GEF2200 Atmosfærefysikk

Gamle midtveiseksamener

A.21.T
Midterm 2004 – 2 (thermodynamics)
A radio sonde has the following reading:

p(hPa)	1000	900	700	550	500	300
T(°C)	12	11	-2	-15	-17	-35

Draw the the temperature curve on a pseudoadiabatic chart and answer the following questions:

– a –
Examine the stability of each layer.

– b –
Define the lifting condensation level (LCL) and determine its value for an air parcel at 900hPa with dew point temperature $T_d = 5°$C.

– c –
This column of air is heated from below, so that a well mixed layer developes (constant mixing ratio). After a while condensation occurs at 850hPa. What is then the temperature and dew point at 1000hPa?

– d –
What kinds of clouds can we expect to form, and at what level can we expect the cloud tops to be?

– e –
Potential density D is defined as the density dry air with pressure p and density ϱ would have if it is moved adiabatically to 1000hPa.

Show by using the First law of thermodynamics or the equation for potential temperature that

$$D = \varrho \left(\frac{p_0}{p}\right)^{c_v/c_p} \tag{1}$$

where $p_0 = 1000$hPa, and c_v and c_p are the specific heats of the air at constant volume and pressure, respectively.

– f –
How is the stability of the air if

$$\frac{\partial D}{\partial z} < 0 \tag{2}$$

Explain your answer.

A.22.T
Midterm 2005 – thermodynamics
Given the following values from a radio sonde

	P (hPa)	T (°C)	T_d (°C)
A	1000	20	16
B	930	16	16
C	850	10	10
D	770	6	-2
E	700	5	-8
F	500	-20	-30

– 1 –
We assume dry air. Which statement is correct?
a. Layer CD is unstable
b. Layer BC is neutral
c. Layer CD is neutral
d. Layer BC is stable
e. Layer AB is unstable

– 2 –
Considering the moisture, which statement is correct?
a. Layer CD is unstable
b. Layer BC is unstable
c. Layer BC is neutral
d. Layer BC is stable

e. Layer AB is unstable

– 3 –
What is the lifting condensation level (LCL) for point A?

– 4 –
What is the level of free convection (LFC) for point A?

– 5 –
The mixing ratio w for point B and C is found on the pseudoadiabatic chart, given in g/kg. Virtual temperature is given by

$$T_v = T(1 + 0.61w) \tag{3}$$

where w is given in kg/kg. What is T_v for point B and C?

– 6 –
If a quantity is unchanged during a transformation, it is *conserved*. Looking at an adiabatic transformation (lifting/lowering) of unsaturated air, where tha air stays unsaturated, which pairs of quantities are conserved?
a. Temperature and mixing ratio
b. Potential temperature and mixing ratio
c. Saturation mixing ratio and potential temperature
d. Dew-point temperature and equivalent potential temperature
e. Equivalent potential temperature and saturated mixing ratio

– 7 –
And which pair of quantities are conserved for saturated air?
a. Temperature and mixing ratio
b. Potential temperature and mixing ratio
c. Saturation mixing ratio and potential temperature
d. Dew-point temperature and equivalent potential temperature
e. Equivalent potential temperature and potential wet-bulb temperature

– 8 –
Looking at a new air parcel between the heights Z_1 and Z_2, where the pressure is $p_1 = 930$hPa and $p_2 = 850$hPa, respectively. In the layer

we have a mean temperature $\overline{T} = 16°\mathrm{C}$, and mean mixing ratio $\overline{w} = 10.8$g/kg. Assume equation (3) applies for the mean values.
The layer thickness between the pressure levels p_1 and p_2 is given by the hypsometric equation:

$$Z_2 - Z_1 = \frac{R_d \overline{T_v}}{g} \ln\left(\frac{p_1}{p_2}\right) \qquad (4)$$

where Z is the height of the level in metres, $R_d = 287$J/kgK, $g = 9.81$m/s^2 and $\overline{T_v}$ is the mean virtual temperature.

How much will the layer thickness increase due to the moisture given ($\overline{w}$)?

A.28.B

Midterm 2006 – 1

– a –

Define the boundary layer.

– b –

Describe a typical diurnal variation of the boundary layer over land, and explain what causes this variation.

– c–

What is the most important transport process in the boundary layer?

A.29.T

Midterm 2006 – 2

– a –

Define the stability criteria for dry air.

– b –

Define the stability criteria for moist air.

We have the sounding given in Table 1 plotted on the pseudoadiabatic chart. For the dew-point temperatures, the levels are marked with primes, A' to I'.

– c –

Level	A	B	C	D	E	F	G	H	I
p(hPa)	1000	950	900	850	700	580	500	470	350
T(°C)	12	10	8	8	-2	-15	-17	-18	-35
T_d(°C)	10	10	8	1.5	-14	-27	-34	-37	-50

Table 1: A sounding of temperature and dew-point temperature.

Is the layer BC stable? Why or why not?

– d –
What do we mean when we say an air parcel is convectively unstable? Are any of the points B, C or D convectively unstable?

– e –
For point D, what is

- the mixing ratio of water vapor
- the relative humidity
- lifting condensation level (LCL)

– f –
For point E we have mixing ratio w = 1.75g/kg. What is the specific humidity (mass fraction of water vapor in the air parcel)?

– g –
The mean virtual temperature in the layer EG can be approximated by the mean temperature in the layer. Use this approximation to calculate the thickness of the layer EG (geopotential thickness).

– h –
The first law of thermodynamics states that

$$dq = c_p dT - \alpha dp \tag{5}$$

Define the parameters.

Will the temperature increase or decrease for an adiabatic compression?

Two identical air parcels at temperature 8°C and pressure 850hPa are compressed, one adiabatically, the other isothermally. Use equation (5) or the sonde diagram to find the difference in temperature after 30hPa compression.
(c_p = 1004J/kgK, R = 287J/kgK)

A.43.C
Midterm 2004 – 1
About droplet growth in warm clouds.

– a –
For heterogeneous nucleation, which physical processes are described by the equations

$$r\frac{dr}{dt} = G_l S \tag{6}$$

and

$$\frac{dr_1}{dt} = v_1 \frac{w_l E}{4\varrho_l} \tag{7}$$

Explain the efficiencies of these two processes as a function of droplet size, where $v_1 = kr_1, k = \text{const}$.

– b –
Given equation (7), let $w_l = 2 \cdot 10^{-4}$kgm^{-3}, $v_1 = 3 \cdot 10^3$s$^{-1}r_1$, $E = 0.8$ and $\varrho_l = 1 \cdot 10^3$kgm^{-3}.

Starting with a large cloud droplet of radius 100μm, how long will it take to form a typical rain drop (radius 1mm) by this process?