Name_____

EVST201a/G&G 140a (2011)

The Atmosphere, Ocean and Environmental Change

Third Exam

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:

; $R_E = 6371km$; $a_E = 0.33$; $g = 9.81\ m/s^2$, Γ =- g/c_p =- 9.8ºC/km, Tilt=23.5º

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

Properties of air:

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

Properties of water:

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

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

$C_{P_{Water}} = 4218 J/kg^\circ C$

Useful definitions:

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

Useful physical laws and balances:

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

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

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

$CF = 2MU\Omega \sin\phi$; $\tau = 0.003 \rho_A U_A^2$; $U_{EKMAN} = \frac{\tau}{2\rho D\Omega sin\phi}$, $\Delta S = S_0(\frac{-d}{D+d})$

$F = \sigma T^4$; $\lambda_m T = 2898 \text{microns}^\circ K$

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

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

$A_S = 4\pi R^2$; $V = (4/3)\pi R^3$; $F = Scos(\varphi)$; $\Delta T = \frac{Q/A}{\rho D C_P}$, $\Delta S = S_1(\frac{-d}{D+d})$

$$WaterFlux = \rho_W UA; \quad SaltFlux = S\rho_W UA; \quad HeatFlux = C_P T\rho_W UA$$

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

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

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

Unit Conversions:

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

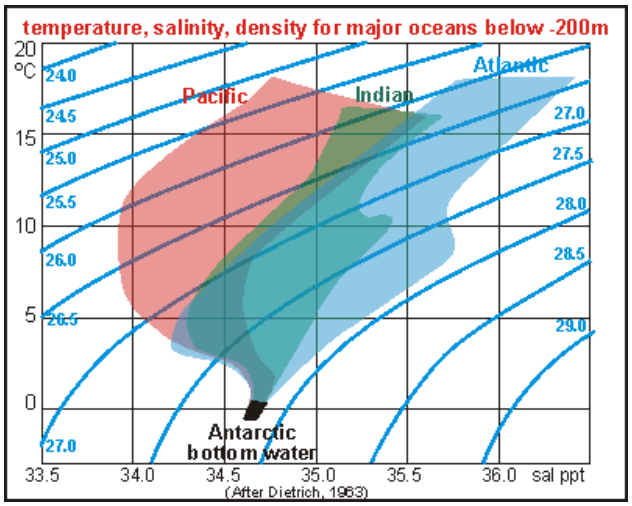
$$1\ knot = 0.54\ m/s;\ 1\ inch = 2.54\ cm;\ {}^{\circ}C = \frac{5}{9}({}^{\circ}F - 32) \quad 1\ tonne = 10^3 kg$$

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] Assuming that the Gulf Stream is in geostrophic balance, answer the following. If the Gulf Stream at 35N latitude is 50km wide, 1km deep and has a pressure difference across it of 4000 Pascal, compute the volumetric flow rate in the current. Express your answer in Sverdrups (i.e. 1SV= one million cubic meters per second)

2. [10] Consider two water masses (A and B) found near each other in the Atlantic Ocean. Mass A has S=36.0ppt and T=16C while Mass B has 35.5 and T=9C.
   a. Determine the density of each water mass
   b. Which water mass will be found higher in the water column?



3. [10] Consider a region of the tropical Atlantic with S=35ppt. A heavy rain adds a half meter of freshwater on the ocean surface and it mixes down to 50 meters. What is the new salinity of the surface waters?

4. [10] In El Nino, the conditions in the eastern tropical Pacific Ocean are:
   a. SST high or low?
   b. Air pressure high or low?
   c. Precipitation high or low?
   d. Biological productivity high or low?
   e. Explain the physical connection between (a) and (d)

5. [10] During the last glacial maximum the conditions were
   a. CO2 in the atmosphere high or low?
   b. Isotopes in fresh snow on Greenland heavy or light?
   c. Oxygen isotopes in new deep sea sediments heavy or light?
   d. Sea level high or low?
   e. Explain the relationship between (c) and (d).

6. [10] In recent centuries, we have the perihelion in January. Explain how the climate would be different if, due to precession, perihelion occurred in June.

7. [10] Explain the difference between sea ice and icebergs emphasizing their origin, thickness and salinity.

8. [10] Compare recent trends in sea ice extent in the Arctic and Southern oceans. Be specific. In what months are they best compared?

9. [10] Estimate the mass of salt in the world ocean (in kg)

10. [10] Define
    a. Antarctic Bottom Water

    b. Terminal moraine

    c. Equatorial upwelling

    d. Mid-ocean ridge

    e. Ekman layer