Key Concepts (a subjective and not-exhaustive list)

Groundwater

Flow Nets: how to draw, characteristics of a properly drawn flow net (Q_{tube} same for all streamtubes, larger squares indicate slower flow and decreased dh/dx), calculating discharge

Well Equations:

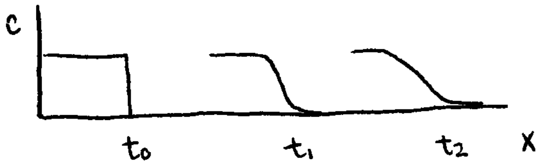
Steady-state ("Theim equation"): ds/dr and s(r) depend on Q_w and aquifer characteristics

Transient ("Theis equation"): depends on Q_w, aquifer characteristics, and S

(S = how much water you get for a given change in head; sponge analogy might help)

Transport Models:

1) Pulse injection: same as in surface water, except accounting for porosity, and $D = \alpha v$ (different flow paths leads to spreading in direction of travel)
2) Continuous input: mostly conceptual
   Equivalent to figure 3-17: "edges mixed", rather than Gaussian spreading



$$C(x,t) = \frac{C_0}{2}\,\mathrm{erfc}\left[\frac{(x-vt)}{2\sqrt{Dt}}\right]$$

Retardation: combined effects of transport and chemistry; for sorption to organic carbon, look up K_{ow} and use empirical equation to get K_{oc}, which leads to K_d and R. Note that retardation affects v and D (advection and diffusion/dispersion are both slowed down).

Atmospheric

Relationship between dew point, vapor pressure, and which lapse rate to use (example 4-2)

Be able to describe local effects (briefly)

Concentration models:

1) box – indoor, or well-defined urban
   gives you steady-state, uniform (throughout box) concentration
2) plume – urban (general)
   gives C at a particular point (x affects σ values, and y,z go into g expressions)

Note that the Pasquill-Gifford equation describes the same physical processes as in surface water, with different notation, so the same reasoning holds (for example, highest concentration at centerline).

Atmospheric Chemistry: most reactions driven by light

[OH] reactions are main sink for most chemicals

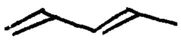
be able to compare timescales (reaction with OH vs. transport into stratosphere – which is more important?)

descriptive: ozone, acid rain

Reactions – the "fate" of fate and transport

Photolysis

a) direct: molecule of interest is broken down by light
   chemicals with double bonds (especially more than one), or aromatic rings

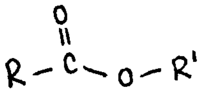


see p. 165 for examples

   this is because only λ > 290 nm light reaches Earth's surface, and these molecules require less energy to excite

b) indirect: light produces OH or other reactive oxygen species
   not selective – these react with almost everything, very quickly (with a few exceptions such as CFC's)

Hydrolysis: molecule is broken apart by water (can be acid/base catalyzed)
Affects esters and "ester analogs"
Basic ester structure: double bond, next to an atom that is not C ("heteroatom")



$R-C(=O)-O-R'$

(can have N, P, S instead – see p. 170 for examples)

Also affects alkyl halides R-X (X = Cl, F, Br, I)

Biodegradation

Oxidative: organic carbon is oxidized to CO_2, happens via ecological redox sequence. Large, branched, or halogen-containing molecules are **less** susceptible (p. 145)
(Can also have reductive biodegradation, which affects mostly chlorine-containing molecules. See p. 147 – the text calls this "anaerobic", somewhat confusingly.)

Model: how fast does chemical get degraded?

1) Michaelis-Menten kinetics

$$V = V_{\max}\frac{C}{C+K_s} \qquad \frac{dC}{dt} = VX \qquad (X = \text{cells/volume})$$

2) Monod – an extension of the model which takes into account growth of the microorganism population. If there are more bugs eating chemical at the same uptake rate, the chemical is being degraded faster...

Cometabolism – organism doesn't get energy from chemical of interest (it lives off something else), but breaks it down anyway
Biofilms – these form because organisms are exposed to more chemical as water advects past, compared to free-floating organisms which must rely on diffusion