so V = n/C = 0.014 dm3 or 14 cm3
5. n = 10/101 = 0.1 so C = 0.1/0.01 = 10 moldm-3 so T = 55 - 57 oC
6. n = 15/101 = 0.15 so C = 0.15/0.02 = 7.5 moldm-3 so T = 46 - 48 oC
7. n = 30/101 = 0.3 so C = 0.3/0.025 = 12 moldm-3 but solubility = 11 moldm-3 so not all will dissolve
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| https://image.freepik.com/free-icon/plus-sign_318-54005.jpg**Extension 2.4: Using solubility curves** |
| Open question so no answers available |

# *Lesson 3 – What is precipitation and what is a precipitation reaction?*

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| **Summary Activity 3.1: Solubility of Ionic Compounds** |
| * Ionic compounds dissolve in water because the positive ions are attracted to the electronegative O atom in water and the negative ions are attracted to the electropositive H atom in water
* The attraction between the ions and water has to be stronger than the attraction of the ions to each other; in some cases the ions are attracted to each other more strongly than they are attracted to water
* sodium chloride, ammonium sulphate, copper sulphate
* silver chloride, calcium carbonate etc
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| Image result for test icon**Test your knowledge 3.2: Predicting the Solubility of Ionic Compounds** |
| 1. Mg(NO3)2; soluble (Rule 1)
2. Na2SO4; soluble (Rule 2)
3. CuCl2; soluble (Rule 3)
4. AgCl; insoluble (Rule 3)
5. PbBr2; insoluble (Rule 3)
6. CuSO4; soluble (Rule 4)
7. BaSO4; insoluble (Rule 4)
8. MgSO4; soluble (Rule 4)
 | 1. BaCO3; insoluble (Rule 5)
2. K2CO3; soluble (Rule 2)
3. CaCO3; insoluble (Rule 5)
4. Cu(OH)2; insoluble (Rule 5)
5. LiOH; soluble (Rule 2)
6. Ba(OH)2; soluble (Rule 5)
7. Mg(OH)2; insoluble (Rule 5)
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| https://image.freepik.com/free-icon/plus-sign_318-54005.jpg**Extension 3.3: Predicting the Solubility of Ionic Compounds** |
| Open question so no answers available |

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| Image result for test icon**Test your knowledge 3.4: Predicting Precipitation** |
| 1. precipitate: Ba2+(aq) + SO42-(aq) 🡪 BaSO4(s)
2. precipitate: Pb2+(aq) + 2Cl-(aq) ( PbCl2(s)
3. precipitate: Cu2+(aq) + 2OH-(aq) ( Cu(OH)2(s)
4. no precipitate
5. precipitate: Ca2+(aq) + CO32-(aq) ( CaCO3(s)
6. no precipitate
7. precipitate: Ag+(aq) + Cl-(aq) ( AgCl(s)
8. no precipitate
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| https://image.freepik.com/free-icon/plus-sign_318-54005.jpg**Extension 3.5: Predicting Precipitation** |
| Open question so no answers available |

# *Lesson 4 – How can we prepare insoluble salts?*

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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 4.1: Observe precipitation reactions** |
| **Equipment needed per group: access to labelled bottles containing 0.05 moldm-3 AgNO3, and 0.1 moldm-3 HCl, H2SO4, BaCl2, CuSO4 and NaOH (25 cm3 per group), with one 10 cm3 measuring cylinder for each bottle, 15 x test tubes, one test tube rack*** **Expected observations:**

* **Equations:**

**AB: Ag+(aq) + Cl-(aq) 🡪 AgCl(s); AC: 2Ag+(aq) + SO42-(aq) 🡪 Ag2SO4(s); AD: Ag+(aq) + Cl-(aq) 🡪 AgCl(s);****AE: Ag+(aq) + Cl-(aq) 🡪 AgCl(s); AF: Ag+(aq) + OH-(aq) 🡪 AgOH(s); CD: Ba2+(aq) + SO42-(aq) 🡪 BaSO4(s); DE: Ba2+(aq) + SO42-(aq) 🡪 BaSO4(s); EF: Cu2+(aq) + 2OH-(aq) 🡪 Cu(OH)2(s)** |

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| **Summary Activity 4.2: Preparation of soluble salts** |
| * Copper sulphate was prepared by reacting excess copper oxide with sulphuric acid; this is an acid-base (or neutralisation) reaction; the excess copper oxide (which is insoluble) was removed by filtration and the soluble salt was extracted by crystallisation (the salt solution was heated and then allowed to cool)

CuO + H2SO4 🡪 CuSO4 + H2O* Ammonium sulphate was prepared by reacting ammonia with sulphuric acid in a 2:1 ratio; this is an acid-base (or neutralisation) reaction; both reactants are also soluble so the exact quantities were needed; the soluble salt was extracted by crystallisation (the salt solution was heated and then allowed to cool)

2NH3 + H2SO4 🡪 (NH4)2SO4* Zinc sulphate was prepared by reacting excess zinc with dilute sulphuric acid; this is a redox reaction; the excess zinc was removed by filtration and the soluble salt was extracted by crystallisation (the salt solution was heated and then allowed to cool

Zn + H2SO4 🡪 ZnSO4 + H2 |

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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 4.3: Prepare a sample of the insoluble salt lead chloride** |
| **Equipment needed per group: 5 cm3 of 1 moldm-3 lead (II) nitrate solution, 5 cm3 of 2 moldm-3 sodium chloride solution; 2 x 10 cm3 measuring cylinders, boiling tube with bung; funnel, 2 x filter paper, small beaker (50 cm3), spatula, access to distilled water*** **Pb2+(aq) + 2Cl-(aq) 🡪 PbCl2(s)**
* **Precipitation**
* **It doesn’t matter; whichever reactant is in excess will be removed during the filtration process**
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***Lesson 5 – How can we use precipitation reactions to identify cations in solution?***

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|  **Summary Activity 5.1: Qualitative Analysis of Cations** |
| * Add blue litmus paper; it will turn red; add a sample of calcium carbonate; a gas will be given off which turns limewater milky
* Add sodium hydroxide solution and warm; a pungent gas should be given off which turns red litmus paper blue
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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 5.2: Use precipitation reactions to identify cations in solution** |
| Chemicals needed: minimum 0.1 moldm-3 solutions of: FeSO4 (labelled A), Na2CO3 (labelled B), ZnSO4 (labelled C), CaCl2 (labelled D), CuSO4 (labelled E), Pb(NO3)2 (labelled F), Al2(SO4)3 (labelled G) and Fe2(SO4)3 (labelled H) - around 10 cm3 per group prepared in a single bottle, each with its own dropping pipette; also 0.5 - 1 moldm-3 of the following solutions: NaOH, HCl - up to 20 cm3 per group; each group needs its own bottle with its own dropping pipetteApparatus needed per group: 16 test tubes, 1 test tube rackExpected observations:* Zn2+ and Al3+ cannot be distinguished by this combination of tests
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**Lesson 6 – How can we use precipitation reactions to identify anions in solution?**

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|  **Summary Activity 6.1: Qualitative Analysis of Anions** |
| 1. Add red litmus paper; it will turn blue; add some ammonium chloride and warm; a pungent gas should be given off which turns red litmus paper blue
2. Add sodium hydroxide solution and aluminium powder and heat; a pungent gas should be given off which turns red litmus paper blue
3. Add HCl(aq); a gas will be given off which turns limewater milky
4. Add HCl(aq); a gas will be given off which turns blue litmus paper red and turns dichromate paper green
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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 6.2: Use precipitation reactions to identify anions in solution** |
| Chemicals needed: minimum 0.1 moldm-3 solutions of: FeSO4 (labelled A), Na2CO3 (labelled B), KI (labelled C), KNO3 (labelled D), CaCl2 (labelled E), Na2SO3 (labelled F) - around 10 cm3 per group prepared in a single bottle, each with its own dropping pipette; also access to 0.05 moldm-3 AgNO3, 0.1 moldm BaCl2, 1 moldm-3 HCl, 1 moldm-3 HNO3 - up to 50 cm3 per group; each bottle needs its own dropping pipetteApparatus needed per group: 17 test tubes, 2 test tube racksExpected observations:CO32- and SO32- cannot be distinguished by this combination of tests; they could be distinguished by adding CaCl2(aq) and then adding HCl(aq) to the resulting precipitate; the gas evolved from CO32- will turn limewater milky; the gas evolved from SO32- will turn blue litmus red and turn dichromate paper green |

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| Image result for test icon**Test your knowledge 6.3: Using precipitation to distinguish between different solutions** |
| 1. add NaOH (aq); no reaction with NaCl; white precipitate with Ca(OH)2
2. add NaOH (aq) dropwise and then in excess; white precipitate with Ca(NO3)2 is insoluble in excess NaOH; white precipitate with Pb(NO3)2 dissolves in excess NaOH
3. add NaOH (aq); dark green precipitate with FeSO4; pale blue precipitate with CuSO4: orange/brown precipitate with Fe2(SO4)3
4. add HCl (aq); no reaction with Ca(NO3)2; white precipitate with Pb(NO3)2
5. Add AgNO3 (aq); no reaction with NaNO3; white precipitate with NaCl
6. Add BaCl2 (aq); no reaction with NaCl; white precipitate with Na2SO4
7. Add BaCl2 (aq) then add HCl(aq); white precipitate with Na2SO4 is insoluble in HCl; white precipitate with Na2CO3 dissolves in HCl
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| https://image.freepik.com/free-icon/plus-sign_318-54005.jpg**Extension 6.4: Further qualitative analysis** |
| 1. add blue litmus paper; it turns red in nitric acid but not in sodium nitrate
2. add HCl; observe bubbles with sodium carbonate but not with sodium hydroxide, or add magnesium chloride solution (or any solution containing a +2 ion); a precipitate forms in both cases; with the carbonate, the precipitate will give off bubbles when it dissolves, but the hydroxide will dissolve without giving off bubbles
3. Add NaOH and heat; with ammonium nitrate, a pungent gas will be given off which turns red litmus blue; with sodium nitrate there will be no reaction
4. Add aluminium powder and sodium hydroxide and hear; with sodium nitrate, a pungent gas will be given off which turns red litmus blue; with water there will be no reaction
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***Lesson 7 – What is hard water?***

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| cid:ii_jepnvfe00_1621fa54a497745d **Practical 7.1: Test the Hardness of Water** |
| Chemicals needed: water from different sources and a solution of soap in ethanol (around 50 cm3 per group)Apparatus needed per group: one conical flask, one measuring cylinder (10 cm3), one burette with clamp, boss and stand and one funnelThe seawater should be the hardest (need the greatest quantity of soap) and the rainwater should be the softest (need the least quantity of soap) |
| https://image.freepik.com/free-icon/plus-sign_318-54005.jpg**Extension 7.2: Testing for Temporary and Permanent Hardness in Water** |
| Take 10 cm3 of water from each source and boil them before adding the soap; then add the soap as in the original experiment; if less soap is required with the boiled sample, some of its hardness is temporary; the bigger the difference, the greater the amount of temporary hardness in the water |

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| Image result for test icon**Test your knowledge 7.3: Understanding the Difference Between Hard and Soft Water** |
| 1. Ca2+, Mg2+ and Fe2+ ions
2. Forms limescale when heated, forms scum instead of lather with soap
3. It is a good source of minerals for humans
4. Distillation, ion exchange, precipitation using sodium carbonate
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***Lesson 8 – How much have I learned about solubility and precipitation reactions?***

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| Image result for test icon**8.1 END-OF-UNIT QUIZ****UNIT 8 – SOLUBILITY AND PRECIPITATION REACTIONS** |
| 1. A solution which contains the maximum amount of dissolved solute which it is possible to dissolve in that quantity of solvent
2. The solid NaCl dissolves and the aqueous NaCl crystallises at equal rates
3. Solubility of solids usually increases with temperature
4. Solubility of gases usually decreases with temperature
5. 7.1 – 7.2 moldm-3 (b) solubility = 8.5 – 8.7 moldm-3 so mass = 23 – 24 g

(c) solubility = 10.0 – 10.2 moldm-3 so volume = 18 – 19 cm3 (d) around 54 oC1. (a) soluble; (b) insoluble; (c) soluble; (d) insoluble; (e) soluble
2. (a) pale blue precipitate; (b) no reaction; (c) white precipitate; (d) white precipitate; (e) white precipitate
3. (a) Add NaOH (aq); FeSO4 gives dark green precipitate, Fe2(SO4)3 gives orange/brown precipitate
4. Add HCl (aq); Pb(NO3)2 gives white precipitate; Zn(NO3)2 gives no reaction
5. Add HCl (aq) and then BaCl2(aq); Na2CO3 gives no reaction; Na2SO4 gives white precipitate
6. (a) Fe2+, Ca2+, Mg2+

(b) causes limescale when heated, causes scum instead of lather with soap(c) ion exchange, distillation, precipitation with sodium carbonate(d) Add soap from a burette to a fixed quantity of different water sample; measure how much is needed to form a lather; the more soap needed, the harder the water |