

Expt. No. 2

Date: 17/07/19

DETERMINATION OF MOLECULAR WEIGHT BY
TRANSITION TEMPERATURE METHOD

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Aim:

To determine the transition temperature of the given salt hydrate and to determine the molar depression of transition temperature of the salt hydrate with the given salt hydrate with given known solute and using the information to determine the molecular weight of the given unknown substance.

principle:

When a salt hydrate changes from hydrated state, changes accompanied by absorption of heat. If the anhydride salt changes to hydrated salt, changes accompanied by evolution of heat. That temperature remains steady on heating or cooling until the transition temperature is complete, the steady temperature correspond to the transition temperature of the salt hydrate is depressed by the addition of the solute, the depression in transition temperature is given by the following expression.

$$\Delta T = \frac{K_{Tr} \times 1000 \times w_2}{m \times w_1}$$

where,

w_1 - weight of salt hydrate

w_2 - weight of solute

K_{Tr} - molar depression constant of the salt hydrate.

m - molecular weight of solute.

TABLE-I

COMPOUND-A

S.NO	Time (minutes)	Temperature (°c)	
		Melting point (°c)	Freezing point (°c)
1.	0	40	72
2.	1	48.5	71
3.	2	45	70
4.	3	48	69
5.	4	51	67.4
6.	5	53.8	65.4
7.	6	55.5	63.8
8.	7	57	61.8
9.	8	58	60
10.	9	58.5	59.4
11.	10	58.8	58.8
12.	11	58.8	58.8
13.	12	58.8	58.8
14.	13	58.8	56.3
15.	14	59.5	54
16.	15	61	52
17.	16	64	50
18.	17	66.5	48.3
19.	18	69	46.5
20.	19	72	44
21.	20	75	42.3
22.	21	78	

procedure:

Accurately weighed ~~ins~~ salt hydrate (above 5g) is taken in a transition temperature apparatus tube which is fitted with a cork carrying a sensitive thermometer and a stirrer. The tube is fixed on an air jacket and mounted vertically in a water bath, taking 250ml beaker. The beaker is heated in the small flame a stop watch is also started at the same time, the temperature is noted for every one minute. The condens~~E~~ of tube was stirred well. The time temperature reading are recorded till the substance reach is a temperature of steady state. The tube is taken out from the bath and substance is allowed to cool slowly and steadily with the constant stirring. The temperature reading is noted for every one minute as the substance cool down. The steady state of temperature on both process of heating and cooling corresponded to the transition temperature of the salt hydrate.

Accurately weighed solute of known molecular weight 0.5g is added to the above salt hydrate and the transition temperature is determined and explained above.

The molecular depression of transition temperature of the salt hydrate is determine using the expression,

$$K_{Tr} = \frac{\Delta T \times w_1 \times M}{w_2 \times 1000}$$

Now the tube is cooled well and accurately weighed salt hydrate (5g) and accurately weighed

TABLE-II.

COMPOUND - A+B.

S.NO	Time (in minutes)	Temperature (°c) melting point (°c)	Freezing point (°c)
1.	0	45	65
2.	1	46	64
3.	2	47	62
4.	3	48.5	61
5.	4	50	60
6.	5	51	58.5
7.	6	52	57.5
8.	7	53	56.5
9.	8	54	55.5
10.	9	55	55
11.	10	55	55
12.	11	55	55
13.	12	55	55
14.	13	55	55
15.	14	56	53
16.	15	56.5	51
17.	16	58	49
18.	17	59	47
19.	18	60	45
20.	19	61.5	44
21.	20	63	42

solute unknown molecular weight of (0.5 g) are taken in tube. The transition temperature determined as explained above knowing the molar depression of transition temperature of the salt hydrate.

0.5 g - The molecular weight of unknown a solute is determined using the expression

$$M = \frac{K_{Tr} \times w_2 \times 1000}{\Delta T \times w_1}$$

$$\cancel{\Delta T \times w_1}$$

$$= \frac{0.001}{0.0001}$$

$$= 1000$$

$$= 1000 \times 0.5 = 500$$

\therefore The molecular weight of unknown solute is 500.

$$P_2 = M \quad 500 = M$$

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$$0.6 = 0.8 - 0.2 = 0.6 = 0.6$$

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TABLE - III

COMPOUND-A+C (Unknown)

A. Hydrosolutuon prepared initially in 40 ml water

S.NO	Time (minutes)	Substance in water	Temperature (°C)	Freezing point (°C)
			Melting point (°C)	
1	0	Water	40	Unfreezable
2	10	Ammonium hydroxide	41.6	Unfreezable
3	20	Hydrogen peroxide	43.2	Unfreezable
4	3	3	44.8	Freezing
5	5	Hydrogen peroxide	46.5	Unfreezable
6	5	Hydrogen peroxide	48.5	Unfreezable
7	6	Unfreezable	50.5	Unfreezable
8	7	Unfreezable	52.5	Unfreezable
9	8	Unfreezable	54	Unfreezable
10	9	Unfreezable	55.2	Unfreezable
11	10	Unfreezable	55.8	Unfreezable
12	11	Unfreezable	56	Unfreezable
13	12	Unfreezable	56	Unfreezable
14	13	Unfreezable	56	Unfreezable
15	14	Unfreezable	56	Unfreezable
16	15	Unfreezable	56	Unfreezable
17	16	Unfreezable	58	Unfreezable
18	17	Unfreezable	59.6	Unfreezable
19			62	
			M.K.W.K.T.D	
			99.9% SW	
			✓	

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Determination of molar mass by freezing point depression

The salt K₂Cr₂O₇ was used.

continuation

 $P_3 = M$ A standard to dilution $C_3 = M$ Molar concentration of dilution $\Delta^{\circ} \text{CRT} = A - \text{Depression to initial reading}$

Result:

i) The transition temperature of $\Delta^{\circ} \text{CRT}$ = 58.8°C

The given salt hydrate

ii) The molar depression constant K_{TR} = 6.8 deg/mole of the salt hydrate K_{TR} iii) The molecular weight of M = 240.85 unknown salt M $1000 \times K_{\text{TR}} \times \Delta^{\circ} \text{CRT}$

ANSWER

Molar mass of salt

 $= 6.8 \times 58.8$ $= 397.04$

Calculated

 $= 397.04$

Actual molar mass

Salt hydrate molar mass = 240.85 g/mol Calculated molar mass = 397.04 g/mol

Actual molar mass and calculated molar mass are same.

calculation:

(i) To find molar depression constant:

$$T_1 = 58.8^\circ\text{C} \quad w_1 = 59$$

$$w_2 = 0.59$$

$$T_2 = 55^\circ\text{C}$$

$$M_2 = 180.15$$

$$\Delta T = T_1 - T_2 = 58.8 - 55$$

$$\Delta T = 3.8^\circ\text{C}$$

$$K_{Tr} = \frac{\Delta T \times w_1 \times M_2}{1000 \times w_2 \times K_{Tr} \times M}$$

$$= \frac{3.8 \times 5 \times 180.15 \times 1000}{1000 \times 0.5}$$

$$= 6.8 \text{ deg/m}$$

$$K_{Tr} = 6.8 \text{ deg/mole}$$

The molar depression constant $K_{Tr} = 6.8 \text{ deg/m}$.

(ii) To find molecular weight of the substance:

$$T_1 = 58.8^\circ\text{C} \quad w_1 = 59$$

$$T_2 = 56^\circ\text{C} \quad w_2 = 0.59$$

$$\Delta T = 58.8 - 56 = 2.8$$

$$\Delta T = 2.8^\circ\text{C}$$

$$M = \frac{K_{Tr} \times w_2 \times 1000}{\Delta T \times w_1}$$

$$= \frac{6.8 \times 0.5 \times 1000}{2.8 \times 5}$$

$$= 248.85$$

The molecular weight of the substance = 248.85