Name_____

EVST201a/G&G 140a (2011)
The Atmosphere, Ocean and Environmental Change
First Exam (closed book, calculator allowed)

Useful physical and mathematical constants:

$R = 8314 \ J/kmole \cdot Kelvin$; $\sigma = 5.735 \times 10^{-8} \ Wm^{-2}K^{-4}$; $\pi = 3.14159$ $G = 6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$

Earth parameters:

$R_E = 6371 km$; $a_E = 0.33$; $g = 9.81 \ m/s^2$; $\Gamma = -g/c_p = -9.8°C/km$, Tilt=23.5°

$H_S = R_a T/g \approx 8.4 km$; $S = 1380 \ W/m^2$; $\Omega = 7.27 \times 10^{-5} \ s^{-1}$; $M = 5.974 \times 10^{24} kg$

Properties of air:

$R_{air} = 287 J/kg.C$; $\rho_{air} = 1.2 kg/m^3$; $C_{P_{Air}} = 1004 J/kg°C$

Properties of water:

$\rho_{water} = 1000 kg/m^3$; $\rho_{ice} = 917 kg/m^3$; $\rho_{SEA} = 1025 kg/m^3$

$L_{COND} = 2.5 * 10^6 \ J/kg$; $L_{FREEZE} = 3.34 \times 10^5 \ J/kg$

$C_{P_{Water}} = 4218 J/kg°C$

Useful definitions:

$RH = P/P_{sat}$; $ResTime = C/F$; $\delta D = [\left(\frac{D}{H}\right)/\left(\frac{D}{H}\right)_{REF} - 1] \times 1000$

Useful physical laws and balances:

$gM = PA$; $F_G = \dfrac{GMm}{r^2}$; $p = \rho RT$; $\Delta p = -\rho g \Delta Z$; $Rgas = Runiversal/M$

$V_e = \sqrt{2gR_E}$; $V_m = \sqrt{\dfrac{3RT}{M}}$; $Q = MC_P \Delta T$; $Q = L \Delta m_v$

$R = \sqrt{K \cdot T}$; $R_{plume} = \sqrt{Kx/U}$;

$CF = 2MU\Omega \sin\phi$; $\tau = 0.003 \rho_A U_A^2$;

$F = \sigma T^4$; $\lambda_m T = 2898 microns°K$

$PET(mm/month) \cong 5 \times T(C)$; $P = P_0 e^{-ДH}$; $\rho = \rho_0 e^{-Z/H_S}$

$T = \sqrt[4]{\dfrac{S(1-a)}{4\sigma}}$; $T_{GH} = T/(1-\frac{\varepsilon}{2})^{1/4}$

$A_S = 4\pi R^2$; $V = (4/3)\pi R^3$; $F = S\cos(\varphi)$

$$WaterFlux = \rho_w UA; \quad SaltFlux = S\rho_w UA; \quad HeatFlux = C_p T\rho_w UA$$

$$(\Delta p / L)\, Vol = \rho \times 2 \times \Omega \times \sin\phi \times U \times Vol$$

$$PE = Mgz \; ; \; EFF = \Delta T/T; \; Qout = K\sqrt{Zeff}, P(t) = P(t=0)\exp(\gamma t)$$

$$P_{Wind} = (\tfrac{1}{2})\varepsilon\rho U^3 A, \; P_{Solar} = \varepsilon S\tau_A A\cos(\varphi), P_{HYDRO} = \varepsilon R\rho_W gzA$$

Unit Conversions:

$$ppmv = \frac{M_{AIR}}{M}\, ppmm; \; 1\, mb = 100\, Pascals; \; 0\,°C = 273.1\, K$$

$$1\, knot = 0.54\, m/s; \; 1\, inch = 2.54\, cm; \; °C = \frac{5}{9}(°F - 32) \quad 1\, tonne = 10^3 kg$$

T (°C)	P$_{sat}$ (mb)
-10	2.9
0	6.1
10	12.3
20	23.4
30	42.4

Molecular Weights	
H$_2$	2
N$_2$	28
O$_2$	32
CO$_2$	44
Air	29

1. [10] Using the following data for Venus [radius= 6052 km, dominant gas CO2, surface gravity 8.87 m/s2, surface pressure 9,300,000Pa, typical atmospheric surface temperature 470C], compute the mass of the Venusian atmosphere.

2. [10] If the water vapor density is 0.01kg/m3 and the temperature is 20C, find:
   a. The partial pressure of water vapor

b.   The relative humidity

3. [10] Explain why clouds always form in rising air.

4. [10] Explain the greenhouse effect on earth; in particular
    a.   Why does it warm rather than cool the surface of our planet?

    b.   Which gases contribute and why?

5. [10] A small rocky asteroid between earth and sun has a solar constant of
    $2000W/m2$ and an albedo of 0.5. Predict the temperature of the asteroid. Mention
    your assumptions.

6. [10] Explain why a planet like earth will have lost its light gases over geologic time
    but retained its heavier gases like N2 and O2.

7. [10] Consider a hot summer day with the earth's surface temperature Ts=30C and a
    deep cumulo nimbus cloud with a cloud top temperature of T= -60C.
    a.   Compute the wavelength most profusely emitted by each surface. Which
         band of radiation is it in (UV, VIS, NIR, TIR, Radiowave)?

    b.   Compute the total power emitted from 1 square kilometer of each surface.

8. [10] Ten tonnes of methane gas is suddenly released into the earth's atmosphere from a ruptured tank. There is no wind blowing, but the daytime turbulence induced by solar heating of the surface is large: giving a diffusivity of 50m2/s.
    a. Compute the **distance** (in meters) from the source reached by the spreading "cloud" of methane six hours after the release.

    b. What is the **concentration of methane** in the "cloud"? Express your answer in ppmm.

9. [10] For Earth, the atmospheric density scale height is about 8400m. If the sea level density is 1.2kg/m3, estimate the air density at an altitude of 30 km?

10. [10] Briefly define and describe each term below.
    a. supercooled water

    b. unstable lapse rate

    c. Archimedes Law

    d. tropopause

    e. advection fog