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MASS DIFFUSIVITY DATA

Typical values for mass and thermal diffusivities, D_i and $a=k/(\rho c_p)$, and Schmith number, Sc, all at 300 K.

Substance	Diffusivity	Typical values	Example [m²/s]	$Sc=\nu/D_i$
Gases[a)]	a	10^{-5} m²/s	$a_{air}=22\cdot10^{-6}$	
			$a_{CH4}=24\cdot10^{-6}$	
	D_i	10^{-5} m²/s	$D_{H2O,air}=24\cdot10^{-6}$	0.66
			$D_{CO2,air}=14\cdot10^{-6}$	1.14
			$D_{CO,air}=19\cdot10^{-6}$	0.84
			$D_{CH4,air}=16\cdot10^{-6}$	0.99
			$D_{He,air}=71\cdot10^{-6}$	0.22
			$D_{H2,air}=78\cdot10^{-6}$	0.20
			$D_{O2,air}=19\cdot10^{-6}$	0.84
			$D_{SO2,air}=13\cdot10^{-6}$	1.22
			$D_{NH3,air}=28\cdot10^{-6}$	0.57
			$D_{methanol,air}=14\cdot10^{-6}$	1.14
			$D_{ethanol,air}=11\cdot10^{-6}$	1.5
			$D_{bencene,air}=8\cdot10^{-6}$	2.0
			$D_{n\text{-}octane,air}=5\cdot10^{-6}$	3.2
			$D_{n\text{-}decane,air}=6\cdot10^{-6}$	2.7
			$D_{H2,O2}=70\cdot10^{-6}$	0.22
			$D_{H2,CO2}=55\cdot10^{-6}$	0.29
Liquids[b)]	a	10^{-7} m²/s	$a_{water}=0.16\cdot10^{-6}$	
	D_i	10^{-9} m²/s	$D_{N2,water}=2.0\cdot10^{-9}$	430
			$D_{O2,water}=2.5\cdot10^{-9}$	340
			$D_{H2,water}=5.3\cdot10^{-9}$	160
			$D_{CH4,water}=1.5\cdot10^{-9}$	570
			$D_{CO2,water}=2.1\cdot10^{-9}$	410
			$D_{CO2,methanol}=8.4\cdot10^{-9}$	100
			$D_{CO2,ethanol}=3.9\cdot10^{-9}$	220
			$D_{NH3,water}=2.4\cdot10^{-9}$	360
			$D_{methanol,water}=1.6\cdot10^{-9}$	540
			$D_{ethanol,water}=1.6\cdot10^{-9}$	540
			$D_{ethylene\text{-}glycol,water}=1\cdot10^{-9}$	860
			$D_{sucrose,water}=0.6\cdot10^{-9}$	1400
			$D_{NaCl,water}=0.12\cdot10^{-9}$	
Solids[c)]	a	10^{-6} m²/s	$a_{steel}=13\cdot10^{-6}$	
			$a_{ice}=1.3\cdot10^{-6}$	
			$a_{fresh\ food}=0.13\cdot10^{-6}$	
	D_i	10^{-12} m²/s	$D_{N2,rubber}=150\cdot10^{-12}$	
			$D_{O2,rubber}=210\cdot10^{-12}$	
			$D_{CO2,rubber}=110\cdot10^{-12}$	
			$D_{H2,polyethylene}=87000\cdot10^{-12}$	
			$D_{H2,steel}=0.3\cdot10^{-12}$	
			$D_{H2,nickel}=1\cdot10^{-12}$	
			$D_{He,pyrex}=0.9\cdot10^{-12}$ ($440\cdot10^{-12}$ at 700 K)	

	$D_{C,iron}=30\cdot10^{-12}$ at 1000 K ($150\cdot10^{-12}$ at 1180 K [d])

[a] According to the kinetic theory of gases, all diffusivities (thermal a, mass D_i, and momentum ν, i.e. the kinematic viscosity), increase with temperature and pressure as $T^{3/2}/p$ (for gases). Temperature effect on liquids may be much larger, and positive or negative (e.g. thermal diffusivity in water has a 7% increase from 290 K to 310 K, but mass diffusivity has a 300% increase, and momentum diffusivity a 36% decrease). Schmidt numbers, $Sc=\nu/D_i$, are presented as a measure of non-ideality in gases (kinetic theory of ideal gases predicts Sc=1); for air solutions, the dynamic viscosity is practically that of air, $\nu=15.9\cdot10^{-6}$ m^2/s at 300 K. for aqueous solutions, the dynamic viscosity is practically that of water, $\nu=0.86\cdot10^{-6}$ m^2/s at 300 K. In practice, mass diffusion (and thermal diffusion) in gases is modelled in the form T^n/p but with a higher value than the n=3/2 predicted by ideal theory; e.g., for water-vapour diffusing in air, an empirical correlation much used in humid-air studies, more accurate between 250 K<T<450 K, uses n=2.072).

[b] Mass diffusion in liquids grows with temperature, roughly inversely proportional viscosity-variation with temperature, so that the Schmidt number, $Sc=\nu/D_i$, quickly decreases with temperature, roughly as $Sc\propto\mu^2$ (e.g. for aqueous solutions, if one uses the approximation $\mu/\mu^\oplus=\exp(-6(1-T^\oplus/T)$ with $T^\oplus$=288 K and $\mu^\oplus$=0.0011 Pa·s, one may approximate $Sc/Sc^\oplus=\exp(-12(1-T^\oplus/T)$ with $T^\oplus$=288 K and Sc(300 K) given by Table 1; mind the difference in reference temperature; you may check that for $Sc_{N2,water,300\ K}=240$, it corresponds e.g. $Sc_{N2,water,273\ K}=750$ and $Sc_{N2,water,323\ K}=100$). Notice that a single diffusion-coefficient value can be ascribed to solutes that separate into ions in solution (electrolytes, like NaCl(aq) above), because, to keep electrical balance, all ions have to diffuse coherently, unless there are several ionic solutes and some ionic coupling.

[c] Mass diffusion in solids is often not well represented by Fick's law, so that diffusion coefficients might not be well-defined, and other (empirical) correlations should be applied instead of Fick's law.

[d] The diffusion coefficient for carbon in steels can be modelled by an Arrhenius' law $D_i(T)=D_{i0}\exp(-E_a/(RT))$, with $D_{i0}=1.1\cdot10^{-6}$ m^2/s and $E_a=87\cdot10^3$ J/mol for diffusion in Fe-α-bcc, i.e. up to the transition temperature $T_{Fe\text{-}\alpha\to Fe\text{-}\gamma}$=1180 K, whereas for higher temperatures, up to the transition temperature $T_{Fe\text{-}\gamma\to Fe\text{-}\delta}$=1670 K, the parameters are $D_{i0}=23\cdot10^{-6}$ m^2/s and $E_a=140\cdot10^3$ J/mol.

Many other properties, like species solubilities in particular media, can be found in Solution properties.

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