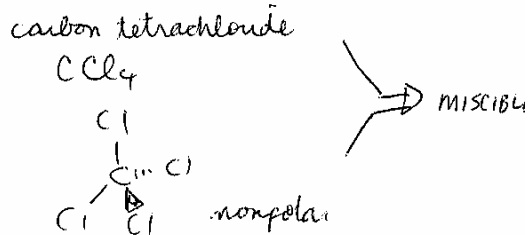
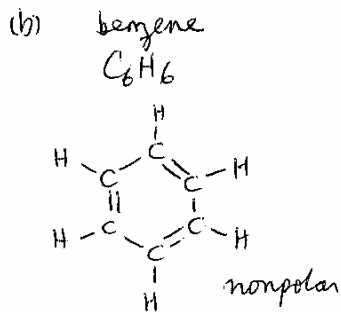
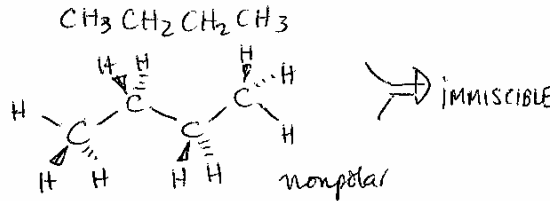
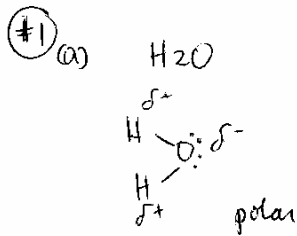
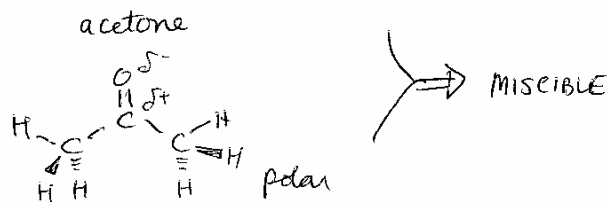


PROPERTIES OF SOLUTIONS EXTRA PROBLEMS

NOTE: solution to #7a has been corrected!



(c) H_2O



#2 $[Ag^+] = 28 \text{ ppb} = \left(\frac{28}{1000}\right) \text{ ppm} = \frac{0.028 \text{ mg Ag}}{1 \text{ kg total solution}}$

(a) $\text{molality} = \frac{\text{moles}}{\text{kg solvent}} = \frac{\frac{0.028 \text{ mg}}{1000 \text{ mg/g}} \times \frac{1 \text{ mol}}{107.87 \text{ g}}}{1 - (0.028 \times 10^{-6}) \text{ kg}}$

$= \frac{2.59 \times 10^{-7} \text{ mol}}{9.99 \times 10^{-1} \text{ kg}}$

$\approx 2.59 \times 10^{-7} \text{ M}$

note: we could have assumed no mass contributed by Ag since so dilute!

(b) wanted: $\frac{1.0 \times 10^2 \text{ g Ag}}{107.87 \text{ g} \cdot \text{mol}^{-1}} = 0.927 \text{ mol}$

Found in: $0.927 \text{ mol} \times \left(\frac{2.59 \times 10^{-7} \text{ mol}}{\text{kg solvent}}\right)^{-1} = 3579150.6 \text{ kg of solvent}$

oops... this means divide...

Assuming density same as pure water, and that mass of solvent + solution are equal since so dilute:

$\Rightarrow \frac{3579150 \text{ kg}}{1.00 \text{ kg/L}} = 3579150 \text{ L} \approx 3.6 \times 10^6 \text{ L} \checkmark$

Lower freezing point? Explain.

#3

(a) 0.20 m KBr vs. 0.30 m sugar

↓

0.20 m K^+
0.20 m Br^-

0.30 m Sugar molecules

0.40 m ions

0.30 m molecules

Higher molality of dissolved solute particles makes depression of freezing point AND elevation of boiling point larger.

∴ KBr solution will freeze at lower temp.

$$\begin{aligned}\Delta T_f &= K_f \cdot m \\ &= \left(1.86 \frac{^\circ C}{m}\right) (0.40 m) \\ &= 0.74^\circ C \text{ lower for KBr soln.}\end{aligned}$$

$$\begin{aligned}\text{vs. } \Delta T_f &= \left(1.86 \frac{^\circ C}{m}\right) (0.30 m) \\ &= 0.56^\circ C \text{ lower for sugar solution}\end{aligned}$$

(b) 0.12 m NH_4NO_3

↓

0.12 m NH_4^+
0.12 m NO_3^-

0.24 m ions

vs. 0.10 m Na_2CO_3

0.10 m $\times 2 = 0.20$ m Na^+
0.10 m CO_3^{2-}

0.30 m ions

will have lower freezing point based on same logic and calculations as above.

4. Solubility of ethylene : $0.300 \text{ atm} \Rightarrow 1.27 \times 10^{-4} \text{ m}$
in water 20°C

(a) Henry's law $C = kP$
 $\therefore k = \frac{C}{P} = \frac{1.27 \times 10^{-4} \text{ m}}{0.300 \text{ atm}}$ but want in $\frac{\text{m}}{\text{torr}}$
 $= \frac{1.27 \times 10^{-4} \text{ m}}{(0.300 \text{ atm}) \left(\frac{760 \text{ torr}}{1 \text{ atm}} \right)}$
 $\therefore k = 5.57 \times 10^{-7} \frac{\text{m}}{\text{torr}}$

(b) How much (in g) dissolves @ 20°C in 1kg water, $P = 500 \text{ torr}$

$$\begin{aligned} C &= kP \\ &= 5.57 \times 10^{-7} \left(\frac{\text{moles}}{\text{kg solvent}} \right) \times 500 \text{ torr} \\ &= 2.785 \times 10^{-4} \frac{\text{moles}}{\text{kg solvent}} \quad \text{but want in g.} \\ &= \frac{2.785 \times 10^{-4} \text{ mol}}{\text{kg}} \times 28.06 \frac{\text{g}}{\text{mol}} \quad \therefore \text{use MM of } \text{C}_2\text{H}_4 \end{aligned}$$

$$\therefore C = 7.81 \times 10^{-3} \text{ g } \text{C}_2\text{H}_4$$

~~7.81 \times 10^{-3} \text{ g } \text{C}_2\text{H}_4~~

$$\Rightarrow C \approx 8 \times 10^{-3} \text{ g } \text{C}_2\text{H}_4 \text{ per kg of water}$$

#5 Blood. $\approx 0.16 \text{ M NaCl}$, $i = 1.9 \Rightarrow 0.304 \text{ m total dissolved "free particles"}$
 instead of predicted 2.

(a) osmotic pressure

$$\Pi V = nRT \quad \text{where } n \text{ is \# moles of dissolved solute particles (free...)}$$

$$\therefore \Pi = \left(\frac{n}{V}\right) RT$$

* NOTE: must make assumption that blood has same density as water, or else we are at dead end already.

Given conc. in molality:

$\approx 0.304 \text{ m dissolved particles}$

$$= \frac{0.304 \text{ mol}}{1 \text{ kg solvent}}$$

... but our osmotic P formula is for $\frac{\text{mol}}{\text{L}}$, so assume that 1 kg solvent makes up the whole volume (+ solute doesn't contribute...)

$$\approx \frac{0.304 \text{ mol}}{1 \text{ L solution}}$$

$$\Rightarrow \Pi = \left(\frac{n}{V}\right) RT = \left(\frac{0.304 \text{ mol}}{1 \text{ L}}\right) \left(0.08206 \frac{\text{L atm}}{\text{mol K}}\right) (37 + 273 \text{ K})$$

$$= 7.73 \text{ atm}$$

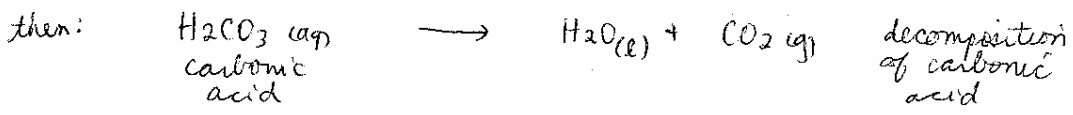
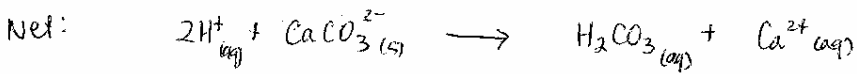
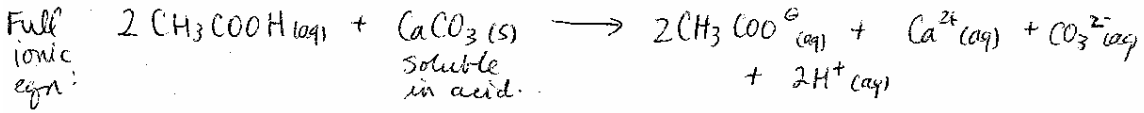
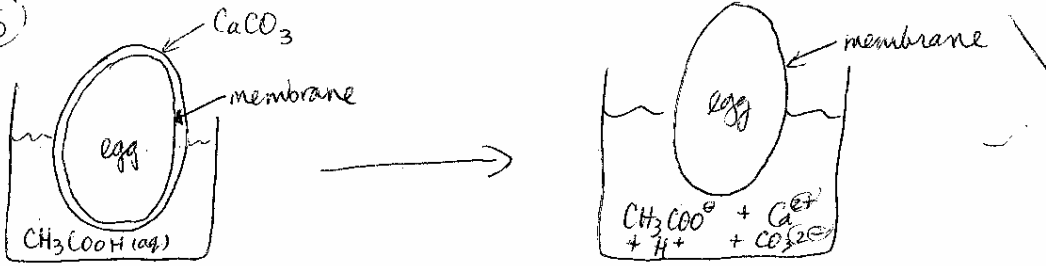
(b) salt restriction: limited electrolytes in stomach \Rightarrow blood
 distilled water: doesn't add any electrolytes either

net: very low electrolytes

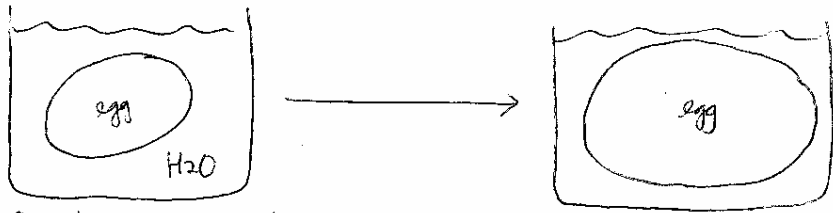
\Rightarrow osmotic pressure will be lower than it should be ...

\Rightarrow cells shrivel up? TONS OF OTHER EFFECTS. Could give an entire biochemistry course on this!!
 * electrolyte balance is important *

#6



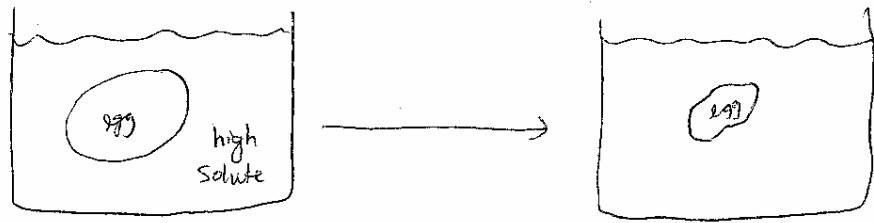
a)



Egg has higher solute concentration than pure water \therefore water passes through membrane into egg, until the solute conc. is roughly equal

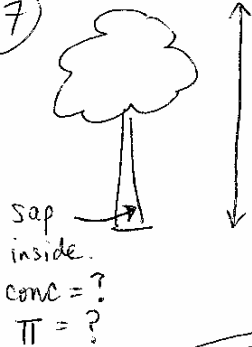
OSMOSIS

b)



Surrounding solution must have higher conc. of solutes than inside egg \therefore water passes through membrane out of egg, until the solute conc. on each side is \approx equal.

#7



$P_{ext} = 0.98 \text{ atm}$ ← note: irrelevant data
 $T = 20^\circ\text{C} = 293 \text{ K}$

Pressure required to push against gravity to reach the top is provided by osmotic pressure.

So: how much Π do we need?

Must calculate how much "gravity" we must push against!

(a)

10 m of sap \approx 10 m of water (assumption that have same density)
 $\approx (10 \text{ m} \times \frac{1000 \text{ mm}}{1 \text{ m}})$ of water
 $\approx (10^4 \text{ mm H}_2\text{O}) \times \frac{1 \text{ mm Hg}}{13.6 \text{ mm H}_2\text{O}}$
 $= 735.3 \text{ mm Hg}$ pressure.

ie: the pressure exerted by a 10m column of water (or sap) is equivalent to that exerted by a column of Hg 73.53 cm tall.

→ can convert this into atm now!

$$P_{\text{sap}} = \frac{735.3 \text{ mm Hg}}{760 \text{ mmHg} \cdot \text{atm}^{-1}} = 0.9675 \text{ atm}.$$

To "fight" this pressure, due to gravity, so that the sap can actually rise up the tree, we need a "pretty concentrated" solution (since Π must equal P_{sap} !!)

$$\Pi V = nRT$$

$$\frac{n}{V} = \frac{\Pi}{RT} = \frac{0.9675 \text{ atm}}{\left(\frac{0.08206 \text{ L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right)(293 \text{ K})} = 0.0402 \frac{\text{mol}}{\text{L}} \quad \text{Not dilute enough to ignore mass of solute!}$$

Again, assuming same density as water: 1 L = 1 kg

∴ Sap contains: 0.0402 mol sucrose
 kg solution ← but some of this mass is sucrose!

Mass of sucrose in 1L sap: (0.0402 mol sucrose)(342.31 g/mol) = 13.76 g sucrose

Mass of water in 1 L sap: (1 kg sap - 0.01376 kg sucrose) = 0.9862 kg H₂O (solvent)

THUS: molality = $\frac{0.0402 \text{ mol sucrose}}{0.9862 \text{ kg water}} = 0.0408 \text{ m} = 0.04 \text{ m}$ (with correct sig. figs.)

Note that molality is very close to molarity here, because the density of the solution in this case is the same as the density of the pure solvent at this temperature. This implies that the [solute] is low enough that in 1kg of solution the mass of solute is very small; in extremely dilute solutions, the entire mass of solution can be safely approximated as pure solvent. Remember that normally we need to know the identity of the solute (as we did here) in order to calculate its mass in a particular total volume of solution (in L), then we subtract the solute mass from the solution mass to determine the mass of pure solvent (in kg) for use in calculating molality.

#7(b) Sucrose $C_{12}H_{22}O_{11}$ MM = 342.31 g/mol

$$\begin{aligned} \text{conc.} &= \frac{0.0402 \text{ mol } C_{12}H_{22}O_{11}}{\text{kg solvent}} \\ &= \frac{(0.0402 \text{ mol})(342.31 \text{ g/mol})}{1 \text{ kg solvent}} \\ &= \frac{13.76 \text{ g Sucrose}}{1 \text{ kg } ~~\text{water}~~ \text{ H}_2\text{O}} \end{aligned}$$

$$\text{mass \%} = \frac{13.76 \text{ g}}{1000 \text{ g} + 13.76 \text{ g}} \times 100\% = 1.36\% \approx 1.4\% \text{ Sucrose}$$

NOTE: the sap of the maple tree has to be highly concentrated by boiling off the water in order to make syrup!!

#8 seawater: $T_f = -2.01^\circ\text{C}$

$$\Delta T_f = 2.01^\circ\text{C} = K_f \cdot m$$

$$\begin{aligned} \therefore m &= \frac{2.01^\circ\text{C}}{1.86^\circ\text{C}/m} \\ &= 1.08 \text{ m} \end{aligned}$$

$$\Delta T_f = (0.5121^\circ\text{C}/m)(1.08 \text{ m})$$

$$= 0.553^\circ\text{C}$$

$$\Rightarrow \text{b.p.} = 100.55^\circ\text{C}$$

$K_f = 1.86^\circ\text{C}/m$
$K_b = 0.5121^\circ\text{C}/m$

Note: the identity of the solutes is completely irrelevant.

#9. BHA MM = ?

0.640 g solute \Rightarrow gives: bp. = 62.22°C for solution
 25.0 g CHCl₃ \rightarrow Must look up bp of pure CHCl₃

bp = ~~61.7~~ 61.7°C
 and boiling point constant
 $K_b = 3.63 \text{ }^\circ\text{C}/m$

So: $\Delta T_b = K_b \cdot m$

$$(62.22 - 61.70) = (3.63 \frac{^\circ\text{C}}{m}) \left(\frac{0.640 \text{ g}}{\text{MM}_{\text{BHA}}} \times \frac{1}{\frac{25.0 \text{ g} \cdot 1 \text{ kg}}{1000 \text{ g}}} \right)$$

$$0.52 = \frac{92.93}{\text{MM}_{\text{BHA}}}$$

$$\text{MM}_{\text{BHA}} = 178.71 \doteq 178 \text{ g/mol}$$

#10.

B_xF_y

22.1% B

77.9% F

100

} enough to determine empirical formula

(a)

(i) To find empirical formula:

	mass%	in 100g	#n	ratio
B	22.1%	22.1g	$\frac{22.1 \text{ g}}{10.811 \text{ g/mol}} = 2.04$	1
F	77.9%	77.9g	$\frac{77.9 \text{ g}}{18.998 \text{ g/mol}} = 4.10$	2

Empirical formula:

BF₂

mass = 48.8 g/mol

(ii) Use given vapour pressure data to find MM.

0.146 g solute
 10.0 g benzene

$$\Rightarrow P_{\text{soln}} = 94.16 \text{ mmHg} = X_{\text{solvent}} \cdot P_{\text{solvent}}^{\circ}$$

$$\Rightarrow 94.16 \text{ mmHg} = X \cdot 95.26 \text{ mmHg}$$

$$X_{\text{soln}} = 0.9885$$

$$\text{Thus: } X_{\text{solute}} = 1 - X_{\text{solvent}}$$

$$= 0.01155$$

So: in our solution of total mass

10.0g + 0.146g = 10.146g : 98.85% of MOLES = C₆H₆
 1.16% of MOLES = (BF₂) solute

$$10.0 \text{ g benzene} = \frac{(10.0 \text{ g})}{78.11 \text{ g/mol}} = 0.128 \text{ mol, since } C_6H_6 \text{ is benzene...}$$

$$\text{Thus: } 0.128 \text{ mol} = (0.9885) n_{\text{TOTAL}} \Rightarrow n_{\text{TOTAL}} = 0.1295 \text{ mol}$$

$$\text{So: our solute: } (0.0116)(0.1295 \text{ mol}) \Rightarrow n_{\text{solute}} = 0.001502 \text{ mol}$$

$$MM = \frac{g}{\text{mol}} = \frac{0.146 \text{ g solute}}{0.001502 \text{ mol}} = 97.2 \text{ g/mol}$$

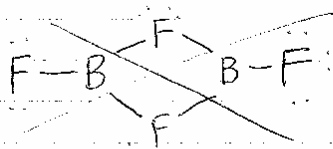
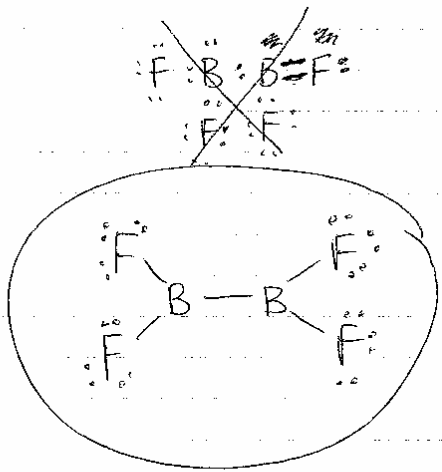
$$\Rightarrow \text{THUS: } \frac{\text{molar mass}}{\text{empirical mass}} = \frac{97.2 \text{ g/mol}}{48.8 \text{ g/mol}} \approx 2.00 \Rightarrow \text{molecular formula is } B_2F_4$$

#10(b) Molecular formula = B_2F_4

Lewis structure:

NO DIPOLE MOMENT
(is symmetric)

$$\begin{array}{l} \text{Valence } e^-: 2 \times B = 2 \times 3 = 6 e^- \\ 4 \times F = 4 \times 7 = 28 e^- \\ \hline 34 e^- \end{array}$$



geometry
& hybridization

- symmetric \therefore NO dipole overall
- 34 valence e^-
- B has open shell (common for B)
- all atoms have ϕ formal charge
- PLANAR molecule
- all bond angles 120°
- B atoms each sp^2 with EMPTY p orbital

\Rightarrow this compound would be very good at interacting (+ REACTING) with other compounds in which there are atoms with lone pairs of e^- !!
= a "Lewis acid"