ANSWER KEY

ESR 320
ENVIRONMENTAL SYSTEMS I
MIDTERM EXAM 1
Fall 2009

Open notes. Partial credit is generously given, so if you are not sure how to do a calculation, try to set it up as best you can and then briefly explain what you think is the way to approach the problem.

Please be <u>neat</u> so that I can understand what you are doing. I give more partial credit when I can follow your work; if it is messy, not so much.

Pay attention to <u>significant digits</u>. A trailing decimal place indicates sig digits on whole numbers that end in zero(es).

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1. A frozen lake has a surface are of 1.5 hectares. The ice at the surface has an average thickness of 25 cm. How many joules of energy does it take to melt all of the ice? (Assume the ice is at 0 deg C and that the resulting melted liquid is also at 0 deg C.) [15 pts]

$A_s = (1.5\ ha)(10^4\ m^2\ ha^{-1}) = 15,000\ m^2$

$h_{ice} = 0.25\ m \qquad V_{ice} = A_s h = (15,000\ m^2)(0.25\ m) = 3,750\ m^3$

$m_{ice} = \rho_{ice} V_{ice}$

ρ_{ice} is slightly less than liquid water but since we did not discuss the exact value in class

use $\rho_{ice} \simeq \rho_{water} = 1.0\ kg/L = 10^6\ g/m^3$ (actually $0.92\ \frac{kg}{L}$ so about 8% error if we ignore)

$m_{ice} = (10^6\ g/m^3)(3,750\ m^3) = 3.8 \times 10^9\ g$

$H_L^{Fusion} = 80\ cal/g$

$Q^{Fusion} = 80\ \frac{cal}{g}(3.8 \times 10^9\ g) = (3.0 \times 10^{11}\ cal)(4.1\ \frac{J}{cal}) =$

$\boxed{1.2 \times 10^{12}\ J}$

(A lot of energy; have to wait until spring time...)

2. A barometer in Timberline Lodge on Mt. Hood (elevation 6000. ft above mean sea level (MSL)) reads 623 mm-Hg. You then drive back to PSU (elevation 125 ft above MSL). Assume that the average temperature at Timberline and at PSU (and everywhere in between) is about 25 deg C, just to keep things simple. [15 pts]

a) What is the atmospheric pressure you would calculate for PSU in mm-Hg

$p_z = p_0 e^{-kz}$

$z = (6000 - 125)\,ft / (3.28\,ft/m) = 1791\,m$

Given p_z, solve for p_0

$p_0 = \frac{p_z}{e^{-kz}} = p_z e^{+kz} = (623\,mm\text{-}Hg)\, e^{(1.14\times10^{-4})(1791)}$

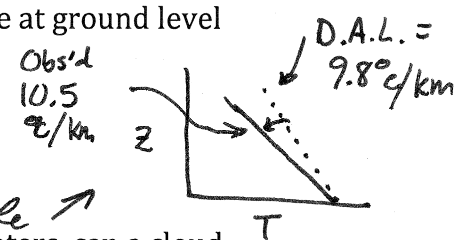
$= 763\,mm\text{-}Hg$

b) What is the calculated pressure in units of atm?

1 atm = 760 mm-Hg

$p = \frac{763}{760} = 1.004\,atm$ (or 1.00 to 3 sig. digits)

3. The lower atmosphere over a large, sunny meadow has an observed temperature lapse rate that is linear at 10.5 deg C/1000 m. The air temperature at ground level is 25 deg C. The relative humidity at ground level is 70%. [15 pts]



a) Is the air above the meadow stable, neutral, or unstable?

Unstable. Ambient temp is always lower than parcel w/ D.A.L. rate, so unstable

b) If the moist air rises off the meadow, at what altitude, in meters, can a cloud start to form?

1. Find Dew pt ⇒ $T_d = T - \frac{100 - RH}{5} = 25° - \frac{100-70}{5}$

$T_d = 19°C$

2. What altitude corresponds to T_d? ($T_z = 19°C$)

$T_z = T_0 - (10.5°C/1000\,m)(z\,km)$

$z = \frac{(T_z - T_0)°C}{-10.5\,°C/km} = \frac{(19-25)°C}{-10.5\,°C/km} = 0.57\,km = 570\,m$

(If you assume parcel rose w/ D.A.L. & not ambient lapse rate then $z = 0.61\,km = 610\,m$)

4. A lake has an *actual* evaporation rate of 0.61 mm/h. Based on the class discussion and notes, what would you expect the *measured* evaporation rate to be (in units of mm/h) in a standard Class A Evaporation Pan mounted in a field near the lake? *Why* is that value different from the lake value? [15 pts]

[If you cannot come up with a number, at least tell me if pan evap is greater, the same, or smaller than lake evaporation, and *why*.]

Class discussion: Pan Rate GREATER than lake because pan in sun heats up more than lake

Evap Lake ≈ 0.8 (Evap Pan) (or Evap Pan ≅ 1.2 Evap Lake)

$= 0.8\,(0.61\ mm\ h^{-1}) = (0.75\ mm\ h^{-1}) = 0.7\ mm\ h^{-1}$ ← If 0.8 is only 1 sig. digit. approximate

5. In the Portland area we expect clouds and rain this week. What type of air lifting is most like responsible for this precipitation? Choose *one* of the *three* major categories we discussed in class/lecture notes. Also state *why* this is the logical answer. [15 pts]

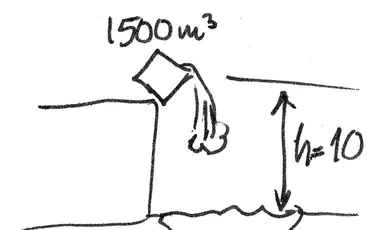
(a/k/a "convergence")

CYCLONIC LIFTING due to low pressure (either frontal or non-frontal)

- Don't expect convective lifting in cool, cloudy weather (need warm, sunny weather to heat the ground
- Orographic lifting not significant over the Willamette Valley except in a few localized hilly areas.

6. A large tank contains 1500. m3 of water and sits on a roof above a small, stagnant pond. You tip over the tank and all the water spills into the pond. After an initial big splash, the pond calms down and is stagnant again. All the water stays in the pond.

a. How much energy (in joules) is transferred to the pond by the falling water?



$$P.E. = \rho g h V = (10^3\ kg\ m^{-3})(1500\ m^3)(9.8\ \tfrac{m}{s^2})(10.\ m)$$

$$= 1.47 \times 10^8\ \frac{kg\ m^2}{s^2} = 1.47 \times 10^8\ J$$

$1.47 \times 10^8\ J$

b. What is the *final* form of the energy: kinetic, thermal, or potential?

Thermal

- Fluid now STAGNANT so no K.E.
- P.E. is always relevant to the "reference level" which in this case is pond level.

7. Match up the following equations (10 pts):

a.	$pV =$	e	$\frac{1}{2} mv^2$
b.	$F =$	c	$Q - W$
c.	$\Delta E =$	d	Fd
d.	$W =$	a	nRT
e.	$KE =$	b	ma