Equations in Atmospheric Chemistry/Physics – May be Used at the Exam

Constants, values and parameters:

Adiabatic lapse rate (dry):	$\Gamma = - dT/dz = g/C_p = 9{,}8$ K/km
Adiabatic lapse rate (wet):	$\Gamma_w = - dT/dz = 2 – 7$ K/km
Aerosol particle/drop diameter:	D
Altitude:	z
Angular velocity:	ω
Atmospheric absorption of radiation:	f
Atmospheric mean composition (dry):	N_2: 0,78; O_2: 0,21; Ar: 0,01 [mole/mole]
Atmospheric mean pressure at sea level:	1013 hPa
Atmospheric mean surface pressure:	984 hPa
Atmospheric mean temperature at sea level:	288 K
Atmospheric mean temperature (vertically):	260 K
Avogadros' number:	$N_{av} = 6{,}023\ 10^{26}$ $kmole^{-1}$
Backscattered fraction:	β
Cloud droplets, number concentration:	N
Cunningham correction factor:	C_c
Density:	ρ
Earth albedo:	A = 0,28
Earth radius:	$R_j = 6{,}37x10^6$ m
Earth-to-sun distance:	$d = 1{,}496x10^{11}$ m
Gas constant:	R = 8314,3 J/(kmole K)
Gravitation:	$g = 9{,}81$ m/s^2
Latitude:	λ
Molar mass:	M
Molar mass, mean for the atmosphere:	M_a
No. ions per salt "molecule":	ν
Optical depth:	δ
Pressure:	P
Solar constant:	$F_S = 1370$ W/m^2
Solar radius:	$R_S = 6{,}96x10^8$ m
Solar surface temperature:	$T_S = 5780$ K
Stefan-Boltzmann constant:	$\sigma = 5{,}67x10^{-8}$ $W/(m^2K^4)$
Surface tension:	σ_D
Target distance:	ΔX
Temperature:	T
Vapour pressure:	P
Vapour pressure, saturated:	P_{sat}
Velocity relative the earth surface:	v
Velocity relative surrounding air:	V
Viscosity:	μ

Physics:

Albedo, aerosol layer:	$A_a = \beta\delta$
Albedo, sum of two layers:	

$$A_T = A_1 + A_0(1-A_1)^2 + A_0^2 A_1(1-A_1)^2 + \sum_{n=2}^{\infty} A_0^{n+1} A_1^n (1-A_1)^2$$

Albedo, change for clouds:	$\Delta A = \frac{A(1-A)}{3}\frac{\Delta N}{N}$
Barometric law:	$P = P_0 \exp(-z/H)$, scale height $H = RT/M_a g$
Boyant acceleration:	$\gamma_b = (\rho' - \rho)g/\rho$
Climate sensitivity parameter:	$\lambda = 1/[4(1 - ½f)\sigma T^3]$
Coriolis acceleration:	$\gamma_c = 2\omega v\, sin(\lambda)$
Coriolis, resultind deviation:	$\Delta Y = \omega(\Delta X)^2\, sin(\lambda)/v$
Drag force (Stokes' law):	$F_m = 3\pi\nu VD/C_c$
Kelvin effekt:	$P^*/P_{sat} = \exp(4\sigma_D M/\rho RTD)$
Köhler equation:	$P/P_{sat} = \exp(4\sigma_D M/\rho RTD)/[1 + 6\nu m_s M_w/(M_s \rho_w \pi D^3)]$
Mass balance equation:	$dm/dt = F_{in} - F_{ut} + E - D + P - L$
Radiative forcing:	$\Delta F = F_{ut,\ jämvikt} - F_{ut,\ störd}$
Radiation from a black body:	$F_T = \sigma T^4$
Raoults law:	$P/P_{sat} = 1/[1 + 6\nu m_s M_w/(M_s \rho_w \pi D^3)]$
Relative humidity:	$RH = 100 P_{H2O}/P_{sat}$ (%)
Residence time:	$\tau = m/(F_{ut} + D + L)$
Sedimentation velocity aerosol:	$V_{TS} = \rho_p D^2 g C_c/(18\eta)$

Chemistry:

Irreversible reaction (A+B $\rightarrow$ C+D):	$\frac{d[C]}{dt} = \frac{d[D]}{dt} = \frac{-d[A]}{dt} = \frac{-d[B]}{dt} = k[A][B]$
Photolysis:	$X + h\nu \rightarrow Y + Z$
	$-d[X]/dt = k[X]$, $k = q\sigma I$ (photolysis rate constant)
Stationary state:	$d[X]/dt = P - L = 0$
Oxygen atoms:	O denotes $O(^3P)$ which is a biradical.

Gases SO_2 and CO_2 dissolves in several steps in water according to the formulae below (K_i equilibrium constants):

(1)	$SO_2(g) \Leftrightarrow SO_2(g)\cdot H_2O$	($K_1 = 1.2$ M·atm^{-1})
(2)	$SO_2(g)\cdot H_2O \Leftrightarrow HSO_3^- + H^+$	($K_2 = 1.3\cdot 10^{-2}$ M)
(3)	$HSO_3^- \Leftrightarrow SO_3^{2-} + H^+$	($K_3 = 6.3\cdot 10^{-8}$ M)

respective

(1)	$CO_2 \Leftrightarrow CO_2(g)\cdot H_2O$	($K_1 = 0.03$ M·atm^{-1})
(2)	$CO_2(g)\cdot H_2O \Leftrightarrow HCO_3^- + H^+$	($K_2 = 9\cdot 10^{-7}$ M)
(3)	$HCO_3^- \Leftrightarrow CO_3^{2-} + H^+$	($K_3 = 7\cdot 10^{-10}$ M)