6.5 RADIOACTIVE DECAY

Recall: $$\frac{\partial c}{\partial t} = D_L \frac{\partial^2 c}{\partial x^2} - v^a \frac{\partial c}{\partial x} - \frac{\rho_d}{\theta} \frac{\partial c^x}{\partial t} + \left(\frac{\partial c}{\partial t}\right)_{rxn}$$

Retardation — Reaction

- Radioactive chain decay
- Abiotic hydrolysis (natural degradation of hydrocarbons

$$\left(\frac{\partial c}{\partial t}\right)_{decay} = -\frac{\ln(2)}{\lambda} c$$

λ = half life (in same units as time)

The previous figure introduced the concept of half-life to define the abiotic rxn rate. You will recall that this derives from the first-order rate laws, which is often assumed to apply to abiotic rxns:

$$-\frac{d(RX)}{dt} = k_T [RX]$$

where half life, $t_{1/2} = 0.693/k_T$

Vogel et al (1987) give the following table of half-lives:

TABLE 3
Environmental half-lives and products from abiotic hydrolysis or dehydrohalogenation of halogenated aliphatic compounds at 20 °C

Compound	Half-life years (reference)	Product(s) (reference)
Methanes		
Dichloromethane	1.5 (10), 704 (8)	
Trichloromethane	1.3 (10), 3500 (8)	
Tetrachloromethane	7000 (8)	
Bromomethane	0.10 (8)	
Dibromomethane	183 (8)	
Tribromomethane	686 (8)	
Bromochloromethane	44 (8)	
Bromodichloromethane	137 (8)	
Dibromochloromethane	274 (8)	
Ethanes		
Chloroethane	0.12 (11)[a]	Ethanol (11)[a]
1,2-Dichloroethane	50 (12)	
1,1,1-Trichloroethane	0.5 (10), 1.7 (12)	Acetic acid (12–14)
	0.8 (15)[b], 2.5 (16)[a]	1,1-Dichloroethylene (14–16)
1,1,2-Trichloroethane	170 (12)	1,1-Dichloroethene (17)
1,1,1,2-Tetrachloroethane	384 (12)	Trichloroethene (12)
1,1,2,2-Tetrachloroethane	0.8 (12)	Trichloroethene (12)
1,1,2,2,2-Pentachloroethane	0.01 (12)	Tetrachloroethene (12)
Bromoethane	0.08 (8)	
1,2-Dibromoethane	2.5 (9)	Bromoethene (9)
	2.5 (18)	Ethylene glycol (18)
Ethenes		
Trichloroethene	0.9 (10), 2.5 (15)[b]	
Tetrachloroethene	0.7 (10), 6 (15)[b]	
Propanes		
1-Bromopropane	0.07 (8)	
1,2-Dibromopropane	0.58 (9)	Bromopropene (9)
1,3-Dibromopropane	0.13 (9)	Bromopropanol (9)
1,2-Dibromo-3-chloropropane	35 (19)	Bromochloropropene (19)

[a]Extrapolated by 2 from Reference 11. [b]At 10 °C in sea water. [c]At 20 °C.