MIDTERM III, April 30, 2004

Geography 4321/5321, Snow Hydrology

Name and Initials ___________________________________ SS# _________________________

Write only in the designated spaces. This test has 205 total points but you will be graded on 200 possible points. Questions are worth different amounts. **Be explicit about the phase of water in your answers: ice, liquid, gas**.

FILL-IN THE BLANKS.

1. Ablation stakes work by measuring the change in _____________________________ over time (5 points).
2. A nitrate concentration of 12.3 mg/L is equal to ________________ ppm (5 points).
3. An ion with a negative charge is known as a(n) ___________________________ (5 points).
4. The pH is defined as the negative log of the ___________________________ (5 points).
5. The pollutant of major concern in snowfall throughout the Rockies is ________________________ (5 points).
6. Meltwater flow through snow generally occurs in _______________________________ (5 points).
7. The primary equation used to understand meltwater flow through snow is called _________________________________ (5 points).
8. Isotopes of the same element differ in their _______________________________ (5 points).
9. The temperature index method of estimating snowmelt is based on the idea that _______________________________________ provide an index of snowmelt (5 points).

10. 4 primary types of snowmelt models presented in class are:

____ (2.5 points)

____ (2.5 points)

____ (2.5 points)

____ (2.5 points)

11. Three disadvantages of regression snowmelt models are:

____ (3 points)

____ (3 points)

____ (3 points)

12. Define an elution curve (10 points).

13. Draw a typical variogram and label the following components: lag distance, semivariance, range, and sill (10 points).

14. Define the degree day factor in the snowmelt runoff model (10 points). Be sure to include units.

15. What are the advantages of using stable water isotopes in mixing models? (10 points).

16. Explain why mercury loading is often greatest at high elevations and high-latitudes, far from emission sources. 25 points.

17. Compare and contrast energy-balance snowmelt models with empirical models. 25 points.

18. Explain why pollution in snow (snowfall and snowpacks) is often worse than in rain. 50 points.

18. Continue answer here.

HELPFUL CONSTANTS

speed of light	c	2.997×10^{8} m s^{-1}
Planck's (energy in each photon)	h	6.626×10^{-34} J s
Boltzmann's (distribution of energy)	k	1.381×10^{-23} J deg^{-1}
Stefan-Boltzmann	σ	5.670×10^{-8} W m^{-2} deg^{-4}

density of water	1,000	kg m^{-3}
density of ice	917	kg m^{-3}
density of air	1.25	kg m^{-3}
specific heat of water	4.2×10^{3}	J kg^{-1} deg^{-1}
specific heat of ice	1.9×10^{3}	J kg^{-1} deg^{-1}
specific heat of air	1.0×10^{3}	J kg^{-1} deg^{-1}
vol. heat capacity of water	4.2×10^{6}	J m^{-3} deg^{-1}
vol. heat capacity of ice	1.9×10^{6}	J m^{-3} deg^{-1}
vol. heat capacity of air	1.25×10^{3}	J m^{-3} deg^{-1}
latent heat of fusion	3.34×10^{5}	J kg^{-1}
latent heat of vaporization	2.5×10^{6}	J kg^{-1}

HELPFUL EQUATIONS

$$R + G + H + L_v E + \Delta F + \Delta M = 0$$

$$E_\lambda = \frac{2\pi h c^2}{\lambda^5 [\exp(h c / k \lambda T) - 1]} \quad \text{and} \quad \int_0^\infty E_\lambda \, d\lambda = \sigma T^4$$

$$q = mass \times specific\ heat \times temperature\ change$$

$q = mass \times latent\ heat$ (use latent heat of fusion for ice/liquid)

Formulas and Tables

Energy balance equation $R + G + H + LE + \text{Melt} + \Delta F = 0$

runoff equation $Q_n = \text{Melt}_n(1 - K) + \text{Melt}_{n-1}K$

Snow water equivalence = $h \ x \ \dfrac{\rho_{snow}}{\rho_{liquid}}$

Stefan-Boltzmann equation $E_{\text{longwave}} = \varepsilon\sigma T^4$

Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4}$

Psychrometric equation $C_p(T_d - T_w) = -L_v[q_a - q_s(T_w)]$

(solved for humidity) $q_a = q_s(T_w) - \dfrac{C_p}{L_v}(T_d - T_w)$

Hydrostatic equation $\dfrac{P}{P_0} = \left(\dfrac{T_0}{T_0 + \gamma h}\right)^{gm/R\gamma}$

(γ is environmental lapse rate, $R = 8.3$ J/mole/deg is gas constant, $g = 9.8$ m/s^2 is gravitational acceleration, $m = .029$ kg/mole is molecular weight of air)

$$\beta = \frac{H}{LE} = \frac{\rho C_p D_H(\theta_a - \theta_s)}{\rho L_v D_{LE}(q_a - q_s)} = \frac{C_p(T_a - T_s)}{L_v(q_a - q_s)}$$

shear stress$\tau = \rho \ x \ h \ x \ g \ x \sin\theta$

Q = b + SWE(x)

$M = M_f\ (T_a - T_0)$

Q = [(C a T S) + P] A