

1. You are provided with;
 - 4.5g of solid **M** in a boiling tube.
 - Solution **Q**, 0.06M acidified potassium manganate (VII).

You are required to determine;

- ✓ The solubility of solid **M** at different temperatures.
- ✓ The number of moles of water of crystallization in solid **M**.

PROCEDURE I

- i. Using a burette, add 4cm³ of distilled water to solid **M** in the boiling tube. Heat the mixture while stirring with the thermometer to about 85°C for the solid to dissolve; allow the solution to cool while stirring. Note the temperature at which crystals of solid **M** first appear. Record the temperature in **table 1**.
- ii. Using a burette, add 2cm³ of distilled water to the contents of the boiling tube. warm the mixture while stirring with the thermometer until all the solid dissolve. Allow the mixture to cool while stirring. Note and record the temperature at which crystals of solid **M** first appear.
- iii. Repeat procedure (ii) two more times and record the temperature in **table 1**. *3 mks*

Retain the contents of the boiling tube for use in procedure II.

Table 1.

Total volume of water in in the boiling tube (cm ³)	4	6	8	10
Temperature at which crystals of T first appear (°C)	66	56	49	44
Solubility of solid M (g/100g of water)	112.5	75.00	56.25	45.00

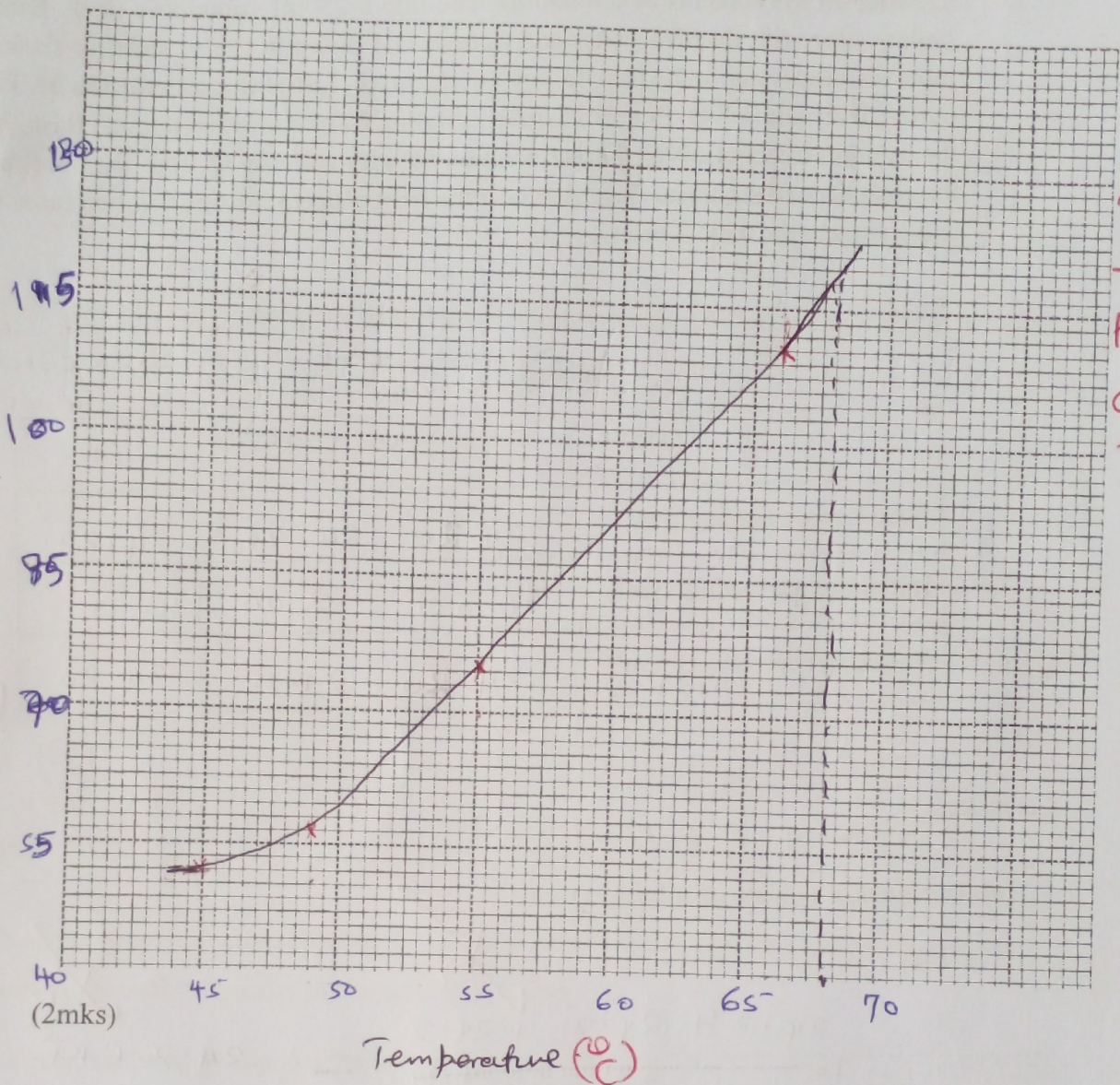
(a) Complete the table 1 by calculating solubility of solid **M** at different temperatures. *2 mks*

(3mks)

$$\begin{aligned}
 c_T &= 1 \text{ mk} \checkmark \\
 D &= \frac{1}{2} \text{ mk} \checkmark \\
 A &= \frac{1}{2} \text{ Mk} \checkmark \\
 T &= 1 \text{ mk} \checkmark \\
 &\quad \underline{\quad\quad\quad} \\
 &\quad 03 \text{ mks} \checkmark
 \end{aligned}$$

(b) On the grid provided, plot a graph of solubility against temperature.

solubility
g/100g of water
mass of solvent



$A = \frac{1}{2}$
 $S = \frac{1}{2}$
 $P = 1$
 $C = 1 \text{mk}$
03mk

(c) Use your graph to find the temperature at which the first crystal will appear if 100g of solid M is dissolved in 100cm³ of distilled water at 68°C then the solution is allowed to cool.

(1mk)

Showing on the graph → 1mk

Correct reading from correct graph = 1mk

WKA

Procedure 2

Transfer all the contents of the boiling tube into a 250ml volumetric flask. Rinse the boiling tube with distilled water and transfer the rinses to the volumetric flask. Add more distilled water to the flask to top it to the mark. **Label this as solution M.** Fill the burette with solution Q. Pipette 25cm³ of solution M into a 250ml conical flask. Warm the solution to about 60°C. Titrate solution M with solution Q from the burette until the contents of the conical flask first become pink. Repeat the titration two more times and complete the table 2 below.

(5mks)

Table 2

	I	II	III
Final burette reading (cm ³)	24.20	24.20	24.20
Initial burette reading (cm ³)	0.00	0.00	0.0
Volume of solution Q (cm ³)	24.20	24.20	24.20

$C_T = 1$
 $D = 1$
 $A = 1$ based on sheet ✓
 $P_A = 1$
 $F_A = 1$ based on sheet ✓
 OS value

Calculate;

(a) The average volume of solution Q used.

(1mk)

$$\frac{24.2 + 24.2 + 24.2}{3} = 24.2 \text{ cm}^3$$

(b) The number of moles of Q that reacted.

(1mk)

Ans in (a) above $\times 0.06$ ✓
 10.00
 correct Ans ✓

(c) The number of moles of **M** that reacted with solution **Q**. (mole ratio of **Q**: **M** is 2:5)

(1mk)

$\frac{5 \times \text{Ans (b) above}}{2} = \text{Correct Ans}$

(d) The number of moles of **M** in 10cm^3 of the original solution (in procedure 1). (2mks)

Ans in (c) above $\times 10$

Correct Ans

(e) If solid **M** was $\text{C}_2\text{H}_2\text{O}_4 \cdot \text{XH}_2\text{O}$, determine the value of **X**. (C = 12, H = 1, O = 16)

(2mks)

$\frac{1 \times 45}{\text{Ans (d) above}} \quad (2 \times 12) + (2 \times 1) + (4 \times 16) + x(18) = \text{R.F.M}$

$90 + 18x = \text{R.F.M}$

$x = \frac{\text{R.F.M} - 90}{18} = \text{Correct Ans}$

NOTE
Ans must be whole number otherwise penalise 1/2 mk on the final answer

R.F.M = Correct Ans

2. You are provided with substance **S**. Use it to carry out the tests that follow. Record your observations and inferences in the spaces provided.

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(a) Describe the appearance of substance **S**.

(1/2 mark)

Colourless liquid

(b) Scoop a little of substance **S** using a clean metallic spatula and ignite it in a Bunsen burner flame.

Observations	Inferences
Burns with a blue flame. (1/2 mark)	Organic Compound with low C:H ratio OR. Saturated organic compound OR. $-\text{C}-\text{C}-$ OR. $\text{C}=\text{C}$, $-\text{C}\equiv\text{C}-$ Absent.

(c) Place about 2cm^3 of substance S in a clean test tube and add solid P, sodium hydrogen carbonate provided.

Observations	Inferences
No effervescence / No bubbles (1 mark)	H^+ , H_3O^+ , R-COOH ($\frac{1}{2}$ mark)

(b) Place about 2cm^3 of substance S in a test tube and add 2cm^3 of acidified potassium dichromate(VI) and warm the mixture.

Observations	Inferences
Acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution changes from orange to green. (1 mark) NOTE: Initial and Final Colours must be mentioned otherwise PENALISE FULLY	R-OH (1 mark)

(e) Place about 2cm^3 of substance S and add 2cm^3 of distilled water.

Observations	Inferences
Forms a uniform solution in water / Forms colourless solution ACC: Liquid are miscible (1 mark) • No separate layers	polar Organic Compound (1 mark)

NOTE: penalise FULLY for any contradictory
3. You are provided with solid T. Carry out the following tests and write your observations and inferences in the spaces provided.

- (a) Place about a half of solid T in a test tube and heat strongly. Test any gases produced with both red and blue litmus papers.

Observations	Inferences
Gas turns moist red litmus paper blue, ✓ Colourless vapour Condense on cooler parts of the test tube, ✓ (2mks)	NH_4^+ ✓ (1mark)

Colourless liquid forms on the cooler parts -

- white sublimate ✓
- Brown Residue ✓

- (b) Place the rest of solid T in a boiling tube and add about 10cm^3 of distilled water.

Shake well.

To a 2cm^3 portion of the solution, add about 1cm^3 of hydrogen peroxide and shake well. To the resulting mixture, add aqueous sodium hydroxide drop wise until in excess.

Observations	Inferences
Yellow/Brown solution forms on adding hydrogen peroxide, ✓ Brown ppt insoluble in excess, ✓ (1 1/2 marks)	Fe^{2+} oxidized to Fe^{3+} ✓ (1/2 mark)

- (c) You are provided with solution R. Carry out the following tests and write your observations in the spaces provided. Divide solution R into two portions.

- (i) To the first portion, of solution R, add three drops of barium nitrate solution. Retain the mixture for use in test (ii) below.

Observations	Inferences
White ppt ✓ (1mark)	SO_4^{2-} , SO_3^{2-} , CO_3^{2-} penalise 1/2mk for each contradiction (out of 1 mark) Maximum of 1mk.

3 correct = 1mk
2 correct = 1/2mk
1 correct = 0mk

(ii) To the mixture obtained in (c(i) above, add about 2cm³ of 2M nitric V acid.

Observations	Inferences
Bubbles of colourless gas White ppt dissolves (1mark)	SO_3^{2-} , CO_3^{2-} 2 correct 1mk. 1 correct 1/2mk. (1mark)

Penalise 1/2mk for any contradictory ion to maximum of 1mk.

(iii) To the second portion of solution R, add two drops of acidified potassium dichromate(VI) and warm the mixture.

Observations	Inferences
Acidified $K_2Cr_2O_7$ Changes from orange to green. (1mark)	SO_3^{2-} (1mark)

d). To 2cm³ of solution R₁ in a test tube add 5 drops of aqueous sodium hydroxide. Add a piece of aluminium foil provided to the mixture and shake. Warm the mixture and test for any gas produced with both red and blue litmus papers.

Observation	Inference
Effervescence (Bubbles) Colourless gas with a pungent smell. Moist red litmus paper turns blue and blue litmus paper remains blue. (2mks)	NO_3^- (1mk)

(21)