

## Atmo 336 homework 2 solutions

1a: 6 points

Use the lapse rate of  $6.5^{\circ}\text{C}/\text{km}$ .

$T(3000\text{ m}) = 10.5^{\circ}\text{C}$ ,  $T(6000\text{ m}) = -9^{\circ}\text{C}$ ,  $T(9000\text{ m}) = -28.5^{\circ}\text{C}$ .

1b: 6 points

Percentage by weight below a point is 100% minus the ratio of pressure at that point to pressure at zero height.

% below at 3000 m =  $100\% - 700\text{ mbar} / 1000\text{ mbar} = 30\%$ .

% below at 6000 m =  $100\% - 500\text{ mbar} / 1000\text{ mbar} = 50\%$ .

% below at 9000 m =  $100\% - 330\text{ mbar} / 1000\text{ mbar} = 67\%$ .

1c: 8 points

The rate of decrease is not constant because air density is highest at the surface and it decreases as one moves upward. This is due to compression of air by the weight of all the air above it.

2a: 2 points

Local times are -7 hours from Z (zulu) time, which is UTC. Mind the dates!

8 September 00Z is 1700 on 7 September in Tucson

8 September 12Z is 0500 on 8 September in Tucson

2b: 3 points

Figure 2b is 12Z, and 2a is 00Z. Can tell because the local morning (12Z) has a temperature inversion, and has lower surface temperatures than local afternoon (00Z).

2c: 5 points; 0.2 points per table entry

altitude [m]	air temp [ $^{\circ}\text{C}$ ]	dew point [ $^{\circ}\text{C}$ ]	wind direction	wind speed [kt]
10870	-45	-60	SW or S	5
9620	-35	-52	W	10
7550	-20	-33	NW or W	5
5850	-7	-25	N	10
3150	10	6	SW or S	5

2d: 3 points

The cloud is at approximately 3700 to 4700 m, and about  $1^{\circ}\text{C}$ . The cloud exists where the air temp is equal to or less than the dew point on the skew-T.

3a: 6 points

Using the table of mixing ratios, calculate relative humidity as the ratio of the true mixing ratio, which corresponds to air temp, and the saturation mixing ratio, which corresponds to dew point.

time	relative humidity
8 am	$\text{RH} = (7.74\text{ g/kg}) / (18.94\text{ g/kg}) = 40.9\%$
11 am	$\text{RH} = (9.32\text{ g/kg}) / (26.48\text{ g/kg}) = 40.9\%$
2 pm	$\text{RH} = (11.19\text{ g/kg}) / (36.56\text{ g/kg}) = 40.9\%$

3b: 3 points

At 2 pm, the relative humidity is the lowest, and the water vapor content is highest. The mixing ratio is a measure of the water vapor content.

3c: 6 points

RH does not tell you in an absolute sense how much water vapor is in the air, but only how close the air is to being saturated. Even though the absolute water vapor increased during the day, and amount needed for saturation increased, as well.

4: 12 points; 4 per main point

Conduction occurs from the environment into the glass because the temperature of the environment is greater than the glass's temperature.

Condensation occurs because the glass's temperature is less than the dew point of the environment. The condensation releases the latent heat in the condensed dew, enters the glass system.

In both processes, the heat added goes into phase-changing the ice into liquid water, not raising the glass's temperature (until the ice has melted).

5: 12 points

Air temp drops because the rain evaporates on the way down. This evaporation adds water vapor to the air, causing the relative humidity to rise. Thus, rain causes air temp to fall and dew point to rise. When the air temp and dew point meet, the air is now saturated and no more net evaporation takes place, and the temperature becomes stable.

6a: 6 points

Tucson heat index: 97, New Orleans heat index: 100. New Orleans is more stressful since the rate of heat loss from the body is slower in NO than in Tucson.

6b: 8 points

Use the formula  $U = RH * U_s$ . Then use the resulting mixing ratio to get the dew point from the table (use the closest value).

Tucson:  $15\% * 43.22 \text{ g/kg} = 6.48 \text{ g/kg}$ , which corresponds to  $T_d = 45^\circ \text{ F}$ .

New Orleans:  $60\% * 31.16 \text{ g/kg} = 18.70 \text{ g/kg}$ , which corresponds to about  $T_d = 75^\circ \text{ F}$ .

Hence New Orleans has more water vapor because it has a higher mixing ratio and a higher dew point temperature.

7a: 6 points

Fairbanks wind chill: -11, Montana wind chill: -8. Fairbanks is more stressful because the rate of heat loss from the exposed skin is faster than in Montana, due to Fairbanks's lower wind chill.

7b: 8 points

With wet clothing, there is additional heat loss due to evaporation. Montana would probably be more stressful with wet clothing because the rate of evaporation will be faster due to the higher wind speed there.