[TP] Then, 35.0 g of ethylene glycol if dissolved in the liquid water. After the water returns to equilibrium with its vapor, the mass of the liquid water ...

15% 1. will have decreased
43% 2. will be unchanged
42% 3. will have increased
1% 4. Further information required

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Lecture 15 CH131 Fall 2020

Thursday, November 5, 2020

- Reminders: Quiz 4 chs 10-12; office hours; final on 12/18
- Complete: Vapor pressure
- Osmotic pressure, $\Pi = RTM_c$;

Ch12: Thermodynamic processes and thermochemistry
- First law of thermodynamics: $\Delta U = q + w$
- Measuring heat and measuring work

Next: Complete ch12: Heat, q, depends on whether $w \neq 0$: $\Delta U = q_V, \Delta H = q_P$; Enthalpy change of reaction, $\Delta_r H$; Hess's law; $\Delta_r H$ from standard enthalpies of formation of X, $\Delta_f H°(X)$; Example problems.

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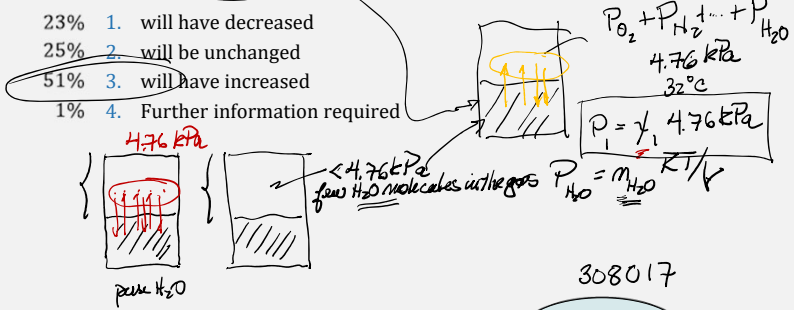
[TP] Then, 35.0 g of ethylene glycol if dissolved in the liquid water. After the water returns to equilibrium with its vapor, the mass of the liquid water ...

23% 1. will have decreased
25% 2. will be unchanged
51% 3. will have increased
1% 4. Further information required



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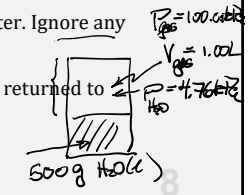
Effect of solute on vapor pressure

The vapor pressure of water at 32°C is 4.76 kPa. A glass of water is sealed in a 1.00 L container filled with air at 32°C. After the water comes to equilibrium with the air in the container,
(1) the total pressure is 100.00 kPa,
(2) there is 500. g of liquid water in the glass,
(3) and the partial pressure of water vapor in the container is 4.76 kPa.

Then, 35.0 g of ethylene glycol is dissolved in the liquid water. Ignore any resulting change in volume of the liquid water.

Calculate change in the mass of the liquid water after it has returned to equilibrium with its vapor.



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Effect of solute on vapor pressure

$T = 32.0°C, P_{gas} = 100$ kPa, $V_{gas} = 1.00$ L, $P°_{H_2O} = 4.76$ kPa

500. g $H_2O(l)$, 35.0 g ethylene glycol ($M = 62.07$)

$\chi_1 = \frac{n_1}{n_1 + n_2}$

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Effect of solute on vapor pressure

$P_1 = \chi_1 P_1^\circ$

$T = 32.0°C, P_{gas} = 100$ kPa, $V_{gas} = 1.00$ L, $P°_{H_2O} = 4.76$ kPa

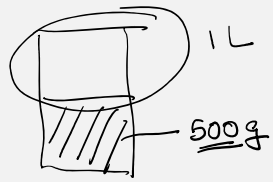
500. g $H_2O(l)$, 35.0 g ethylene glycol ($M = 62.07$)

$x_{H_2O(l)} = 0.980, \Delta P_{H_2O(g)} = -0.0948$ kPa

$P_1 - P_1^\circ = -0.0948$ kPa

$= \Delta n_{H_2O} RT/V$

$\Delta n_{H_2O(l)} = 3.43 \times 10^{-5}$ mol, $\Delta m_{H_2O(l)} = +0.000616$ g



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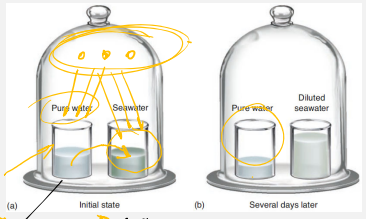
Differing vapor pressures → osmotic pressure

We have seen that solutes cause condensation of water vapor.



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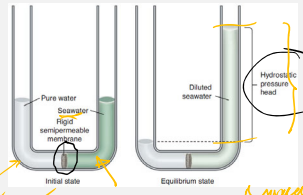
Differing vapor pressures → osmotic pressure

The same differing vapor pressure leads to osmotic pressure.



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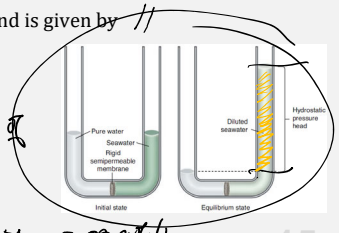
Differing vapor pressures → osmotic pressure

The same differing vapor pressure leads to osmotic pressure.

The flow stops when the pressure, $\Pi = Dgh$, due to the column height difference, h, is equal to the vapor pressure difference, $\Pi = P^\circ_1 - P_1$.

This difference is called osmotic pressure and is given by

$$P^\circ_1 - P_1 = \Pi = ic_{\text{solute}}RT = M_c RT$$



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Recipe for osmotic pressure calculations

Osmotic pressure $\Pi = ic_{\text{solute}}RT = M_c RT$.

1. Use measured osmotic pressure, Π, and temperature, T, to evaluate concentration, $c_{\text{solute}} = \Pi/(i\ R\ T)$, in mol/L.
2. Use cell volume to express concentration in terms of moles, $n = c_{\text{solute}}V$.
3. Use solute mass to calculate molar mass, $M = \text{mass}/n$.

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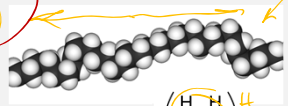
Osmotic pressure $\Pi = i\ c_{\text{solute}}\ R\ T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$

1. Calculate the concentration…



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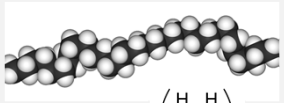
Osmotic pressure $\Pi = i\ c_{\text{solute}}\ R\ T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$

1. Calculate the concentration…

1.00×10^{-4} mol/L



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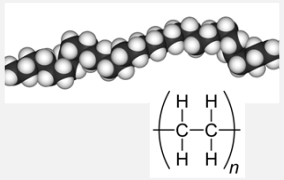
Osmotic pressure $\Pi = i\, c_{solute}\, R\, T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$



1. Calculate the concentration…
   1.00×10^{-4} mol/L
2. Calculate the moles…

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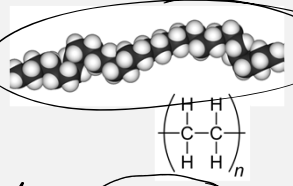
Osmotic pressure $\Pi = i\, c_{solute}\, R\, T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$



1. Calculate the concentration…
   1.00×10^{-4} mol/L
2. Calculate the moles…
   10^{-5} mol

1.00×10^{-4} mol × 0.100 L = 1.00×10^{-5} mol

3. molar mass = 1.40 g / 1.00×10^{-5} mol =

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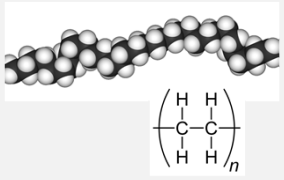
Osmotic pressure $\Pi = i\, c_{solute}\, R\, T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$



1. Calculate the concentration…
   1.00×10^{-4} mol/L
2. Calculate the moles…
   10^{-5} mol
3. Calculate the molar mass…

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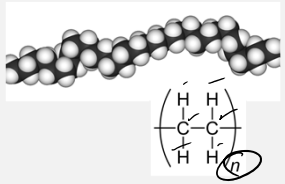
Osmotic pressure $\Pi = i\, c_{solute}\, R\, T$

1.40 g of polyethylene ($i = 1$) dissolved in 100. mL of benzene generates an osmotic pressure of 0.248 kPa at 25 °C. Calculate the molar mass of the polyethylene. $\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$



1. Calculate the concentration…
   1.00×10^{-4} mol/L
2. Calculate the moles…
   10^{-5} mol
3. Calculate the molar mass…
   $1.40 \times 10^{+5}$ g/mol

140,000 g / mol ÷ 28 g / mol

28 g / mol for each unit.

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[TY] 1.0 mg of a substance dissolved in 1.0 mL of water generates an osmotic pressure of 1.0 kPa, at 25 °C. The molar mass of the solute ($i = 1$) is ...

$\left(R = 8.3145 \times 10^3 \frac{\text{L Pa}}{\text{K mol}}\right)$

5% 1. 250 g/mol
13% 2. 500 g/mol
17% 3. 1000 g/mol
56% 4. 2500 g/mol
5% 5. 5000 g/mol
3% 6. Some other value

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First law of thermodynamics

Energy, U, is exchanged between system and surroundings as heat, q, and work, w,

$\Delta U = q + w$

Positive values increase energy of system

$\Delta U = q + w$

$q > 0$: heat flow into the system

$w > 0$: work done on the system

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How do we know heat is present?

Heat flow is measured indirectly by temperature change in the surroundings.

The temperature of the chemical system (reactants and products) does not change, only the temperature of the surroundings.

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How do we know heat is present?

Since $q_{sur} = mc\Delta T_{sur}$ ...

we can use temperature change of surroundings to monitor heat flow.

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How do we know heat is present?

"cold pack"

Temperature decrease in surroundings, $\Delta T_{sur} < 0$ means ...

energy flow into system from surroundings ...

energy of system goes up ...

and so, $q > 0$.

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How do we know heat is present?

If $q > 0$ the process is called endothermic.

The system gains energy in the form of heat from the surroundings.

The surroundings cools, $\Delta T_{sur} < 0$.

There is no change in the temperature of the system, $\Delta T_{sys} = 0$, since all of the energy is used in the net breaking of chemical bonds, rather than to increase motion of the particles of the system.

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How do we know heat is present?

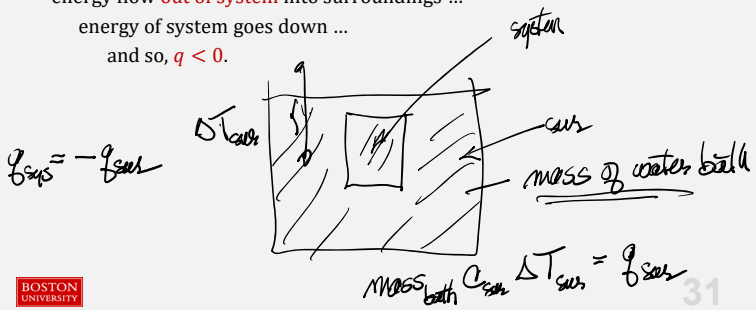
"hot pack"

Temperature increase in surroundings, $\Delta T_{sur} > 0$, means ...

energy flow out of system into surroundings ...

energy of system goes down ...

and so, $q < 0$.



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How do we know heat is present?

If $q < 0$ the process is called exothermic.

The system loses energy in the form of heat to the surroundings.

The surroundings warms, $\Delta T_{sur} > 0$.

There is no change in the temperature of the system, $\Delta T_{sys} = 0$, since all of the energy comes from net making of chemical bonds, rather than the slowed motion of the particles of the system.

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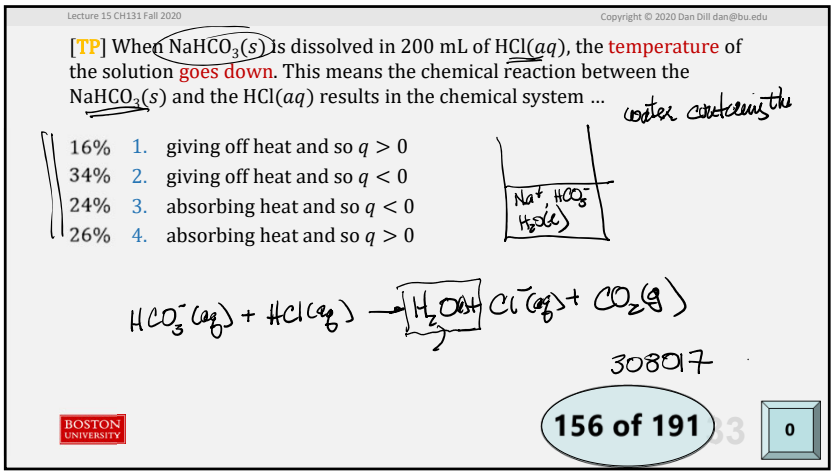
Lecture 15 CH131 Fall 2020
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[TP] When $NaHCO_3(s)$ is dissolved in 200 mL of $HCl(aq)$, the temperature of the solution goes down. This means the chemical reaction between the $NaHCO_3(s)$ and the $HCl(aq)$ results in the chemical system ...
16% 1. giving off heat and so $q > 0$
34% 2. giving off heat and so $q < 0$
24% 3. absorbing heat and so $q < 0$
26% 4. absorbing heat and so $q > 0$
water container
Na^+, HCO_3^-
$H_2O(\ell)$
$HCO_3^-(aq) + HCl(aq) \rightarrow H_2O(\ell) + Cl^-(aq) + CO_2(g)$
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