Practical Test

Deriving a Solubility Curve

Writing time: 45 minutes

Student's Name: ___________________________

Teacher: ____________________________________

Structure of booklet

Section	Number of Questions	Number of questions to be answered	Marks
Short Answer	6	6	42
		Total:	**42**

Directions to students

Materials
- Students **are permitted** to bring into the examination room: pens/pencils, highlighters, erasers, sharpeners, rulers, and an approved scientific calculator.
- Students are **NOT permitted** to bring into the examination room: white out liquid/tape, phones or electronic devices, including smart watches.
- Students are provided with the following: Question and answer book of **7** pages and VCAA Data booklet.

The task
- Please ensure that you write your name and teacher's name on this booklet. This paper consists of short answer questions.
- There are a total of **40** marks available.
- Be sure to include states with all chemical equations.

- All numerical answers need to be quoted to the correct number of significant figures.

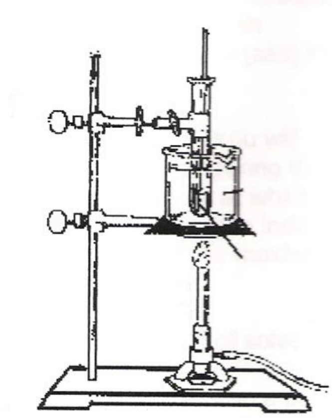
1) Below is the procedure of a practical investigation to determine the solubility curve of KNO_3.

Procedure

1. Number four test tubes and place them into a test tube rack.
2. Using a balance to measure the KNO_3, prepare the test tubes as indicated below:

Test tube	grams of KNO_3	Volume of H_2O (mL)
1	2.00	5
2	4.00	5
3	6.00	5
4	8.00	5

3. Fill a 400 ml beaker about ¾ full of tap water. This will be used as a hot water bath.
4. Place the test tube 1 in the water bath and heat the water to 90 °C
5. Stir the KNO_3-mixture with a glass stirring rod until the KNO_3 is completely dissolved.
6. One lab partner repeats step 4 for next test tube. The other lab partner holds test tube 1 with thermometer up to the light and at the first sign of crystallisation record the temperature. Record the data in a table and partners swap roles.
7. Repeat steps 4 and 6 for the remaining test tubes. Partners should now change roles, one will do step 5 and the other step 6. Record all temperatures in the data table.



Mass of KNO_3 (g)	Mass of water (g)	Grams of KNO_3 / 100g of water	Crystallisation temperature (C°)
4	20	20	6
3	10	30	13
8	20		24
12		60	60
7	10	70	43
	30	90	55
28	20	140	75

Above is a table of data derived from a student's experiment

a. Complete the table above *3 marks*

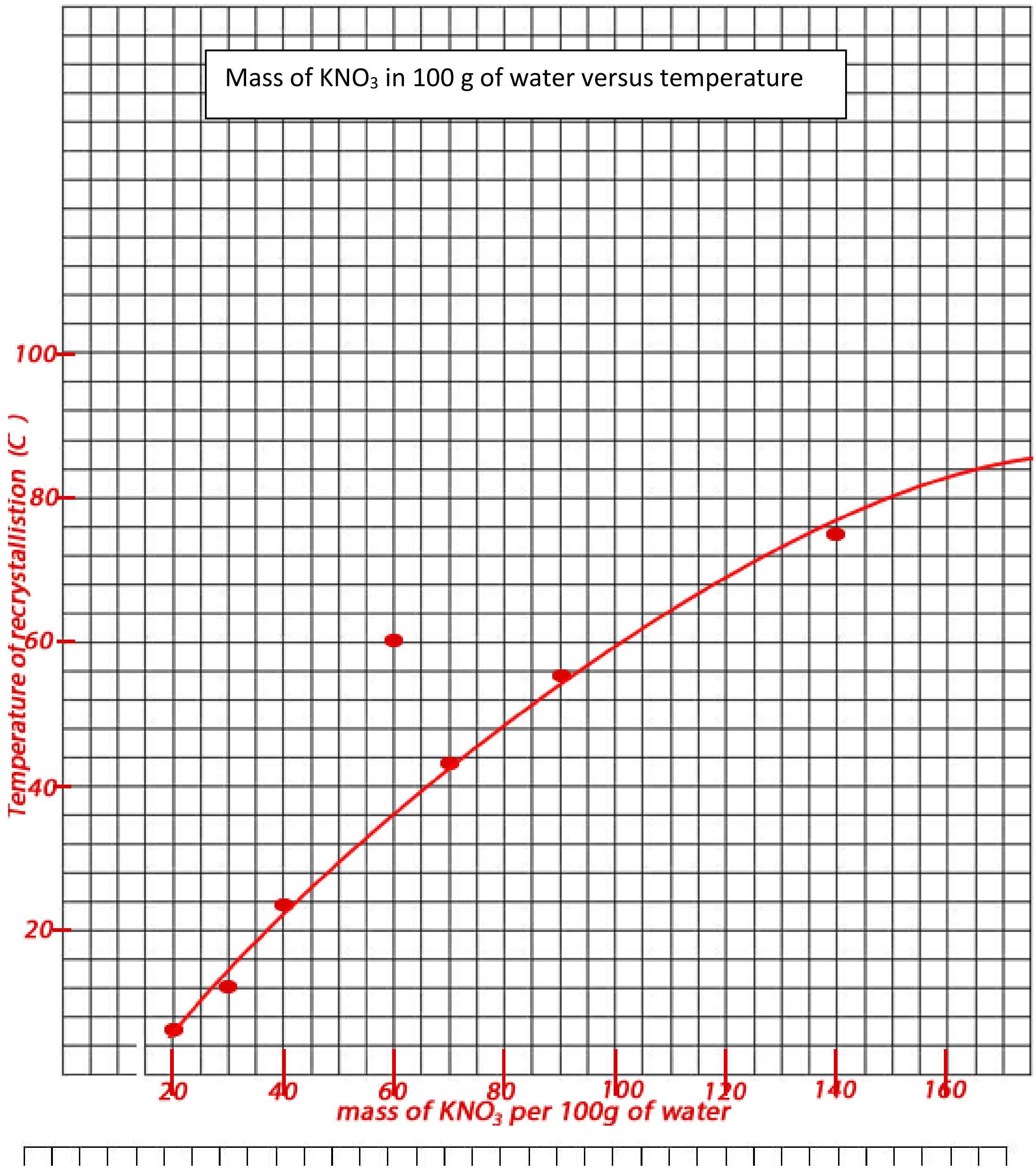
b. Use the graph paper on the next page to accurately plot the graph of "mass of KNO_3 in 100 g of water versus temperature" using a line of-best-fit. *6 marks*

Labelled y-axis with units + equal increments 2 marks

Labelled x-axis with units + equal increments 2 marks

Data points correctly plotted 1 mark

Line of best fit correctly drawn with outlier taken into account 1 mark



c. Use the graph that you have plotted in question 1a to answer the following questions. Show all working out in the space provided for maximum marks.

i. What is the maximum amount, in grams, of KNO_3 that can be dissolved in 25 g of distilled water at 65°C . *2 marks*

38g/100g at 65°C *1 mark for correct reading of the graph at 65°C*

=> (38/100) X 25g = 9.5g *1 mark for correct calculation*

allow for slight error in reading from the graph.

ii. A saturated solution of KNO_3 is formed using 50.0 g of water at 80 °C . This solution is then cooled to 60 °C. Calculate the amount, in grams, of KNO_3 that precipitates out of solution. *2 marks*

At 80°C a saturated solution formed with 50 g of water can hold 48g of KNO_3

At 60°C as saturated solution formed with 50g of water can hold 36g of KNO_3

1 mark for correctly reading off the graph and calculating the amount of KNO_3.

=> 48-36=12g will precipitate out of solution. 1 mark for correct calculation.

iii. Describe one improvement to the procedure and describe how this would benefit the experimental design. *2 marks*

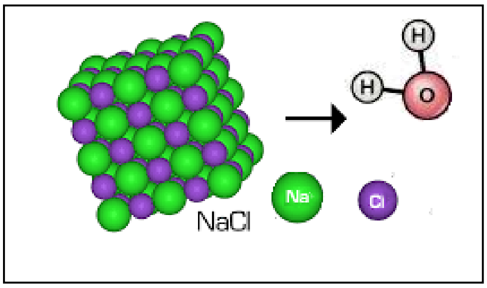
Any plausible change (1 mark) and a description of how it would impact on improving the experimental design (1 mark).
eg Same person should always be looking for recrystallization. This eliminates the subjective nature of the observation and hence the identification of recrystallization.

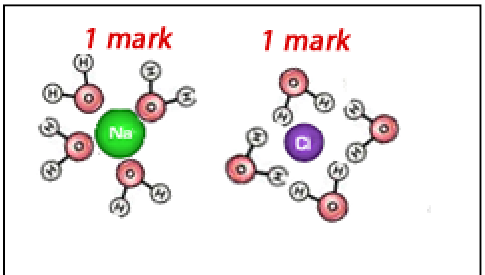
iv. Discuss one error that may have occurred during the experiment and suggest what could be done to minimise this error. *2 marks*
Any plausible error with a suggestion that clearly answers the problem.
for example- lighting throughout the room was not consistent and hence the observation of the formation of crystal is not accurate as we rely on reflective light to sense the start of crystal formation. 1 mark
Solution would be to turn all lights in the room on so that there is uniform light at every station and not just stations that are near windows with natural light coming through the window.
or
Analog thermometers are too slow to react to rapid decrease in temperature and digital thermometers should be used to accurately record the immediate temperature.
Human error is not an acceptable response.

v. Is the error mentioned in iv, above, a random or systematic error? Explain your answer. *2 marks*
Any plausible answer that correctly identifies the error in iv as random or systematic. 1 mark.
Accurately explains that if the error is unlikely to occur on repeating the practical investigation then it is random or if it will occur in a consistent manner every time the practical investigation is conducted the error is a systematic error. 1 mark
The errors given above will both be systematic.

vi. Why do salts such as potassium nitrate have a higher solubility at higher temperatures? *1 mark*
Increase in temp = Greater average kinetic energy of solvent particles that easily disrupts the electrostatic attraction between ions in the crystal lattice of solid salt.

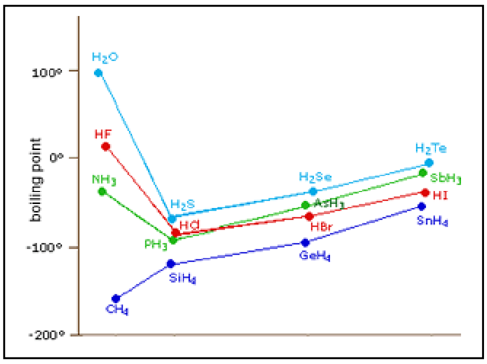
2) Use the representations on the right of a crystal of NaCl and a water molecule to :
a. draw a diagram, in the space below, to show how the water molecules and ions interact in solution. Individual species not drawn to scale. *2 marks*





b. Name the type of bonding that exists between the water molecules and each ion. *Ion-dipole bonding*

3) The image below shows the relationship between the first four hydrides of groups 4,5,6 and 7 and boiling temperature.



a. Give a clear explanation as to why:

i. the first hydride of groups 5, 6 and 7 has a greater boiling point than all the other three hydrides in the same group; *2 marks*

H_2O, NH_3 and HF exhibit the much stronger intermolecular force of attraction known as H-bonding. 1 mark

While the other exhibit the weaker intermolecular force of dipole-dipole interactions. 1 mark

ii. the first hydride from group 4 (CH_4) has a lower boiling point than all the other hydrides in the same group; *2 marks*

CH_4 is a symmetrical molecule as are all the molecular hydrides of group 4, hence has only dispersion forces are acting 1 mark

and so the strength relies on size of molecule. CH_4 is the smallest in the group. 1 mark

iii. the last three hydrides in all the groups steadily increase in boiling temperature;

1 mark

Mention of increasing size and hence increasing strength of dispersion forces 1 mark

4) The specific heat capacity of an unknown liquid (Z) is given at 2.15 J/g/°C.

a. A mass of 15.6 g of this liquid "Z"at 25.0 °C is heated to 45.0 °C. Calculate the amount, in joules, of heat energy absorbed by the liquid. *2 marks*

=> Energy (J) = 2.15 J/g/°C X 15.6X 20°C 1 mark for correct expression

=> 671J 1 mark correct units and answer

b. A 4.67 gram sample of an unlabelled liquid is found in the laboratory. This sample is heated using 0.4016 kJ of heat energy and it's temperature changes from 25.0 °C to 65 °C. Is it liquid "Z"? Justify your answer with a calculation.

2 marks

Both marks are awarded only if the calculation supports the initial claim of yes or no.

Yes.

Supported by finding the unique specific heat capacity of "Z".

=> 401.6J = S_c X 4.67 X 40.0°C

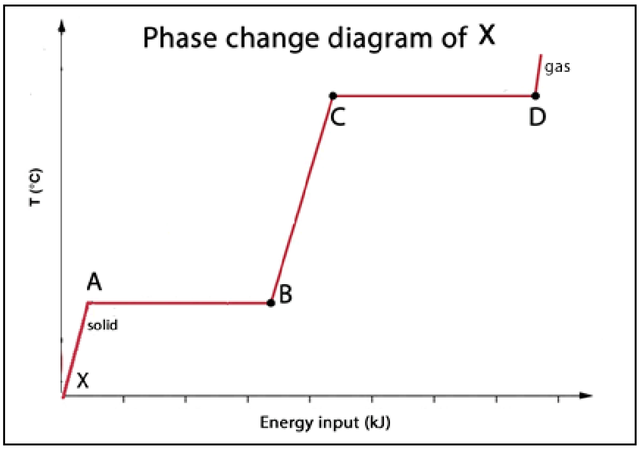
=> Specific heat capacity = 2.15J/g/°C

Same S_c as "Z"

c. The phase diagram of 2.00 mol of Z is shown below. Its **latent heat of vaporization** is 2.16 J/mol while its **latent heat of fusion** is 1.25 J/mol

i. In what state/s does liquid "Z" exist in segment C-D *1 mark*

Liquid and gas



ii. Explain the difference in inter-molecular bonding of "Z" between segments A-B and C-D. *2 marks*

In segments A-B the intermolecular bonds are disrupted but still present as the substance changes state from solid to liquid. 1 mark

In segments C-D the intermolecular bonds are totally broken as the substance changes state from liquid to gas and in an ideal state, totally non-existent. 1 mark

iii. Calculate the amount of energy needed to go from C to D on the graph above. *2 marks*

Region C-D represents the phase change from liquid to gas, hence use latent heat of vaporisation 1 mark

=> 2.00 mol X 2.16 J/mol = 4.32 J 1 mark

5) A sample of contaminated water is analysed and found to have a lead (Pb) concentration of 450 ppm. Calculate the lead concentration in %m/v. *2 marks*

450mg/L → g/100mL
=> 1 mark for correct conversion of units (450mg = 0.450g)

=> 1 mark for correct calculation
=> (0.045g/100mL) = 0.045%w/v

6) A wine bottle is labelled as having an alcohol concentration of 13.5% v/v.
a. What volume, in mL, of alcohol is present in 75.0 mL of wine? *1 mark*

(13.5/100) X 75.0 = 10.13 mL

b. If the density of alcohol, at room temperature, is 0.789 g/mL, calculate the concentration of the alcohol in the wine in %m/v.

3 marks

13.5mL of ethanol / 100 mL of wine
Mass of alcohol 13.5 mL represents = V X density - 1 mark correct formula
= 13.5mL X 0.789 g/mL = 10.65g - 1 mark correct calculation
Express the concentration in %w/v = (10.65/100) X 100
= 10.65%w/v – 1 mark expression