4. SOLUBILITY EXPERIMENT

This question concerns the **solubility** of **FB 1**, potassium nitrate, in water.

The **solubility** of a substance in water is defined as: the mass of substance that will dissolve in and just saturate 100 g of water at a particular temperature. When a solution is saturated the dissolved solid is in equilibrium with undissolved solid. When a solution of potassium nitrate is cooled it becomes saturated when crystals form in the solution.

You are to investigate how the **solubility** of **FB 1** in water varies with temperature.

You are provided with the following materials.

weighing bottle, labelled **FB 1**, containing potassium nitrate
distilled water

Read through the instructions before starting any practical work.

Method

- Weigh an empty boiling-tube. = 27.70g
- Add the contents of the weighing bottle labelled **FB 1** to the weighed boiling-tube. ~~Say 5g.~~ 5
- Reweigh the boiling-tube and its contents. = 32.74g
- Record, in an appropriate form below, your weighings and the mass of **FB 1** used.

(a) Weighings

Mass of Empty boiling tube / g	Mass of boiling tube + FB1 / g	Mass of FB1 / g
27.70	32.74	32.74 − 27.70 = 5.04

[2]

(b) Preparing a saturated solution

- Fill the burette with distilled water.
- Add 5.00 cm^3 of distilled water from the burette to the weighed boiling-tube containing **FB 1**.
- Use the clamp as a holder for the boiling-tube. Take care not to break the tube by clamping it too tightly.

https://www.youtube.com/watch?v=clElbStD8Q0

- Warm the tube carefully, while stirring the contents with a thermometer, until all the solid has dissolved. (Take care that you do not break the thermometer bulb or the tube while stirring.)
- Keeping the tube in the clamp attach the clamp to a stand.
- Let the tube cool and continue to stir gently with the thermometer.
- Watch the solution carefully. Note and record (**on the next page**) the temperature at which you **first** notice crystals forming in the solution.
- If you are uncertain about the temperature when crystals first form, warm the tube again for a few moments and repeat the cooling.
- As soon as you have recorded the temperature add a further **1.00** cm^3 of distilled water to the tube from the burette.
- Warm to redissolve the solid and cool as before.
- Note and record (**on the next page**) the temperature at which crystals now form in the solution. This will be lower than the temperature obtained with **10.00** cm^3 of water.
- Repeat the addition of **1.00** cm^3 of distilled water, the heating and the cooling, until you have four readings in total.

Volume of dist. H_2O / cm^3	Temperature (°C)
5	50
6	45
7	40

(c) In an appropriate form in the space below, record the following.

- the total volume of distilled water in the boiling-tube
- the temperature at which crystals first appeared for each solution

Make certain that your results show the precision of your working.

[8]

(d) For each solution, calculate the **solubility** (in grams of solid per 100 g of water) using the following formula.

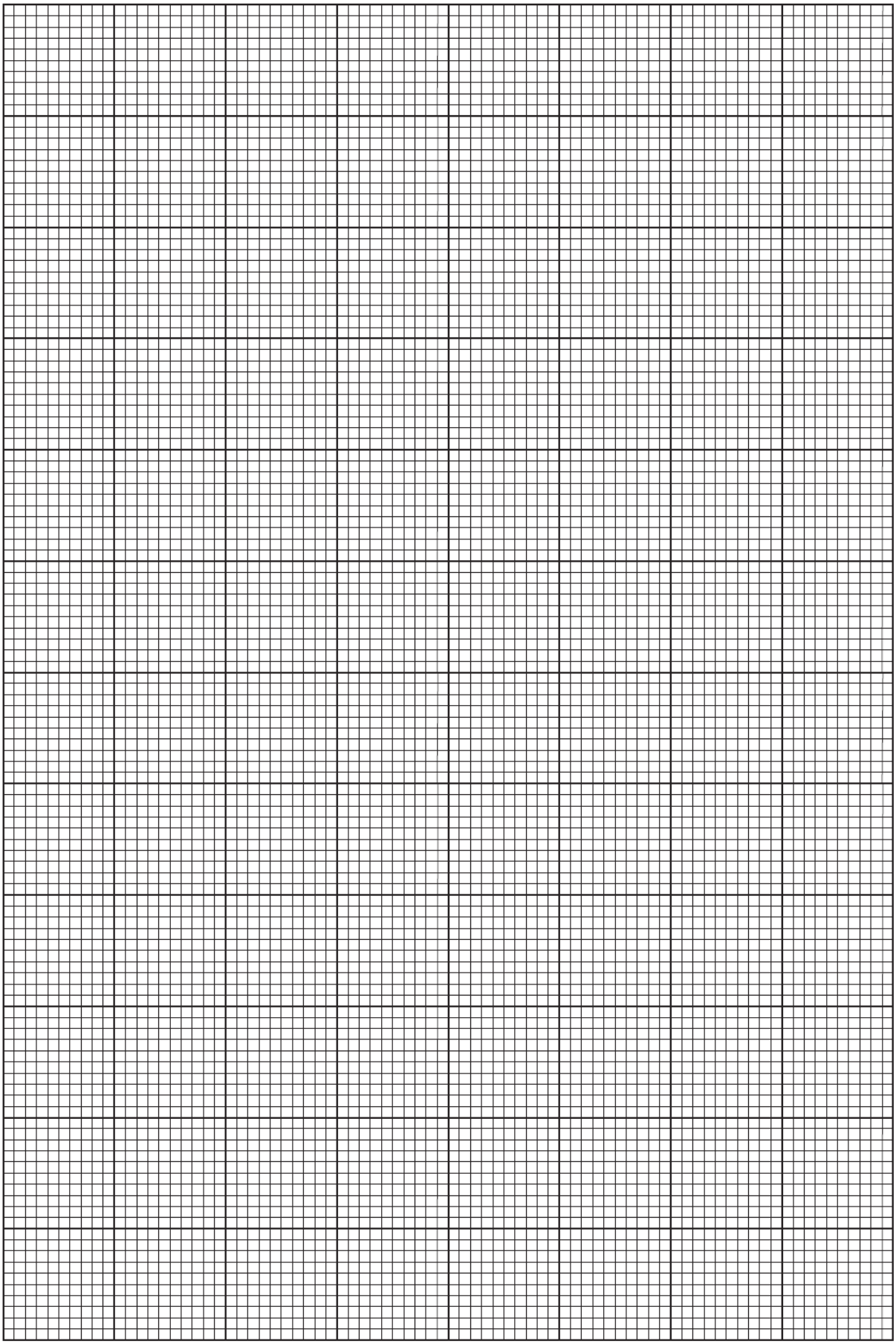
$$\textbf{solubility} = \frac{100}{\text{volume of water}} \times \text{mass of } \textbf{FB 1} \text{ dissolved}$$

Complete the table below to show the **solubility** at different temperatures.
In all calculated values show appropriate significant figures.

solubility (in grams of solid per 100 g of water)	temperature / °C
	50

[3]

(e) Plot **solubility** against temperature and draw an appropriate line through the points plotted. Do **not** start at zero on either axis. You will need to be able to find the solubility of **FB1** at 42.5°C.



From the graph plotted the **solubility** of **FB 1** in water at 42.5 °C is

…….. g of solid per 100 g of water.
[6]

(f) Describe how the **solubility** of **FB 1** changes with temperature.

there is a higher solubility at higher temperature

[1]

(g) Use your answer to **(f)** and your understanding of equilibrium systems to explain if dissolving **FB 1**, KNO_3, under equilibrium conditions is exothermic or endothermic.

$$KNO_3(s) + aq \rightleftharpoons KNO_3(aq)$$

is endothermic.

absorption of heat energy to dissolve potassium nitrate

a rise in temperature shifts equilibrium to the right. (or words to that effect).

[2]

(h) Suggest **two** possible sources of inaccuracy, other than poor experimental technique, in this experiment.

1 Evaporation of water;

Supercooling;

Thermal time lag in thermometer;

2 Difficulty in seeing crystals form;

Time delay in seeing crystals and reading thermome

Some solid forms on side of tube – not initial FB1

Precision of thermometer; not human error [2]

(i) A solution of KNO_3, saturated at 60 °C, is prepared in a thermostatically controlled water bath.

The **solubility** of KNO_3 at 60 °C can be calculated if the mass of the solution and the mass of solid dissolved in the solution can be determined.
Suggest steps to enable you to find these masses.
You may not need all of these numbered steps.

1 Outlines steps necessary to determine solubility, (weigh

2 solution, evaporate, weigh residue)
Shows working for calculating the solubility.

3

Solubility = (mass of solid)/(mass of water) x 100

4

Mass of water = mass of solution - mass of solid

5

6

7

Show how you would calculate the **solubility** of KNO_3 at 60 °C from the mass of the solution and the mass of solid dissolved in the solution.

[2]

[Total: 26]

P32 ON'09