

R-package marelac : utilities for the MARine, Riverine, Estuarine, LAcustrine and Coastal sciences

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Abstract

Rpackage **marelac** (Soetaert, Petzoldt, and Meysman 2008) contains chemical and physical constants and functions, routines for unit conversion, and other utilities useful for MARine, Riverine, Estuarine, LAcustrine and Coastal sciences.

Keywords: marine, riverine, estuarine, lacustrine, coastal science, utilities, constants, R.

1. Introduction

R-package **marelac** has been designed as a tool for use by scientists working in the MARine, Riverine, Estuarine, LAcustrine and Coastal sciences.

It contains:

- chemical and physical constants, e.g. atomic weights, gas constants.
- conversion factors, e.g. gram to mol to liter conversions.
- functions, e.g. to estimate concentrations of conservative substances as a function of salinity, gas transfer coefficients, diffusion coefficients, ...

2. constants

2.1. AtomicWeight

```
> unlist(AtomicWeight)
```

H	He	Li	Be	B	C	N
1.007940	4.002602	6.941000	9.012182	10.811000	12.010700	14.006700
O	F	Ne	Na	Mg	Al	Si
15.999400	18.998403	20.179700	22.989769	24.305000	26.981539	28.085500
P	S	Cl	Ar	K	Ca	Sc

30.973762	32.065000	35.453000	39.948000	39.098300	40.078000	44.955912
Ti	V	Cr	Mn	Fe	Co	Ni
47.867000	50.941500	51.996100	54.938045	55.845000	58.933195	58.693400
Cu	Zn	Ga	Ge	As	Se	Br
63.546000	65.409000	69.723000	72.640000	74.921600	78.960000	79.904000
Kr	Rb	Sr	Y	Zr	Nb	Mo
83.798000	85.467800	87.620000	88.905850	91.224000	92.906380	95.940000
Tc	Ru	Rh	Pd	Ag	Cd	In
NA	101.070000	102.905500	106.420000	107.868200	112.411000	114.818000
Sn	Sb	Te	I	Xe	Cs	Ba
118.710000	121.760000	127.600000	126.904470	131.293000	132.905452	137.327000
La	Ce	Pr	Nd	Pm	Sm	Eu
138.905470	140.116000	140.907650	144.242000	NA	150.360000	151.964000
Gd	Tb	Dy	Ho	Er	Tm	Yb
157.250000	158.925350	162.500000	164.930320	167.259000	168.934210	173.040000
Lu	Hf	Ta	W	Re	Os	Ir
174.967000	178.490000	180.947880	183.840000	186.207000	190.230000	192.217000
Pt	Au	Hg	Tl	Pb	Bi	Po
195.084000	196.966569	200.590000	204.383300	207.200000	208.980400	NA
At	Rn	Fr	Ra	Ac	Th	Pa
NA	NA	NA	NA	NA	232.038060	231.035880
U	Np	Pu	Am	Cm	Bk	Cf
238.028910	NA	NA	NA	NA	NA	NA
Es	Fm	Md	No	Lr	Rf	Db
NA	NA	NA	NA	NA	NA	NA
Sg	Bh	Hs	Mt	Ds	Rg	
NA	NA	NA	NA	NA	NA	

```
> AtomicWeight$H
```

```
[1] 1.00794
```

```
> (W_H2O<- with (AtomicWeight, 2*H + O))
```

```
[1] 18.01528
```

2.2. Constants

```
> data.frame(cbind(acronym=names(Constants),
+                   matrix(ncol=3,byrow=TRUE,data=unlist(Constants),
+                   dimnames=list(NULL,c("value","units","description")))))
```

	acronym	value	units	description
1	g	9.8	m/s ²	gravity acceleration
2	SB	5.6697e-08	W/m ² /K ⁴	Stefan-Boltzmann constant

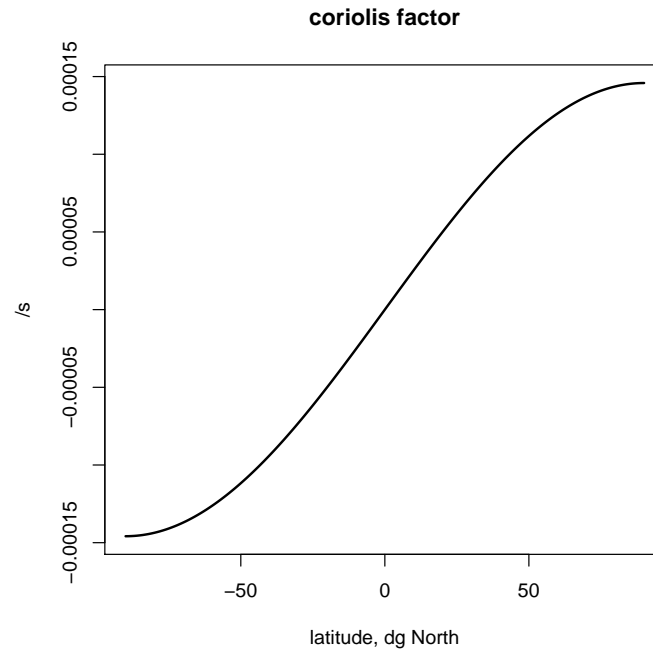


Figure 1: The coriolis function

3	gasCt1	0.08205784	L*atm/K/mol	ideal gas constant
4	gasCt2	8.314472	m3*Pa/K/mol	ideal gas constant
5	gasCt3	83.1451	cm3*bar/K/mol	ideal gas constant
6	F	96485.3	C/mol	charge per mol of electrons
7	P0	101325	Pa	one standard atmosphere
8	B1	1.3806504e-23	J/K	Boltzmann constant
9	B2	8.617343e-05	eV/K	Boltzmann constant

3. functions

3.1. coriolis

Estimates the coriolis factor, f , units sec^{-1} according to the formula: $f=2*\omega*\sin(\text{lat})$, where $\omega=7.292\text{e-}5$ radians/sec

```
> plot(-90:90,coriolis(-90:90),xlab="latitude, dg North",
+      ylab= "/s" , main ="coriolis factor",type="l",lwd=2)
```

3.2. heat capacity

Estimates the heat capacity of seawater, using (R 2008) or according to the UNESCO 1983 polynomial (Fofonoff and Millard 1983)

```
> sw_cp(S=40,t=1:20)

[1] 3958.545 3959.028 3959.576 3960.180 3960.831 3961.523 3962.247 3962.997
[9] 3963.768 3964.553 3965.348 3966.148 3966.949 3967.747 3968.540 3969.324
[17] 3970.098 3970.859 3971.605 3972.336

> sw_cp(S=40,t=1:20,UNESCO=TRUE)

[1] 3956.080 3955.898 3955.883 3956.021 3956.296 3956.697 3957.209 3957.819
[9] 3958.516 3959.288 3960.124 3961.013 3961.945 3962.911 3963.900 3964.906
[17] 3965.918 3966.931 3967.936 3968.927
```

3.3. molecular diffusion coefficients

Calculates molecular and ionic diffusion coefficients (cm²/hour), for several species at given salinity (S) temperature (t) and pressure (P).

Based on the code "CANDI" by Bernie Boudreau ([Boudreau 1996](#)).

```
> diffcoeff(S=15,t=15)*24 # cm2/day

      O2      CO2      NH3      H2S      CH4      HCO3      CO3      NH4
1 1.429209 1.205459 1.422551 1.229482 1.133013 0.7693278 0.6126982 1.314600
      HS      NO3      H2PO4      HP04      PO4      H      OH      Ca
1 1.214089 1.283190 0.6168861 0.4954354 0.3991123 6.51018 3.543850 0.5264263
      Mg      Fe      Mn      SO4      H3PO4      BOH3      BOH4
1 0.4682136 0.4657009 0.4610941 0.7002265 0.555835 0.7602404 0.6652104
      H4SiO4
1 0.6882134

> diffcoeff(t=10)$O2

[1] 0.04930629

> difftemp <- diffcoeff(t=0:30)[,1:13]
> diffsal <- diffcoeff(S=0:35)[,1:13]

> matplot(0:30,difftemp,xlab="temperature",ylab="cm2/hour",
+         main="Molecular/ionic diffusion",type="l")
> legend("topleft",ncol=2,cex=0.8,title="mean",col=1:13,lty=1:13,
+         legend=cbind(names(difftemp),format(colMeans(difftemp),digits=4)))
```

3.4. shear viscosity of water

Calculates the shear viscosity of water, in centipoise. Valid for 0<t<30 and 0<S<36.

Based on the code "CANDI" by Bernie Boudreau ([Boudreau 1996](#)).

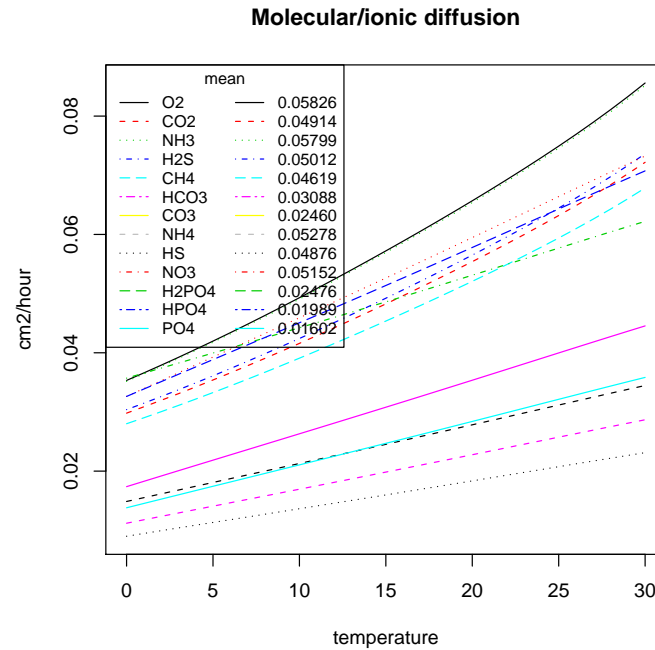


Figure 2: molecular diffusion coefficients as a function of temperature

```
> plot(0:30,viscosity(S=35,t=0:30,P=1),xlab="temperature",ylab="centipoise",
+      main="shear viscosity of water",type="l")
> lines(0:30,viscosity(S=0,t=0:30,P=1),col="red")
> lines(0:30,viscosity(S=35,t=0:30,P=100),col="blue")
> legend("topright",col=c("black","red","blue"),lty=1,
+      legend=c("S=35,P=1","S=0,P=1","S=35,P=100"))
```

3.5. atmospheric composition

```
> atmComp("O2")
```

```
      O2
0.20946
```

```
> atmComp()
```

```
      He      Ne      N2      O2      Ar      Kr      CH4
5.2400e-06 1.8180e-05 7.8084e-01 2.0946e-01 9.3400e-03 1.1400e-06 1.7450e-06
      CO2      N2O      H2      Xe      CO      O3
3.6500e-04 3.1400e-07 5.5000e-07 8.7000e-08 5.0000e-08 1.0000e-08
```

```
> sum(atmComp())    #!
```

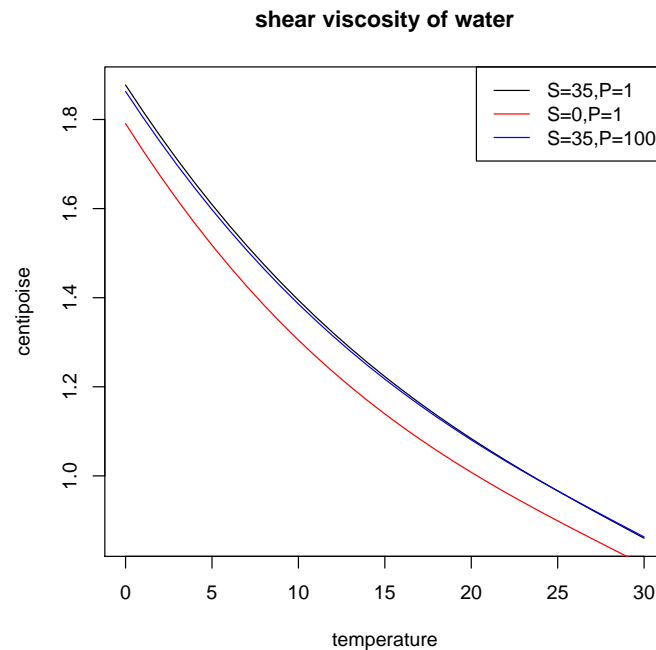


Figure 3: shear viscosity of water as a function of temperature

```
[1] 1.000032
```

3.6. saturated oxygen concentrations

```
> gas_O2sat(t = 20)
```

```
[1] 7.374404  
attr(,"unit")  
[1] "(g/m3)"
```

```
> t <- seq(0, 30, 0.1)
```

```
> plot(t, gas_O2sat(t = t), type = "l", ylim = c(0, 15), lwd=2)  
> lines(t, gas_O2sat(S = 0, t = t, method = "Weiss"), col = "yellow",  
+       lwd = 2, lty = "dashed")  
> lines(t, gas_O2sat(S = 35, t = t, method = "Weiss"), col = "red", lwd = 2)
```

3.7. solubilities and saturated concentrations

```
> gas_satconc(x="O2")
```

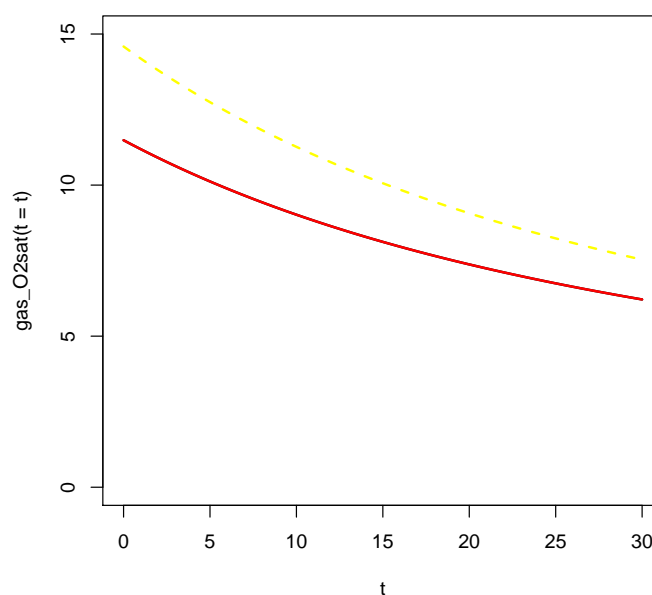


Figure 4: Oxygen saturated concentration as a function of temperature, and for different salinities

```

02
213.7760

> Temp<-seq(from=0,to=30,by=0.1)
> Sal <- seq(from=0,to=35,by=0.1)

> mf <-par(mfrow=c(2,2))
> plot(Temp,gas_solubility(t=Temp,x="CCl4"),xlab="temperature",
+       ylab="mmol/m3/atm",main="solubility (S=35)",type="l",lwd=2,ylim=c(0,100000))
> lines(Temp,gas_solubility(t=Temp,x="CO2"),col="red",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="N2O"),col="blue",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="Rn"),col="green",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="CCl2F2"),col="yellow",lwd=2)
> legend("topright",col=c("black","red","blue","green","yellow"),lwd=2,
+       legend=c("CCl4","CO2","N2O","Rn","CCl2F2"))
> plot(Temp,gas_solubility(t=Temp,x="Kr"),xlab="temperature",
+       ylab="mmol/m3/atm",main="solubility (S=35)",type="l",lwd=2,ylim=c(0,4000))
> lines(Temp,gas_solubility(t=Temp,x="CH4"),col="red",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="Ar"),col="blue",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="O2"),col="green",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="N2"),col="yellow",lwd=2)
> lines(Temp,gas_solubility(t=Temp,x="Ne"),col="grey",lwd=2)
> legend("topright",col=c("black","red","blue","green","yellow","grey"),lwd=2,

```

```
+      legend=c("Kr", "CH4", "Ar", "O2", "N2", "Ne"))
> plot(Temp, gas_satconc(t=Temp, x="N2"), xlab="temperature", log="y",
+      ylab="mmol/m3", main="Saturated conc (S=35)", type="l", lwd=2, ylim=c(1, 700))
> lines(Temp, gas_satconc(t=Temp, x="CO2"), col="red", lwd=2)
> lines(Temp, gas_satconc(t=Temp, x="O2"), col="blue", lwd=2)
> lines(Temp, gas_satconc(t=Temp, x="CH4"), col="green", lwd=2)
> lines(Temp, gas_satconc(t=Temp, x="N2O"), col="yellow", lwd=2)
> plot(Sal, gas_satconc(S=Sal, x="N2"), xlab="salinity", log="y",
+      ylab="mmol/m3", main="Saturated conc (t=20)", type="l", lwd=2, ylim=c(1e-3, 700))
> lines(Sal, gas_satconc(S=Sal, x="CO2"), col="red", lwd=2)
> lines(Sal, gas_satconc(S=Sal, x="O2"), col="blue", lwd=2)
> lines(Sal, gas_satconc(S=Sal, x="CH4"), col="green", lwd=2)
> lines(Sal, gas_satconc(S=Sal, x="N2O"), col="yellow", lwd=2)
> legend("right", col=c("black", "red", "blue", "green", "yellow"), lwd=2,
+      legend=c("N2", "CO2", "O2", "NH4", "N2O"))
> par("mfrow"=mf)
```

3.8. Schmidt number and gas transfer velocity

```
> gas_schmidt(x="CO2", t=20)

[1] 665.988

> useq <- 0:15

> plot(useq, gas_transfer(u10=useq, x="O2"), type="l", lwd=2, xlab="u10, m/s",
+      ylab="cm/hr", main="O2 gas transfer velocity", ylim=c(0, 75))
> lines(useq, gas_transfer(u10=useq, x="O2", method="Nightingale"), lwd=2, lty=2)
> lines(useq, gas_transfer(u10=useq, x="O2", method="Wanninkhof1"), lwd=2, lty=3)
> lines(useq, gas_transfer(u10=useq, x="O2", method="Wanninkhof2"), lwd=2, lty=4)
> legend("topleft", lty=1:4, lwd=2, legend=c("Liss and Merlivat 1986",
+      "Nightingale et al. 2000", "Wanninkhof 1992", "Wanninkhof and McGills 1999"))
```

3.9. Concentration of conservative species in seawater

```
> sw_conserv(S=seq(0, 35, by=5))
```

	Borate	Calcite	Sulphate	Fluoride
1	0.00000	0.000	0.000	0.000000
2	59.42857	1468.571	4033.633	9.760629
3	118.85714	2937.143	8067.267	19.521257
4	178.28571	4405.714	12100.900	29.281886
5	237.71429	5874.286	16134.534	39.042515
6	297.14286	7342.857	20168.167	48.803144
7	356.57143	8811.429	24201.801	58.563772
8	416.00000	10280.000	28235.434	68.324401

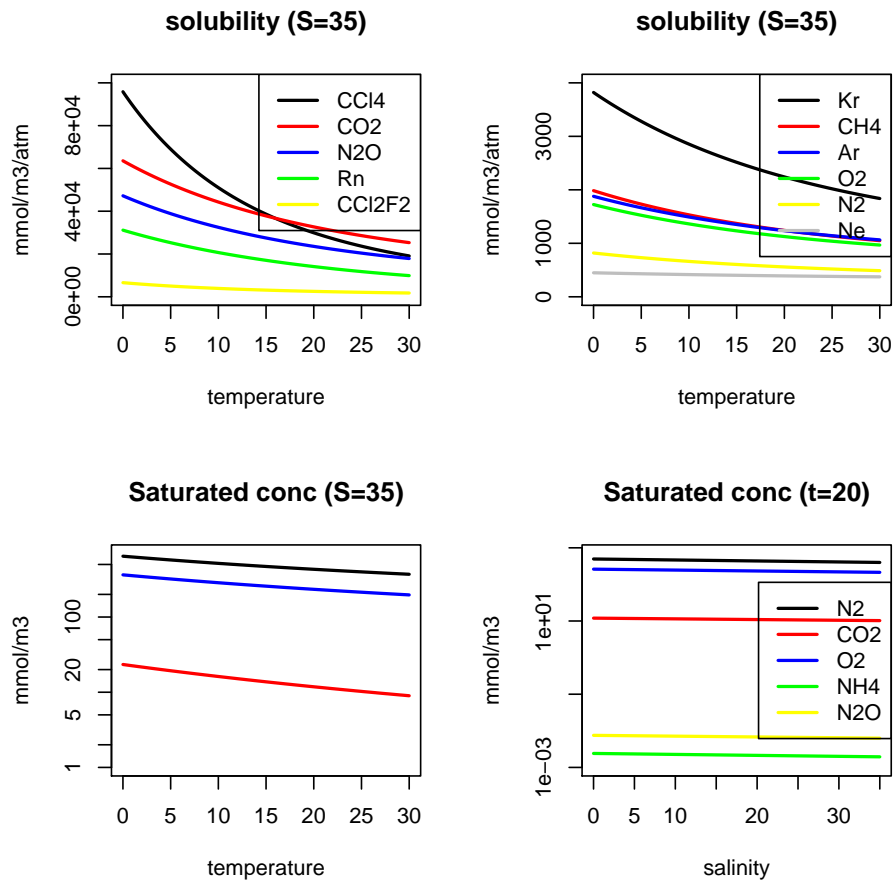


Figure 5: Saturated concentrations and solubility as a function of temperature and salinity, and for different species

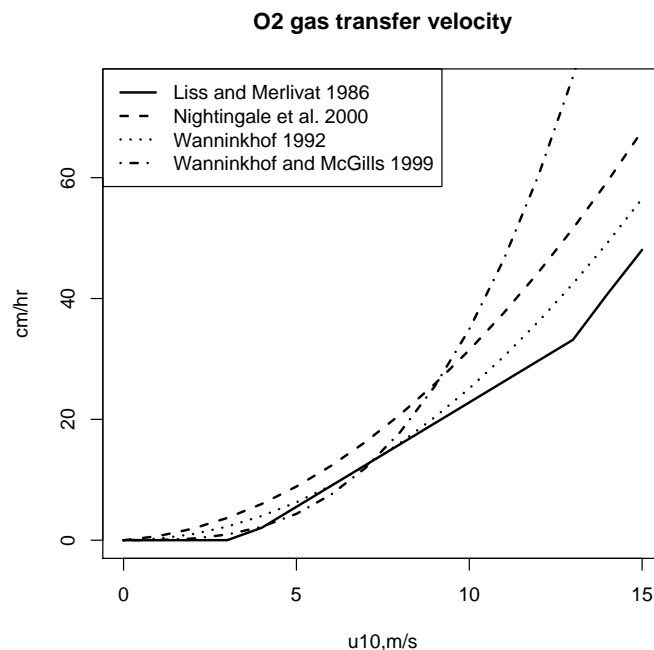


Figure 6: gas transfer velocity for seawater

4. conversions

4.1. gram, mol, liter conversions

gram to moles and vice versa

```
> 1/mol.weight("CO3")
```

```
CO3
0.01666419
```

```
> 1/mol.weight("HCO3")
```

```
HCO3
0.01638892
```

```
> 1/mol.weight(c("C2H5OH", "CO2", "H2O"))
```

```
C2H5OH      CO2      H2O
0.02170683  0.02272237 0.05550844
```

```
> mol.weight(c("SiOH4", "NaHCO3", "C6H12O6", "Ca(HCO3)2", "Pb(NO3)2", "(NH4)2SO4"))
```

SiOH4	NaHCO3	C6H12O6	Ca(HCO3)2	Pb(NO3)2	(NH4)2SO4
48.11666	84.00661	180.15588	162.11168	331.20980	132.13952

liter to moles and vice versa

```
> 1/mol.vol(x="O2",t=0)*1000
```

```

      O2
45.86736
```

```
> 1/mol.vol(x="O2",q=1:6,t=0)
```

```

      O2
[1,] 0.045867360
[2,] 0.022933679
[3,] 0.015289117
[4,] 0.011466842
[5,] 0.009173472
[6,] 0.007644560
```

```
> 1/mol.vol(t=1:10,x="O2")
```

```

      O2
[1,] 0.04569936
[2,] 0.04553258
[3,] 0.04536702
[4,] 0.04520267
[5,] 0.04503950
[6,] 0.04487752
[7,] 0.04471669
[8,] 0.04455702
[9,] 0.04439848
[10,] 0.04424108
```

molar volume of an ideal gas

```
> mol.vol(x="ideal")
```

```

      ideal
24.46559
```

```
> mol.vol(x="ideal",t=1:10)
```

```

      ideal
[1,] 22.49620
[2,] 22.57826
```

R package **marelac** : utilities for the *M*arine, *R*iverine, *E*stuarine, *L*acustrine and *C*oastal sciences

```
[3,] 22.66032
[4,] 22.74237
[5,] 22.82443
[6,] 22.90649
[7,] 22.98855
[8,] 23.07061
[9,] 23.15266
[10,] 23.23472
```

4.2. pressure conversions

```
> convert_p(1, "atm")
```

	Pa	bar	atm	torr
1	101325.3	1.013253	1.033214	760.0008

4.3. salinity and chlorinity

```
> convert_StoCl(S=35)
```

```
[1] 19.37394
```

5. finally

This vignette is mainly a Sweave ([Leisch 2002](#)) translation of part of the **marelac** help files.

References

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