CE 203 Comprehensive Exam
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1. An air parcel of mass 3 *kg*, temperature 15 ^oC, and mixing ratio 4.0 *g/kg* is lifted from 1000 *mb* to 700 *mb*. Using the pseudoadiabatic chart (attached) in which the constant potential temperature (θ) and constant equivalent potential temperature (θ_e) lines are in ^oK, and the saturation mixing ratio (ω_s) lines are in *g/kg*, find answers for the following questions.

(1). What is the latent heat released when this air parcel is lifted from 1000 *mb* to 700 *mb*? (latent heat of condensation of water vapor = 2.5x10^6 $J\ kg^{-1}$)
(2). What is the equivalent potential temperature in ^oK of this air parcel?
(3). What is the dew-point temperature in ^oC of this air parcel?

2. Consider an agricultural field in which the crop covers 60% of the surface area. Assume that only transpiration occurs from regions covered with vegetation. An irrigation scheme is used to keep the soil moisture level (i.e., volumetric soil moisture content) of the agricultural field to be at 0.3 so that the particular crop can grow healthily. The actual evaporation from moist soil is assumed to be directly proportional to the level of saturation. Assume the porosity of the soil is 0.45. Answer the following questions based on the information given below:

(1). Compute the rate of transpiration from the crop in unit of *cm/day*;
(2). Compute the actual evaporation from the bare soil in unit of *cm/day*;
(3). What is the maximum daily required amount of water (in unit of *cm/day*) needed to irrigate this agricultural field (crop land plus the bare soil area) under the given conditions described in this problem?

Atmospheric pressure = 1000 *mb*, air temperature = 25 ^oC, relative humidity = 0.6, the net energy exchange is 0.0029 $cal \cdot cm^{-2} \cdot sec^{-1}$ for the cropped area, and is 0.0035 $cal \cdot cm^{-2} \cdot sec^{-1}$ for the bare soil, respectively, latent heat of vaporization is $L_e = 597.3 - 0.57T\ \ cal \cdot g^{-1}$ (T in ^oC), psychrometric constant $\gamma = 0.66\ \ mb/^oC$, crop conductance is 2 *cm/sec*, $r_{av} = 1.6\ \ sec/cm$ (assume to be the same over the crops and bare soil), and $c_p = 0.22\ \ cal \cdot g^{-1} \cdot {}^oC^{-1}$, $\rho_m = 1.15 \times 10^{-3}\ \ g \cdot cm^{-3}$, $\rho_w = 1\ g/cm^3$.

Useful equations:

Penman-Monteith Equation:

$$\rho_w L_e E_t = \frac{\Delta(R_n - G) + \rho_m c_p \left[e_{sat}(T_a) - e_a\right]/r_{aH}}{\Delta + \gamma(r_{av} + r_{st})/r_{aH}}$$

$$e_{sat}(T) = 6.11 \cdot \exp\left(\frac{17.3 \cdot T_a}{T_a + 237.3}\right)$$

where e_{sat} is in *mb*, and T_a is air temperature in ^oC.

$$\Delta = \frac{de_{sat}}{dT} = \frac{d\left[6.11 \cdot exp\left(\frac{17.3 \cdot T}{T + 237.3}\right)\right]}{dT} = \frac{25083}{(T + 237.3)^2} \cdot exp\left(\frac{17.3 \cdot T}{T + 237.3}\right)$$

where T is in ^oC, and Δ is in $mb/^oC$.