O-level chemistry

SOLUBILITY

A solute is a substance that dissolves in another substance. For example, sugar dissolves in water

A solvent is a substance that dissolves another, for example, water dissolves sugar.

In a solution of sugar and water, therefore, the solvent is water and solute is sugar

If a solution can dissolve more solute in presence of undissolved solute at the same temperature it is **unsaturate**d. If we shake much sugar or common salt with water, some solid dissolves but the rest settles on standing. The water cannot dissolve any more solid and the solution is **saturated.**

Therefore, a saturated solution of a solute at a particular temperature is one which can dissolve no more solute at that temperate (in the presence of undissolved solute)

A supersaturated solution: is one that contains more solute than it can hold at the same temperature in the presence of undissolved solute.

SOLUBILITY

The solubility of a solute in a solvent at a particular temperature is the number of grams of solute required to saturate 100g ($100cm^3$) of solvent at that temperature. **(ie solubility is the amount of a solute required to saturate 100g of a solvent at that given temperature and pressure.)**

Solubility of gases in liquids.

Solutions of gasses differ from solution of solids in two ways.

1. All gases are less soluble in hot solvents than in cold.
2. An increase of pressure causes a greater mass of gas to dissolve but has practically no effect on the solubility of solids.

N.B The mass of gas dissolved by a given volume of solvent is directly proportional to the pressure (Henry's law) e.g. if the pressure is double the mass is doubled.

Aerated drinks contain CO_2 under pressure: on opening a bottle the gas bubbles out of solution. When a diver goes deep into water, more nitrogen dissolves in his blood. As he rises to the surface, this gas

forms bubbles in his veins and may kill him. For this reason, divers breath oxygen and helium; helium passes (diffuses) easily through skin and forms no bubbles.

Example 1

The solubility of salt W is 35g per 100cm^3 of water at 20^{0}C. The mass of W in 40cm^3 of water at the same temperature is

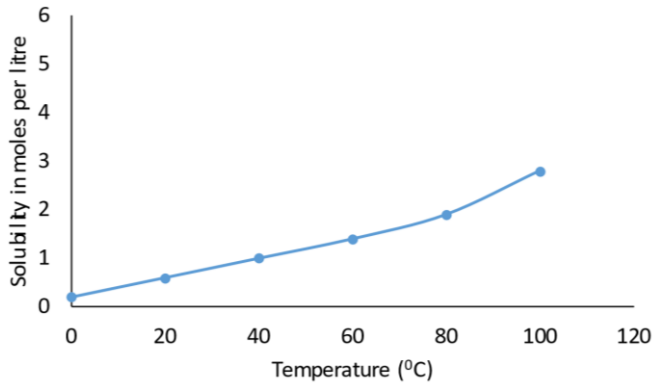
Solution

100cm^3 contain 35g

40cm^3 contain $\frac{40\ x\ 35}{100} = 14g$

Example 2

The solubility of hydrated copper (II) sulphate, $CuSO_4.5H_2O$ in moles per litre at various temperature is shown in the figure below



(a) Determine the solubility of copper (II) sulphate at 80^{0}C.
2mole per litre

(b) Calculate the solubility of hydrated copper (II) sulphate in g/100g of water at 80^{0}C.
(H = 1, O = 16, S = 32, C = 64)

Solution
Formula mass of $CuSO_4.5H_2O$ = 61 + 32 + 16 x 4 + 5(2 + 16) = 250
1000g (1000cm^3) of water contain 2 x 250 = 500g of copper
100g contain $\frac{100\ x\ 500}{1000}$= 50g/100g of water

Exercise

1. The solubility of copper (II) sulphate at 30^0C is 25g per 100g of water. The mass of copper (II) sulphate that would crystallize out if a solution that contain 50g of copper (II) sulphate in 100g of water at 60^0C is cooled to 30^0C is

   A. 12.5g B. 25g C. 50g D. 75g

2. The table below shows the solubilities of a salt in water at different temperatures

Temperature ^{0}/C	10	20	30	40	50	60
Solubility (g/100g) of water	18	20	24	30	38	50

   (a) Plot a graph of solubility of P against temperature.

   (b) Use your graph to determine the solubility of P at 25^0C.

   (c) Calculate the mass of P that would dissolve in 45g of water at 25^0C.

3. (a) Explain what is meant by the term saturated solution

   (b) Describe how the solubility of potassium chloride can be determined in the laboratory

   (c) the table below shows the solubility of potassium chloride and potassium nitrate at various temperatures.

Temperature ^{0}/C	0	20	40	60
Solubility of potassium chloride (g)	28.2	33.5	38.8	44.7
Solubility of potassium nitrate (g)	12.9	31.8	61.2	108.2

   (i) On the same axis, plot graphs of solubilities of potassium chloride and nitrate versus temperature.

   (ii) Determine temperature at which the solubility of the two salts are equal

   (iii) which of the two salts dissolve more rapidly with increase in temperature?

   (iv) state what would happen if a saturated solution of potassium chloride at 40^0C was cooled to 30^0C.

   (v) Of what industrial application is the study of solubility of salts

4. (a) Define the terms

   (i) solute

   (ii) saturated solution

(b) The solubilities of potassium chloride and potassium nitrate at certain temperatures are shown in the table below

Temperature ^{0}/C	0	11	15	30	40	50	57
Solubility of potassium chloride (g)	27.9	31.0	32.0	36.5	40.0	43.0	45.0
Solubility of potassium nitrate (g)	14.0	21.5	25.0	43.0	63.0	84.0	102.0

(i) Plot on the same axes, a graph of solubility against temperature for solubilities of potassium chloride and potassium nitrate (5. ½ mark)

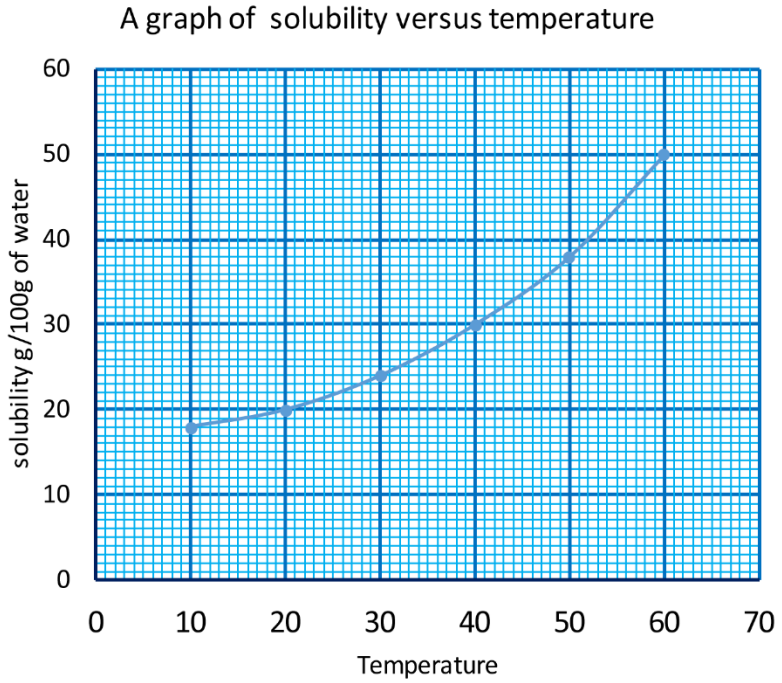
(ii) State which of the two salts has a solubility which increases less rapidly with increase in temperature.

(iii) Determine the temperature at which the solubilities of the two salts are equal

(c) a saturate solution of potassium nitrate at 30^0C was cooled to 5^0C. calculate the number of moles of potassium nitrate crystals formed.

Answers

1. B (50-25 = 25)
2. (a)



(b) The solubility at 25^0C = 22g per 100g of water.

(c) 100g of water contain 22g

45g of water contain $\frac{45\ x\ 22}{100}$ 9.9g

3. (a) A saturated solution of a solute is one that cannot dissolve any more of a solute at a given temperature

(b) (i) Add KCl in a given volume of water to form a saturated solution.

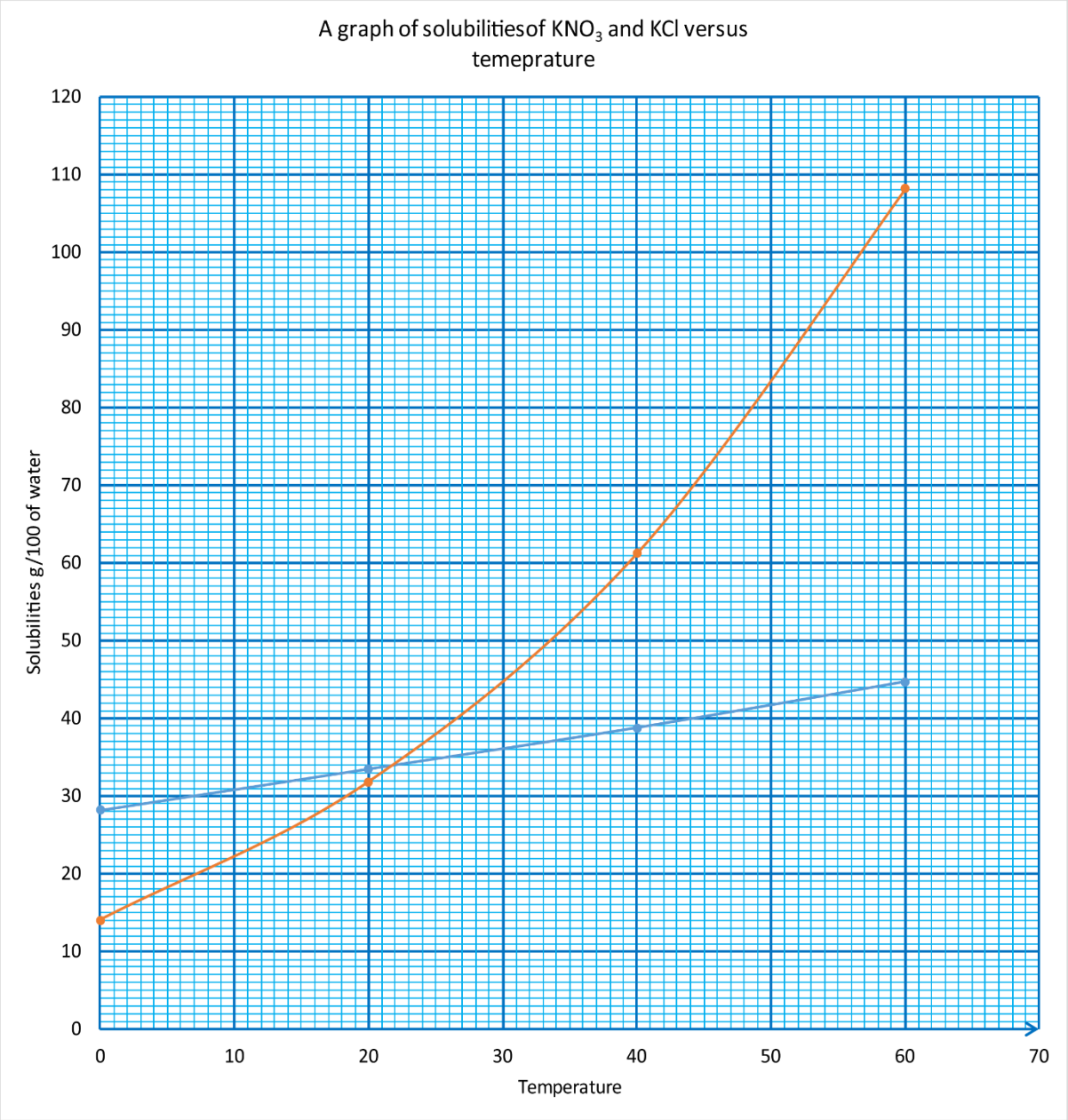
(ii) Filter and weigh the filtrate (mg)

(iii) evaporate to dryness to determine the mass of the residue of dissolve KCl = (m_s g)

(iv) mass of water = (m – ms)

(iv) Calculate solubility of KCl in g/100gof water = $\frac{100m_s}{(m-m_s)}$

(c)(i)



(ii) the temperature at which the solubility of two salts are equal = 22^0C

(iii) potassium nitrate

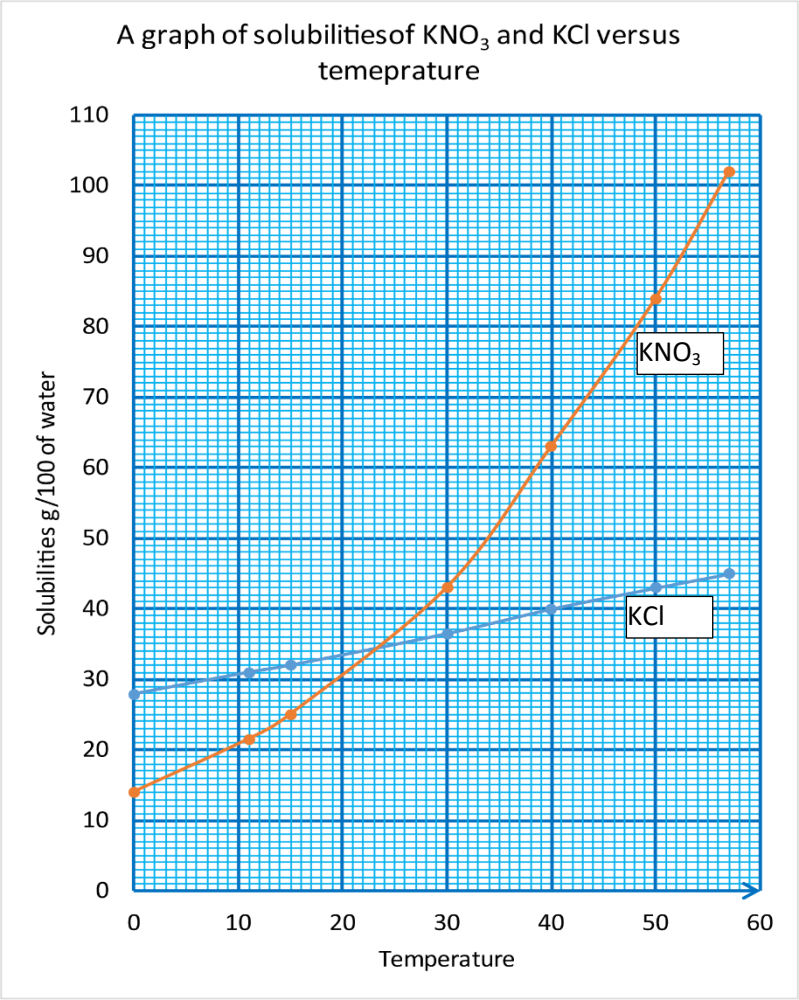
(iv) crystals of potassium chloride form

(d) Purification of salts by crystallization

4. (a)(i) a solute is that dissolves in a liquid (solvent) to form a solution.

(ii) a saturated solution is that cannot dissolve any more solute at a particular temperature in presence of undissolved solute

(c) (i)



(ii) potassium chloride

(iii) 23^0C

(c) from the graph solubility of potassium nitrate at 300C and 50C are 43g/100g of water and 17g/100g of water respectively.

The mass of potassium nitrate that formed crystals = 43 – 17 = 26g

Formula mass of potassium nitrate, KNO_3 = 39 + 14 + 16 x 3 = 101

Moles = $\frac{26}{101} = 0.26moles$