HW8 Answer Key

ATSC 201 Fall 2024
Chapter 5: A5, A6, A10f, A11f, A14c, A16f, A17f
Chapter 14: A3f, A7f(1), A8f, A11f, A16f, A39f
Total marks: 56.5

HW8 Answer Key

CHAPTER 5

A5)
(2 marks)

Using thermodynamic state of the air parcel given in the previous exercise, plot it on the end-of-chapter large thermo diagram specified by your instructor (tephigram). Use data from A4f) P(kPa) = 90, T(degC) = 20, Td(degC)= 10

See tephigram

Check: Td less than T. Makes sense.
Discussion: The dew-point temperature point on a tephigram also shows us the water-vapour mixing ratio of the air parcel at that height. The temperature point, on the other hand, shows us what the maximum mixing ratio of water vapour the air parcel can hold for that given temperature and pressure.

A6)
(9 marks)

For the plotted point from A5, use a tephigram (not equations) to find the values of:
i) mixing ratio
ii) potential temperature
iii) wet-bulb temperature
iv) wet-bulb potential temperature
v) saturation mixing ratio
vi) LCL
vii) relative humidity
viii) equivalent potential temperature

r = 9 g/kg
θ = 30 °C

Tw =	14	°C
θw =	17	°C
rs =	17	g/kg
LCL =	78	kPa
RH = r/rs =	52.94	%
θe =	55	°C

Check: All values make reasonable sense.
Discussion: The convenience of a tephigram is evident in this problem. We don't need to apply several equations like last HW to get some of the important variables. For example, the LCL would require us to do several steps of computation.

A10f)
(6 marks)

Use the data below as an air-parcel initial state, and plot it on the specified thermo diagram. Assume this air parcel is then lifted to a final height where P = 25kPa. Find the final values of the following variables Td, rs, T, rL and rT:
f) P = 100 kPa, T = 25 degC, Td = 5 degC, (Emagram)

Td =	-65	°C
rs =	0.02	g/kg
T =	-65	°C
rL =	6.98	g/kg
rT =	7	g/kg

Check: Physics ok.
Discussion: As the air parcel is lifted from the surface, its temperature decreases dry adiabatically. Notice that as the parcel is being lifted past saturation, its saturated mixing ratio decreases. The saturated mixing ratio decreases because colder air can hold less water vapour. At temperatures below about -38°C, all hydrometeors are in the form of ice crystals. Therefore, here rL very close to ri.

A11f)
(1.5 marks)

Using the same thermo diagram as specified in exercise A10, find the pressure at the LCL for an air parcel that started with the conditions as specified in that exercise.

LCL =	76	kPa

HW8 Answer Key

Check: Physics ok.
Discussion: Colder air can hold less water vapour, and thus it eventually reaches saturation and cannot hold any more water vapour. As the parcel continues to rise, it gets even colder moist adiabatically. The excess water vapour then condenses into liquid droplets and forms cloud. This begins at the lifting condensation level.

A14c)
(3 marks)

Plot the above sounding on a large thermodynamic diagram from the end of this chapter. Use solid dots (of red color if possible) for the temperature and mark an open circle (blue color if available) for the dew points. Draw a solid (red, if possible) line to connect the temperature dots, starting from the bottom up, and draw a dashed (blue, if possible) line for the dewpoints.
c) Skew-T

see Skew-T

Check: looks reasonable
Discussion: The temperature line shows us the environmental temperature sounding of the atmospheric column. The dew-point temperature line shows us how much moisture is in the atmospheric column. At each level with data, the closer the temperature and dew-point temperature are, the more saturated it is.

A16f)
(3 marks)

Given the sounding from the previous question, suppose that you create an air parcel at the pressure-level (kPa) indicated below, where that parcel has the same initial thermodynamic state as the sounding at that pressure. Then move that parcel up through the environment to the next higher significant level (ie. next lower pressure). What is the value of the buoyant force/mass acting on the parcel at its new level?
f) 50

Given:	Pi =	50 kPa		
	Pf =	45 kPa		
	Tf_env	-15 deg C	258.15	K
	Tf_parcel	-17 deg C	256.15	K

Find:	F/m	?	m/s^2

Use eqn. 5.3b:

$$\frac{F}{m} \approx \frac{T_p - T_e}{T_e} \cdot |g| = g'$$

where |g| = 9.8 m/s^2

F/m= -0.076 m/s^2

Check: Units ok. Physics ok
Discussion: As the air parcel rises dry adiabatically from 50kPa to the next significant level (P=45kPa) we see that the temperature of the parcel is less than that of the environment, hence the parcel has negative buoyancy.

A17f)
(7 marks)

Given the previous sounding data, find NBV and PBV for an air parcel that starts in the middle of the layer indicated below, and for which its initial displacement and subsequent oscillation is contained within that one layer. Use the layer with a bottom pressure-level (kPa) of:
f) 40

Given:	P_bot	40 kPa	
	P_top	30 kPa	
	r_bot	2 g/kg	0.002 g/g
	r_top	0.13 g/kg	0.00013 g/g
	T_bot	-20 °C	253.15 K
	T_top	-25 °C	248.15 K

Find:	Nbv =	?
	Pbv =	?

We will need to use eq 5.4 to find NBV. So we need to find virtual temps and Δz.
eqn 5.4a:

$$N_{BV} = \sqrt{\frac{|g|}{T_v} \cdot \left(\frac{\Delta T_v}{\Delta z} + \Gamma_d\right)}$$

Use eqn. 1.21:

$$T_v = T \cdot [1 + (a \cdot r)]$$

where a= 0.61 g/g

Tv_bot =	253.458843	K	-19.691157	°C
Tv_top =	248.169678	K	-24.980322	°C
ΔTv =	-5.2891647	K	-5.2891647	°C
Tv_avg =	-22.335739	°C	250.814261	K

Use eqn. 1.26a:

$$z_2 - z_1 \approx a \cdot \overline{T_v} \cdot \ln\left(\frac{P_1}{P_2}\right)$$

where a= 29.3 m/K

Δz = 2114.13465 m

now we can use eq 5.4a
where |g| = 9.8 m/s^2
and Γd = 9.8 K/km 0.0098 K/m
(since g is in m/s^2, Δz and Γd need to have m, not km)

NBV = 0.01688669 rad/s

Use eqn 5.5:

$$P_{BV} = \frac{2\pi}{N_{BV}}$$

PBV = 372.07919 s
6.20131984 min

Check: Units ok. Physics ok
Discussion: Since the environmental lapse rate is less than the dry adiabatic lapse rate, this parcel will oscillate between the layers approximately every 6.2 minutes.

CHAPTER 14

A3f)
(6.5 marks)

Given the following prestorm sounding. Plot it on a thermo diagram (use a skew-T). Find the mixedlayer height, tropopause height, LCL, LFC, and EL, for an air parcel rising from the surface. Use a surface (P = 100 kPa) dew-point

temperature (°C) of: **f) 17**

Mixed layer height = 90 kPa or 1 km
Tropopause height = 25 kPa or 9.3 km
LCL = 82 kPa, 1.7 km
LFC = 75 kPa, 2.4 km
EL = 27 kPa, 9 km

Check: Units ok. Physics ok **Discussion:** As expected, the top of the mixed layer is somewhere within the inversion layer of the vertical temperature profile (The inversion layer is between 92 kPa and 88 kPa).

A7f(1)
(4 marks)

For the sounding from exercise A3, find the value of surface-based CAPE, using: **(1) the height (z) tiling method.** **Assume Tv ≈ T. Also, on the plotted sounding, shade or color the CAPE area.**

I will break the area into blocks that are 1km x 5 deg C

Area = # of blocks x area of each block
Area = 12 * (1 km * 5 deg C)
Area = 60 °C km 60000 °C m
(or K m)

Use eqn. 14.3: CAPE = |g|*Total area/ avgTe
where
where |g| = 9.8 m/s^2

av_Te = -15 °C 258.15 K

CAPE = 2277.7455 J/kg

Check: Units ok. Physics ok
Discussion: Surface based CAPE indicates the amount of available potential energy for the thunderstorm to grow if the air parcel from the surface reaches and goes beyond the level of free convection.

A8)
(4 marks)

Start with the sounding from exercise A3. Assume that the forecast high temperature for the day is 2°C warmer than the surface temperature from the sounding. Find the value of surface-based CAPE. Assume Tv ≈ T.

I will again break the area into blocks that are 1km x 5 deg C

Area = # of blocks x area of each block
Area = 15 * (1 km * 5 deg C)

Area =	75	°C km	75000	°C m (or K m)

Use eqn. 14.3: CAPE = |g|*Total area/ avgTe
where

where |g| =	9.8	m/s^2		
av_Te =	-15	°C	258.15	K

CAPE = 2847.18187 J/kg

Check: Units ok. Physics ok
Discussion: We see that with a greater surface temperature, the CAPE for the sounding increases. This explains why many convective thunderstorms occur in the late afternoon when surface heating in the daytime allows the surface temperature to reach its maximum.

A11f)
(3.5 marks)

Forecast the thunderstorm and/or tornado intensity, and indicate the uncertainty (i.e., the range of possible storm intensities) in this forecast, given a ML CAPE (J·kg–1) value of:
f) 2250

MLCAPE = 2250 J/kg

Find: Thunderstorm/tornado intensity and uncertainty

From Table 14-1, a MLCAPE of 2250 indicates a moderately unstable atmosphere, therefore a **moderate thunderstorm is likely and severe is possible**.

From Figure 14.42, a MLCAPE of 2250 J/kg usually corresponds to a Category 5 storm. It is **likely that a supercell will form, possible that a significant tornado will form**.
The shading in Figure 14.42 indicates that the **range of possible storms is from Category 1 all the way to Category 5.**

Discussion: There is a huge amount of uncertainty in this method, as can be seen with the dark shadings in Fig 14.42. This speaks to the difficulty of trying to forecast thunderstorms as well as the uncertainty that all these averaging methods bring.

A16f) (3.5 marks)

Estimate the max likely updraft speed in a thunderstorm, given a SB CAPE (J·kg–1) value of: f) 2250

Given: SB CAPE = 2250 J/kg
Find ω_max= ? m/s

use eqn. 14.7:

$$w_{max} = \sqrt{2 \cdot CAPE}$$

ω_max= 67.08 m/s

Use eqn. 14.8:

$$w_{max\ likely} \approx w_{max} / 2$$

ω_max_likely = 33.5410197 m/s

Check: Units ok. Physics ok.

Discussion: This is a fairly large updraft speed and could indicate violent updrafts.

A39f)
(3.5 marks)

What value of the Bulk Richardson Number, BRN-Shear, ML CAPE, MU CAPE, CIN, Energy Helicity Index, Lifting Condensation Level, Supercell Composite Parameter, 0-6 km Shear, Storm-Relative Helicity, effective Storm-Relative Helicity, and Significant Tornado Parameter would you anticipate for the following intensity of thunderstorm (CB)? f) supercell with EF2 - EF5 tornado

From Table 14-7:

BRN =	30		
BRN Shear =	70	m^2/s^2	
CAPE ML =	2152	J/kg	
CAPE MU =	2850	J/kg	
CIN =	12		(N/A is also correct)
EHI =	2.1		
LCL =	1	km	
SCP =	11.1		
0-6km Shear	24	m/s	
SRH =	231	m^2/s^2	
effective SRH =	239	m^2/s^2	
STP =	2.7		

Discussion: The different stability indices help forecasters to predict the likelihood of thunderstorm and tornadic activity. These values are approximate and provide only a rough guide.