CHEM 302 Exam Review

Terms/Concepts

Atmospheric composition	Mixing ratios and concentration units
Troposphere, stratosphere	Catalytic depletion cycles (freons, halons)
Temperature profiles	Smog, Photochemical smog
Photochemistry	Residence time (lifetime)
Scale height	Reaction rates
Vertical mixing	Adiabatic lapse rate
Radicals	Half-life (first and second order rxns)
Solar irradiance (UVa, UVb, UVc)	Thermal and photochemical rate constants
Planetary boundary layer	Steady state concentrations
Sources, sinks & resevoirs	Exhaust emissions
Ozone depletion potential (ODP)	ΔH^{o}_{rxn} & bond dissociation energies (BDE)
Ozone hole (Polar Stratospheric Clouds)	Henry's law (K_H) and pH
Composition of rain & fog	NO_x & SO_x oxidations
Ground level ozone	$PM_{2.5}$ & PM_{10}
Sea spray aerosols	Fly ash composition and removal
Combustion by-products - PAHs	Chemical concentration factor (CCF)
Scrubbers and electrostatic precipitators	Desulfurization
Condensation aerosols–organic&inorganic	Urban air quality – SO_2, NO_x, O_3, CO, PM
Co-agulation and settling velocity	Aerosol lifetimes
VOC oxidations	Indoor air quality – radon & formaldehyde
Air changes per hour (ach)	IR absorption and 'IR window'
Blackbody radiation	Fossil fuel energy production
Greenhouse gases (GHG) and conc trends	Radiative forcing & albedo
Global warming potential (GWP)	Climate feedbacks

Chemical Species

hydroxyl radical	OH	CFC's, HCFC's, HFCs	CFC-*xyz*
hydroperoxyl	O_2H	aldehydes	RCHO
singlet atomic O	O*	formaldehyde	CH_2O
singlet molecular O_2	O_2*	PAH's	e.g., BaP
ozone	O_3	hydrocarbons	HC's
nitrous oxide	N_2O	peroxyacetylnitrate (PAN)	$CH_3CO_2ONO_2$
nitric oxide	NO	chlorine nitrate	$ClONO_2$
nitrogen dioxide	NO_2	dimethyl sulfide	$(CH_3)_2S$
nitrate radical	NO_3	nitric acid	HNO_3
dinitrogen pentoxide	N_2O_5	ammonia	NH_3
dihydrogen sulfide	H_2S	hypochlorous acid	HOCl
carbon monoxide	CO	hydrogen peroxide	H_2O_2
carbonyl sulfide	COS	carbonic acid	H_2CO_3
carbon dioxide	CO_2	sulfurous acid	H_2SO_3
sulfur dioxide	SO_2	sulfuric acid	H_2SO_4
sulfur trioxide	SO_3	sulfur hexafluoride	SF_6
methane	CH_4	ammonium sulfate	$(NH_4)_2SO_4$

Chemical Reactions

Chapman Reactions

Ozone Depletion Cycles

Hydroxyl Radical Production

Hydrocarbon Oxidations (e.g., methane)

PAN and Smog Production

Nitric Oxide Oxidation

Sulfur Dioxide Oxidation

Dissolution and Acid Precipitation

NOx and SO_2 abatement chemistry

Calculations

units of concentration (P, molecules/cm^3, ppmv, ppbv, mol/L, $\mu g/m^3$)

pressure/concentration at altitude, scale height

residence times/lifetimes and half-life

rates of reaction, rate constants

first, second and *pseudo* order (differential and integrated rate laws)

steady state concentrations

Henry's law (K_H, P_X, [X])

acid-base reactions ($[H^+]$, pH)

stoichiometry of desulfurization scrubbers

co-agulation rates and settling velocities

air exchange and indoor air conc's and rates

radiative energy balance (greenhouse and albedo effects)

CHEMISTRY 302: CONVERSION AND FORMULA SHEET

Conversions:

$$1\ \text{ppmv} = \frac{1 \text{ x } 10^{-6}\ \text{mol}}{1\ \text{mol}} = \frac{1\ \mu\text{mol}}{1\ \text{mol}} = \frac{1\ \text{molecule}}{1 \text{ x } 10^{6}\ \text{molecule}} = \frac{1 \text{ x } 10^{-6}\ \text{atm}}{1\ \text{atm}} = \frac{1 \text{ x } 10^{-6}\ \text{Pa}}{1\ \text{Pa}}$$

$$n_x = \chi\, n_{air}$$

n_{air} (Loschimdt's number) = 2.69 x 10^{19} molecules cm^{-3} (at STP)

Kelvin Temperature = ^{o}C - 273.2

1.00 atm = 101,300 Pa = 760 torr

1 m^3 = 10^3 L = 10^6 cm^3

1 mol of gas at STP = 22.41 L

pH = - log a_{H+} ≈ - log $[H^+]$

Newton (force) N = kg m s^{-2}

Pascal (pressure) Pa = kg m^{-1} s^{-2}

Joule (energy) J = kg m^2 s^{-2}

STP: T = 273 K, P = 1.00 atm

1 Bq = 1 disintegration per second

1 Ci = 3.7 x 10^{10} Bq

1 rad = 10^{-2} J kg^{-1}

1 rem = 1 rad x RBE

General Formulas:

PV = nRT

$$\text{Residence time (lifetime)} = \frac{\text{amt in resevoir}}{\Sigma \text{ flux rates}} = \frac{1}{\Sigma k} \text{ (first or pseudo first order)}$$

$$P_z = P_o \, e^{-\left\{\frac{g \bar{M} z}{R T}\right\}}$$

$$E_{photon} \text{ (mole)} = \frac{h c N_A}{\lambda}$$

$$\Delta H^o_{rxn} = \Sigma \Delta H^o_f \text{ (products)} - \Sigma \Delta H^o_f \text{ (reactants)}$$

$$K_H = \frac{[X(aq)]}{P_X(g)}$$

$$\ln \frac{[A]_t}{[A]_o} = -k_1 t$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_o} = k_2 t$$

$$t_{1/2} = \frac{0.693}{k_1}$$

$$t_{1/2} = \frac{1}{k_2 [A]_o}$$

$$k = A \, e^{-\left\{\frac{E_a}{R T}\right\}}$$

$$\ln \frac{k_{T1}}{k_{T2}} = -\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$CCF = \frac{(C_x / C_{Na})_{aerosol}}{(C_x / C_{Na})_{seawater}}$$

$$\nu_t = \frac{(\rho_p - \rho_a) C g d_p^{\,2}}{18 \eta}$$

$$\frac{-dN}{dt} = 4 \pi D C d_p N^2$$

$$E_{total} = \frac{2 \pi^5 k^4 T^4}{15 c^2 h^3} = 5.67 x 10^{-8} T^4 = \sigma T^4$$

$$\sigma T^4 = \frac{(1-A)\Omega}{4} + \Delta E$$

$d[X]_{inside}/dt = k_e [X]_{outside} + R_{emission} - k_e [X]_{inside}$

$ln ([X]_{outside} - [X]_{inside}) = - k_e t + \text{Constant}$, when $R_{emission} = 0$

CHEMISTRY 302: DATA SHEET

Universal Constants

$R = 8.314\ J\ mol^{-1}\ K^{-1} = 0.08206\ L\ atm\ mol^{-1}\ K^{-1}$
$g = 9.81\ m\ s^{-2}$
$h = 6.626 \times 10^{-34}\ J\ s$
$c = 3.00 \times 10^{8}\ m\ s^{-1}$
$N_A = 6.023 \times 10^{23}$ molecule mol^{-1}
$\sigma = 5.67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$

Planetary constants

Average Molar Mass (MW_{air}) = 28.96 g mol^{-1}
Mass of Atmosphere = 5.3 x 10^{18} kg
Radius of Earth = 6400 km
Surface Area of Earth = 5.1 x 10^{14} m^2
$\rho_{air} = 1.2 \times 10^{3}\ g/m^3$ (at P=1.0 atm & T = 298K)
$\eta = 1.9 \times 10^{-2}$ g/m s (at P=1.0 atm & T = 298K)
$\Omega = 1372\ W\ m^{-2}$
A = 0.30

Gas Composition of Dry Atmosphere

N_2	78.01%
O_2	20.95%
Ar	0.93%
CO_2	0.0390%

Specific Constants

Thermodynamic Constants

$\Delta H^o{}_f$ (**N_2O**, g) = 82 kJ mol^{-1}
$\Delta H^o{}_f$ (**N_2**, g) = 0 kJ mol^{-1}
$\Delta H^o{}_f$ (**O**, g) = 247 kJ mol^{-1}

Henry's Law Constants

K_H (**SO_2**) = 1.2 x 10^{-5} mol L^{-1} Pa^{-1} = 1.2 mol L^{-1} atm^{-1}
K_H (**CO_2**) = 3.3 x 10^{-7} mol L^{-1} Pa^{-1} = 3.3 x 10^{-2} mol L^{-1} atm^{-1}
K_H (**NH_3**) = 5.7 x 10^{-4} mol L^{-1} Pa^{-1} = 58 mol L^{-1} atm^{-1}

Acid Dissociation Constants

H_2CO_3	$K_{a1} = 4.5 \times 10^{-7}$	$K_{a2} = 4.7 \times 10^{-11}$
H_2SO_3	$K_{a1} = 1.72 \times 10^{-2}$	$K_{a2} = 6.43 \times 10^{-8}$
H_2SO_4	$K_{a1} > 1$	$K_{a2} = 1.0 \times 10^{-2}$