

**Chemistry.** — *Equilibria in systems, in which phases, separated by a semi-permeable membrane XXII.* By F. A. H. SCHREINEMAKERS.

(Communicated at the meeting of May 28, 1927).

*Influence of the temperature on osmotic systems.*

In the communications XVIII—XXI we have discussed the influence of a change of pressure on osmotic equilibria and on the osmotic pressure; now we shall discuss briefly the influence of a change of temperature.

In communication XVIII we have a.o. deduced the following. If we have a system  $E(P)$  viz. a system (of one or more phases) under the pressure  $P$  and we bring this, while the temperature and the total composition remain constant, under the pressure  $P + dP$ , then arises a new system  $E'(P + dP)$  the phases of which can differ a little in composition from those of the first system. If we represent the *O.W.A.* and the total thermodynamical potential of the first system by  $\xi$  and  $Z$ , then we have found:

$$\xi = - \frac{\partial Z}{\partial w} \quad . \quad . \quad (1^a) \qquad d\xi = - \Delta V_E \cdot dP \quad . \quad . \quad (1^b)$$

The *O.W.A.* of the system  $E(P)$  is defined by (1<sup>a</sup>); the change  $d\xi$  which the *O.W.A.* of this system endures, when it passes into the new system  $E'(P + dP)$ , is defined by (1<sup>b</sup>). We found for the meaning of  $\Delta V_E$  that  $\Delta V_E \cdot \delta w$  represents the change, which gets the total volume of the system  $E$ , of this takes in  $\delta w$  quantities of water. If we call  $\Delta V_E$  the osmotic increase of volume of system  $E$ , then follows from (1<sup>b</sup>):

with increase of pressure the *O.W.A.* of a system becomes smaller, when its osmotic increase of volume is positive and greater, when this is negative.

A corresponding property is valid for the change in temperature of a system. If we bring the system  $E(T)$  viz. a system of the temperature  $T$ , while the pressure and total composition remain constant, to the temperature  $T + dT$ , then we find:

$$\xi = - \frac{\partial Z}{\partial w} \quad . \quad . \quad (2^a) \qquad d\xi = \Delta H_E \cdot dT \quad . \quad . \quad (2)$$

The change of the *O.W.A.* which the system endures, if we bring its temperature from  $T$  to  $T + dT$ , is defined by (2<sup>b</sup>). For the meaning of  $\Delta H_E$  we find, that  $\Delta H_E \cdot \delta w$  is the change, which the total entropy of the system endures, if it takes in  $\delta w$  quantities of water. We shall call  $\Delta H_E$  the osmotic increase of entropy of the system  $E$ .

When the systems  $E_1$  and  $E_2$  have the same *O.W.A.* at the temperature  $T$ , then exists the osmotic equilibrium:

$$(E_1 | E_2)_T \dots \dots \dots (3)$$

If we bring the temperature to  $T + dT$  then these systems change their *O.W.A.* with:

$$d\xi_1 = \Delta H_{E_1} \cdot dT \dots (4^a) \qquad d\xi_2 = \Delta H_{E_2} \cdot dT \dots (4^b)$$

If we take  $\Delta H_{E_1} > \Delta H_{E_2}$  then, with increase of temperature, the *O.W.A.* of the left system becomes greater than that of the right system; consequently water must diffuse from right to left. We shall represent this by:

$$\Delta H_{E_1} > \Delta H_{E_2} \qquad [E_1 \leftarrow E_2]_{T+dT} \dots \dots \dots (5)$$

in which  $dT$  is positive. Consequently we may say:

with increase of temperature water diffuses towards the system, which has the greatest increase of osmotic entropy;

or also: with increase of temperature water diffuses in such direction that the total entropy of the whole system increases.

We shall represent by  $Q_{1,2} \delta w$  the quantity of heat, which is taken up, when  $\delta w$  quantities of water diffuse from a system  $E_1$  towards a system  $E_2$ ; we call  $Q_{1,2}$  the heat of diffusion of water from system  $E_1$  towards system  $E_2$ ; the heat of diffusion of water from  $E_2$  towards  $E_1$  is then  $Q_{2,1} = -Q_{1,2}$ . We now have:

$$\Delta H_{E_1} - \Delta H_{E_2} = \frac{Q_{2,1}}{T} = -\frac{Q_{1,2}}{T} \dots \dots \dots (6)$$

Therefore we can say also: with increase of temperature water diffuses in an osmotic equilibrium in that direction, in which the heat of diffusion is positive or in other words: that heat is absorbed.

We now can deduce the influence of a change of temperature in a corresponding way as in the communications XVIII—XXI, in which is discussed the influence of the pressure on osmotic systems; we shall discuss only some cases.

We take at the temperature  $T$  the liquid  $c$  of fig. 1 Comm. XVIII; all liquids, which have at this temperature  $T$  the same *O.W.A.* as this liquid  $c$  are situated on the isotonic curve  $acb$  going through point  $c$ . As the liquid  $q$  is, therefore, at the temperature  $T$  isotonic with the liquid  $c$ , we have the osmotic equilibrium:

$$[L_c | L_q]_T \quad \text{fig. 1. XVIII} \dots \dots \dots (7)$$

If we represent the osmotic increases of entropy by  $\Delta H_c$  and  $\Delta H_q$ , then, if we bring the temperature to  $T + dT$ , the *O.W.A.* at the left and at the right of the membrane, changes with:

$$d\xi_c = \Delta H_c \cdot dT \dots (8^a) \qquad d\xi_q = \Delta H_q \cdot dT \dots (8^b)$$

so that in general the two liquids are no more in osmotic equilibrium with one another. If we put  $\Delta H_c > \Delta H_q$  then consequently water diffuses from  $q$  towards liquid  $c$ . We can represent this by:

$$\Delta H_c > \Delta H_q \quad \left[ L_c \leftarrow L_q \right]_{T+dT} \quad \text{fig. 1. XVIII . . . (9)}$$

in which  $dT$  is positive.

As in the osmotic system (9) the *O.W.A.* of the liquid  $c$  is greater than that of the liquid  $q$ , we can get an osmotic equilibrium of the temperature  $T + dT$  by replacing the liquid  $q$  by a liquid  $q'$  with an *O.W.A.* which is somewhat greater, so that the *O.W.A.* on both sides of the membrane becomes equal again. Amongst others we can get such a liquid  $q'$ , as we have seen in previous communications, by withdrawing a little water from the liquid  $q$ . We then have the osmotic equilibrium:

$$\left[ L_c \mid L_{q'} \right]_{T+dT} \quad \text{fig. 1. XVIII . . . . . (10)}$$

in which the liquid  $q'$  can be represented by the point  $q'$  of fig. 1 XVIII, situated on the line  $Wq$ .

Also the following appears a.o. from this. If the liquids, which are isotonic with the liquid  $c$  at the temperature  $T$ , are represented by curve  $acb$ , then the liquids, which are isotonic with liquid  $c$  at the temperature  $T + dT$ , will be represented by a curve  $a_1c b_1$  (fig. 1 XVIII) which does not coincide with  $acb$ .

We are able to deduce the above yet also in another way. For the osmotic equilibrium (7) is valid the relation:

$$\left( \zeta - x \frac{\partial \zeta}{\partial x} - y \frac{\partial \zeta}{\partial y} \right)_c = \left( \zeta - x \frac{\partial \zeta}{\partial x} - y \frac{\partial \zeta}{\partial y} \right)_q . . . . . (11)$$

For the osmotic equilibrium (10), of which we assume that the liquid  $q'$  differs infinitely little (*viz.*  $dx$  and  $dy$ ) from the liquid  $q$ , then is valid, as follows from (11).

$$\left( \eta - x \frac{\partial \eta}{\partial x} - y \frac{\partial \eta}{\partial y} \right)_c dT = \left( \eta - x \frac{\partial \eta}{\partial x} - y \frac{\partial \eta}{\partial y} \right)_q dT + \left. \begin{aligned} &(rx + sy) dx + \\ &+ (sx + ty) dy \end{aligned} \right\} (12)$$

in which, as we deduce easily, the coefficients of  $dT$  are the osmotic increases of entropy of the liquids  $c$  and  $q$ . As we can satisfy (12) for a definite value of  $dT$  still by an infinite number of values of  $dx$  and  $dy$ , there exists, therefore, in the vicinity of liquid  $q$  (fig. 1 XVIII) an infinite number of liquids  $q'$ , which are all isotonic with the liquid  $c$  at the temperature  $T + dT$ . Of all those liquids we take a liquid  $q'$ , which can arise from  $q$  by taking in or giving a little water, so that it is situated in fig. 1 XVIII anywhere on the line  $Wq$ ; then  $dx$  and  $dy$  must satisfy:

$$dx : x = dy : y = d\lambda . . . . . (13)$$

We now can write for (12):

$$(\Delta H_c - \Delta H_q) dT = (rx^2 + 2sxy + ty^2) d\lambda . . . . (14)$$

by which the value of  $d\lambda$  is defined. If we assume, in accordance with above, that  $\Delta H_c$  is greater than  $\Delta H_q$  and if we take  $dT$  positive, then it follows from (14) that  $d\lambda$  is positive also. As it follows from (13) that  $dx$  and  $dy$  are positive also now, it follows that this liquid  $q'$  must be situated, as is drawn in fig. 1 XVIII, viz. further from the point  $W$  than the point  $q$ .

The above is valid no more when point  $c$  and consequently also point  $q$  are situated in the vicinity of point  $W$ , so that the isotonic curves are straight lines, which cut off equal parts of the sides  $WX$  and  $WY$ ; the isotonic curves of the temperatures  $T$  and  $T + dT$  going through point  $c$ , will coincide then. This follows a.o. also from (12); for infinitely small values of  $x$  and  $y$  the coefficients of  $dT$  in (12) approach both the entropy of the pure water, so that their difference approaches zero. As  $s$  remains finite,  $sx$  and  $sy$  approach zero;  $rx$  and  $ty$ , however, approach both  $RT$ . Then follows from (12):

$$0 = dx + dy . . . . . (15)$$

from which the above follows at once. We are able to find this also by substituting in (11):

$$\zeta = \varphi + RT(\log x + \log y) . . . . . (16)$$

$\varphi$  and its derivations with respect to  $x$  and  $y$  then remain finite for infinitely small values of  $x$  and  $y$ . We then find:

$$\left[ \varphi - x \frac{\partial \varphi}{\partial x} - y \frac{\partial \varphi}{\partial y} - RT(x + y) \right]_c = \left[ \varphi - x \frac{\partial \varphi}{\partial x} - y \frac{\partial \varphi}{\partial y} - RT(x + y) \right]_q$$

For infinitely small values of  $x$  and  $y$  follows again from this the equation (15).

In order that two systems  $E_1$  and  $E_2$  can be in osmotic equilibrium with one another, it is not sufficient that they have the same  $O.W.A.$ , but also their temperature must be the same; the pressure of the two systems, however, can be as well equal as different. Consequently, provided that the temperature of the separate systems is the same, an osmotic equilibrium:

$$(E_1)_{P_1} \mid (E_2)_{P_2} . . . . . (17)$$

may exist, in which  $P_1$  and  $P_2$  can represent the same pressures or not. Let us take f.i. the osmotic equilibrium:

$$L_P \mid L_P . . . . . (18)$$

in which on both sides of the membrane the same liquid and the same pressure. If we bring the pressure on the right side of the membrane to  $P + dP$ , then we can compare the  $O.W.A.$  on both sides of the membrane

with one another; at the right side it increases with respect to the left with  $-\Delta V_L \cdot dP$ ; if we take  $dP$  positive, then the *O.W.A.* at the right side of the membrane decreases, therefore; consequently in the osmotic system:

$$L_P \leftarrow L_{P+dP} \dots \dots \dots (19)$$

a little water diffuses from the right towards the left. By changing a little the composition of one or of both liquids, so that the *O.W.A.* becomes equal again on both sides of the membrane, we are able to prevent the diffusion of water; we then get, instead of (19) one of the osmotic equilibria:

$$L_P^{(1)} | L_{P+dP} \quad L_P | L_{P+dP}^{(2)} \quad L_P^{(3)} | L_{P+dP}^{(4)} \dots \dots \dots (20)$$

in which the liquids  $L^{(1)}$   $L^{(2)}$   $L^{(3)}$  and  $L^{(4)}$  differ a little in composition with the liquid  $L$ .

If we take, however, the osmotic equilibrium:

$$(E_1)_T | (E_2)_T \dots \dots \dots (21)$$

in which the pressure on both sides of the membrane is equal or not and if we bring the temperature on the right side of the membrane to  $T + dT$  then we get:

$$(E_1)_T | (E_2)_{T+dT} \dots \dots \dots (22)$$

which is not an osmotic system, however, and which never can pass into an osmotic equilibrium, in whatever way we change the composition and the pressure of the separate systems. Consequently we cannot compare the *O.W.A.* of both the separate systems with one another. Of course this is really the case, when we bring the temperature on both sides of the membrane to  $T + dT$ , so that we get the osmotic system:

$$(E_1)_{T+dT} | (E_2)_{T+dT} \dots \dots \dots (23)$$

While at change of pressure the osmotic changes of volume  $\Delta V_{E_1}$  and  $\Delta V_{E_2}$  may assume a part separately, this is not the case at a change of temperature with the osmotic changes of entropy  $\Delta H_{E_1}$  and  $\Delta H_{E_2}$ ; as viz. the temperature must be always the same on both sides of the membrane, and must change therefore, also always with a same amount, here always occurs the difference  $\Delta H_{E_1} - \Delta H_{E_2}$  and also, therefore, the diffusion heat  $Q_{2,1}$ .

In communication XIX we have deduced the osmotic change of volume  $\Delta V_E$  for different systems  $E$ ; in a corresponding way we are able to find the osmotic change of entropy  $\Delta H_E$ . If we take f.i. the system:

$$E = (Y + L_w)_T \quad \text{fig. 1. III} \dots \dots \dots (24)$$

then we find for the osmotic change in entropy:

$$\Delta H_E = \frac{\eta - y \eta_y}{1 - y} \dots \dots \dots (25)$$

in which  $\eta$  represents the entropy of the liquid and  $\eta_y$  that of the solid substance  $Y$ . If we take one of the systems:

$$E_1 = (Y + L_a)_T \quad \text{fig. 1. III} \quad E_2 = (X + Y + L_c)_T \quad \text{fig. 1. V}$$

$$E_3 = (Y + H + L_d)_T \quad \text{fig. 2. V}$$

then the osmotic changes in entropy are defined by:

$$\Delta H_{E_1} = \eta + \frac{\partial \eta}{\partial x} + \frac{s}{t} \left( \eta_y - \eta - \frac{\partial \eta}{\partial y} \right)$$

$$\Delta H_{E_2} = \frac{\eta - x \eta_x - y \eta_y}{1 - x - y} \quad \Delta H_{E_3} = \frac{\eta_H - \beta \eta_y}{1 - \beta}$$

in which  $H$  represents a hydrate with the composition  $\beta$  Mol.  $Y + (1 - \beta)$  Mol.  $W$ ; the entropies of the solid substances  $X$ ,  $Y$  and  $H$  are indicated by  $\eta_x$ ,  $\eta_y$  and  $\eta_H$ .

We assume that fig. 1. III is valid for a definite temperature  $T$  and pressure  $P$ ; the *O.W.A.* of the solid substance  $Y$  at this  $T$  and  $P$  then is the same as that of the liquid  $w$  saturated with solid  $Y$  and also therefore, equal to the *O.W.A.* of every liquid of the isotonic curve  $wm$ . If we take on this curve an arbitrary liquid  $e$ , then we have, therefore, the osmotic equilibrium:

$$(Y + L_w)_T \mid (L_e)_T \quad \text{fig. 1. III} \quad . . . . . (26)$$

with which the index  $P$  is omitted, as further we shall keep the pressure constant. We now bring the pressure on both sides of the membrane to  $T + dT$ , while we keep constant the composition of the both separate systems; we then get the osmotic system:

$$(Y + L_w)_{T+dT} \mid (L_e)_{T+dT} \quad . . . . . (27)$$

Although the total composition at the left side of the membrane remains constant, yet the liquid  $w$  will change a little its composition by dissolving or depositing solid  $Y$ ; we can imagine this new liquid  $w'$  to be represented in fig. 1. III by a point  $w'$  (on the side  $WY$ ) in the vicinity of point  $w$ .

If we represent the *O.W.A.* and the osmotic increase of entropy of the left system by  $\xi_E$  and  $\Delta H_E$  and those of the right system by  $\xi_e$  and  $\Delta H_e$ , then the *O.W.A.* on the left and the right side of the membrane increases with:

$$d\xi_E = \Delta H_E dT \quad d\xi_e = \Delta H_e \cdot dT \quad . . . . . (28)$$

in general, therefore, (27) forms no more an osmotic equilibrium and a little water must diffuse through the membrane. The direction of this diffusion is defined by the sign of:

$$d\xi_E - d\xi_e = (\Delta H_E - \Delta H_e) dT = \frac{Q_{e.E}}{T} \cdot dT \quad . . . . . (29)$$

in which  $Q_{e.E}$  represents the diffusion-heat of water from the liquid  $e$  towards the system  $E = Y + L_w$ .

We shall divide into two parts the reaction, which occurs when  $\delta w$  quantities of water are taken in by the system  $Y + L_w$ ; at first viz. we shall mix this water with the liquid  $L_w$  and afterwards we shall dissolve  $y \delta w : (1 - Y)$  quantities of solid  $Y$  in this liquid. If we represent the mixtion-heat of water with the liquids  $L_w$  and  $L_e$  by  $Q_w$  and  $Q_e$  and the dissolving-heat of the solid substance  $Y$  in the liquid  $L_w$  by  $Q_y$ , then we have:

$$Q_{e.E} = Q_w - Q_e + \frac{y}{1-y} \cdot Q_y \dots \dots \dots (30)$$

Hence it appears that the diffusion-heat can be as well positive as negative; if the liquid  $w$ , however, contains still little water only, so that  $y$  approaches the unity, then this diffusion-heat is in general positive. If the liquid  $w$  viz. contains still little water only, then the dissolving heat  $Q_y$  approaches the melting-heat of the solid substance  $Y$  and is positive, therefore; as  $1 - y$  then is small also, the last term of (30) shall get such a great positive value that the total value of (30) is positive also.

We now take  $Q_{e.E}$  positive. Then follows from (29) that in the osmotic system (27) the *O.W.A.* at the left side of the membrane is greater than that at the right side; consequently a little water must diffuse from right to left. The osmotic system (27) passes by this into the osmotic equilibrium:

$$(Y + L_w)_{T+dT} | (L_e)_{T+dT} \dots \dots \dots (31)$$

The liquid  $w'$  at the left of the membrane keeps with this (by dissolving or depositing a little  $Y$ ) its composition. On account of its giving of a little water the right liquid  $e$  passes into a liquid  $e'$ , which we can imagine to be represented in fig. 1. III by a point  $e'$  on the line  $We$  and somewhat further from  $W$  than point  $e$ .

We are able to deduce the previous in another way also. For the osmotic equilibrium (26) viz. is valid the equation:

$$\left( \zeta - y \frac{\partial \zeta}{\partial y} \right)_w = \left( \zeta - x \frac{\partial \zeta}{\partial x} - y \frac{\partial \zeta}{\partial y} \right)_e \dots \dots \dots (32)$$

which expresses that the *O.W.A.* is equal on both sides of the membrane. As however the liquid  $w$  on the left side of the membrane is still also in equilibrium with solid  $Y$  we have:

$$\left[ \zeta + (1 - y) \frac{\partial \zeta}{\partial y} \right]_w = \zeta_y \dots \dots \dots (33)$$

If we represent the difference in composition of the liquids  $e'$  and  $e$  by  $dx$  and  $dy$  and that of the liquids  $w'$  and  $w$  by  $dy'$  then the osmotic equilibrium (31) is defined by:

$$\left( \eta - y \frac{\partial \eta}{\partial y} \right)_w dT + (y t)_w \cdot dy' = \left( \eta - x \frac{\partial \eta}{\partial x} - y \frac{\partial \eta}{\partial y} \right) dT + \left\{ \begin{aligned} &+ (rx + sy)_e \cdot dx + (sx + ty)_e \cdot dy \end{aligned} \right. \dots \dots \dots (32^a)$$

$$\left[ \eta + (1 - y) \frac{\partial \eta}{\partial y} \right] dT - [(1 - y) t]_w \cdot dy' = \eta_y \cdot dT \dots \dots \dots (33^a)$$

of which (32<sup>a</sup>) follows from (32) and (33<sup>a</sup>) from (33). By elimination on  $dy'$  follows:

$$A \cdot dT = (rx + sy)_e dx + (sx + ty) dy \dots (34)$$

in which:

$$A = \left( \frac{\eta - y \eta_y}{1 - y} \right)_w - \left( \eta - x \frac{\partial \eta}{\partial x} - y \frac{\partial \eta}{\partial y} \right)_e \dots (35)$$

It appears from (24) and (25) that the term with the index  $w$  in (35) represents the osmotic increase of entropy of the system  $Y + L_w$ ; the term with the index  $e$  represents the osmotic increase of entropy of the liquid  $L_e$ . Consequently we have:

$$A = \Delta H_E - \Delta H_e = \frac{Q_{e.E}}{T} \dots (36)$$

If we substitute this value of  $A$  in (34) and if we use (13), then (34) passes into:

$$\frac{Q_{e.E}}{T} \cdot dT = (rx^2 + 2sxy + ty^2) d\lambda \dots (37)$$

If we take, as above,  $Q_{e.E}$  positive, then follows that  $d\lambda$  is positive also; hence follows for the position of liquid  $L_e'$  of (31) the same as we have deduced already above.

In fig. 1 are represented by curve  $w_1 v_1$  the solutions saturated with the solid substance  $Y$  at the temperature  $T_1$ ; the isotonic curve of the same temperature going through point  $w_1$  is indicated by  $w_1 m_1$ . For

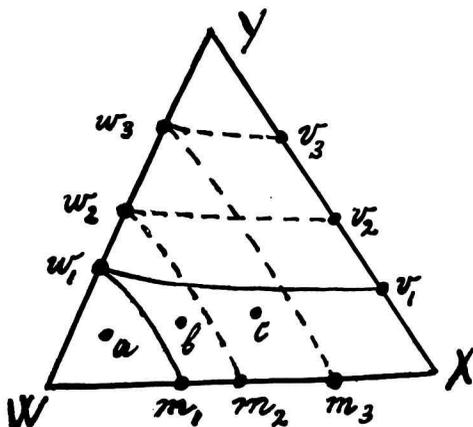


Fig. 1.

fixing the ideas we shall assume now that the solubility of the solid substance  $Y$  increases with increase of temperature; if we put  $T_1 < T_2 < T_3$  then  $w_2 v_2$  and  $w_3 v_3$  can represent the saturation-curves of the temperatures  $T_2$  and  $T_3$ ; further we assume that  $w_2 m_2$  and  $w_3 m_3$  represent the isotonic curves of those temperatures.

The O.W.A. of the solid substance  $Y$  is equal to that of the liquid  $w_1$  (at the temperature  $T_1$ ) and, therefore, also equal to that of every liquid of the curve

$w_1 m_1$ . Consequently the solid substance  $Y$  has at this temperature a greater O.W.A. than the liquid  $a$ , but a smaller O.W.A. than the liquids  $b$  and  $c$ . In the first of the three systems:

$$\left[ L_a \mid Y \right]_{T_1} \quad \left[ L_b \mid Y \right]_{T_1} \quad \left[ L_c \mid Y \right]_{T_1} \quad \text{fig. 1.} \dots (38)$$

water diffuses, therefore, in the direction of the arrow; if there is sufficient solid  $Y$  then is formed the osmotic equilibrium:

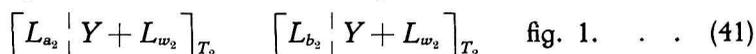
$$\left[ L_{a_1} \mid Y + L_{w_1} \right]_{T_1} \quad \text{fig. 1.} \dots (39)$$

in which  $a_1$  is the point of intersection of the line  $Wa$  with the isotonic curve  $w_1m_1$ . The second and the third system are osmotic complexes, in which nothing happens.

We now bring the three systems (38) to the temperature  $T_2$ ; water will diffuse in the two first systems from left to right; consequently we have:

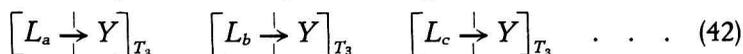


In the third of those systems nothing happens. If a sufficient quantity of solid  $Y$  is present, then both the first pass into:



in which  $a_2$  and  $b_2$  are the points of intersection of the lines  $Wa$  and  $Wb$  with the curve  $w_2m_2$ .

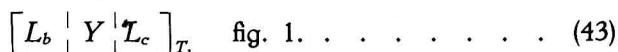
If we raise the temperature to  $T_3$  then we get:



viz. a diffusion of water in each of the three systems. If there is a sufficient quantity of solid  $Y$  then arises on the right side of the membrane  $Y + L_{w_3}$ .

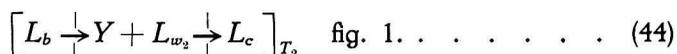
It is apparent from those examples that the diffusing or not of water through the membrane towards a solid substance, also is dependent on the temperature.

We now take the osmotic system:

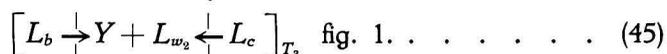


with a double-membrane. (Compare a.o. also Communication X). Although the *O.W.A.* of both liquids is different, herein nothing happens, because the *O.W.A.* of the solid substance  $Y$  is smaller than that of each of the liquids. Consequently the double-membrane is impermeable for water.

If we raise, however, the temperature to  $T_2$  then the *O.W.A.* of the solid substance  $Y$  becomes greater than that of the liquid  $b$ , while it is smaller than that of the liquid  $c$ . At the beginning of the diffusion we then have the system:



If we bring the temperature to  $T_3$  then the *O.W.A.* of the solid substance  $Y$  is greater than that of each of the liquids; at the beginning of the diffusion we then have the system:



As we have discussed already in Communication X it depends on the ratio of the quantities of the phases, etc., which osmotic equilibria will be formed at last from (44) and (45).

It appears from those examples that, therefore, it depends also on the temperature whether a double-membrane is permeable or not.

(To be continued).

*Leiden, Laboratory for Inorg. Chem.*