Review Problems

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Conservation of energy:

$$c_p dT + L dw = 0.$$

Solve for temperature change:

$$dT = -\frac{L}{c_p} dw.$$

What is dw (change of water vapor mixing ratio)?

$$dw = \frac{M_{\text{vapor}}}{M_{\text{air}}} = \frac{5 \text{ g}}{2 \text{ kg}} = 2.5 \times 10^{-3}$$

. Then

$$dT = -\frac{L}{c_p} dw = \frac{2.5 \times 10^6 \text{J/kg}}{1004 \text{ J/(kg K)}} 2.5 \times 10^{-3} = 6.25 \text{ K}$$

5. (12 points) Rain falls into subsaturated air and eventually isobarically saturates and cools the air due to evaporation. The initial air temperature is $T = 40°$ C, the initial dewpoint temperature is $T_d = 13.8°$ C, and the pressure is $p = 1000$ mb.

(a) What is the air temperature after it is saturated and cooled?

(b) What is the water vapor mixing ratio after the air is saturated and cooled?

(c) How much rain water per unit mass of air evaporates to saturate and cool the air?

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(a) What is the air temperature after it is saturated and cooled?

22 C

(b) What is the water vapor mixing ratio after the air is saturated and cooled?

16.8 g/kg

(c) How much rain water per unit mass of air evaporates to saturate and cool the air?

16.8 - 9.8 = 7 g/kg

11. What is the LCL for air with $T = 28^\circ$ C and $T_d = 9^\circ$ C at $p = 900$ hPa?

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680 mb

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12. How much water vapor condenses as the parcel described in the previous problem ascends to 590 mb?

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2 g/kg

11. What is the LCL for air with $T = 28^\circ$ C and $T_d = 9^\circ$ C at $p = 900$ hPa?

12. How much water vapor condenses as the parcel described in the previous problem ascends to 500 mb?

13. If half of the condensed water falls out of the ascending parcel described in the previous problem, and the parcel then descends, what is the SEL (Sinking Evaporation Level)? What is T at 800 mb after descent? What is T_d at 800 mb after descent?

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SEL=640 mb, T(800) = 21 C, Td(800) = 5 C

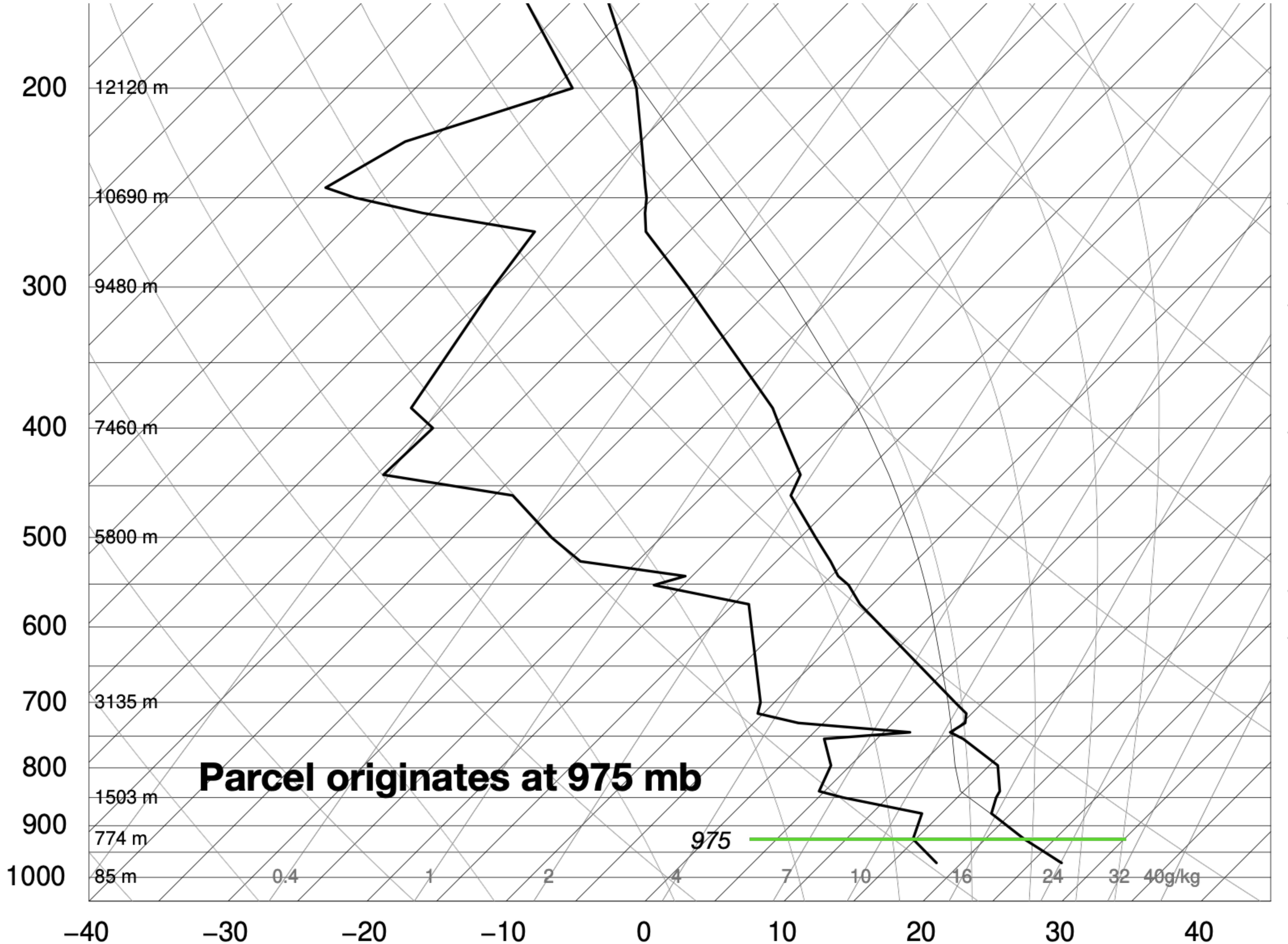
14. (6 points) The temperature and dewpoint values measured by a radiosonde are plotted on the accompanying skew T-log p diagram.

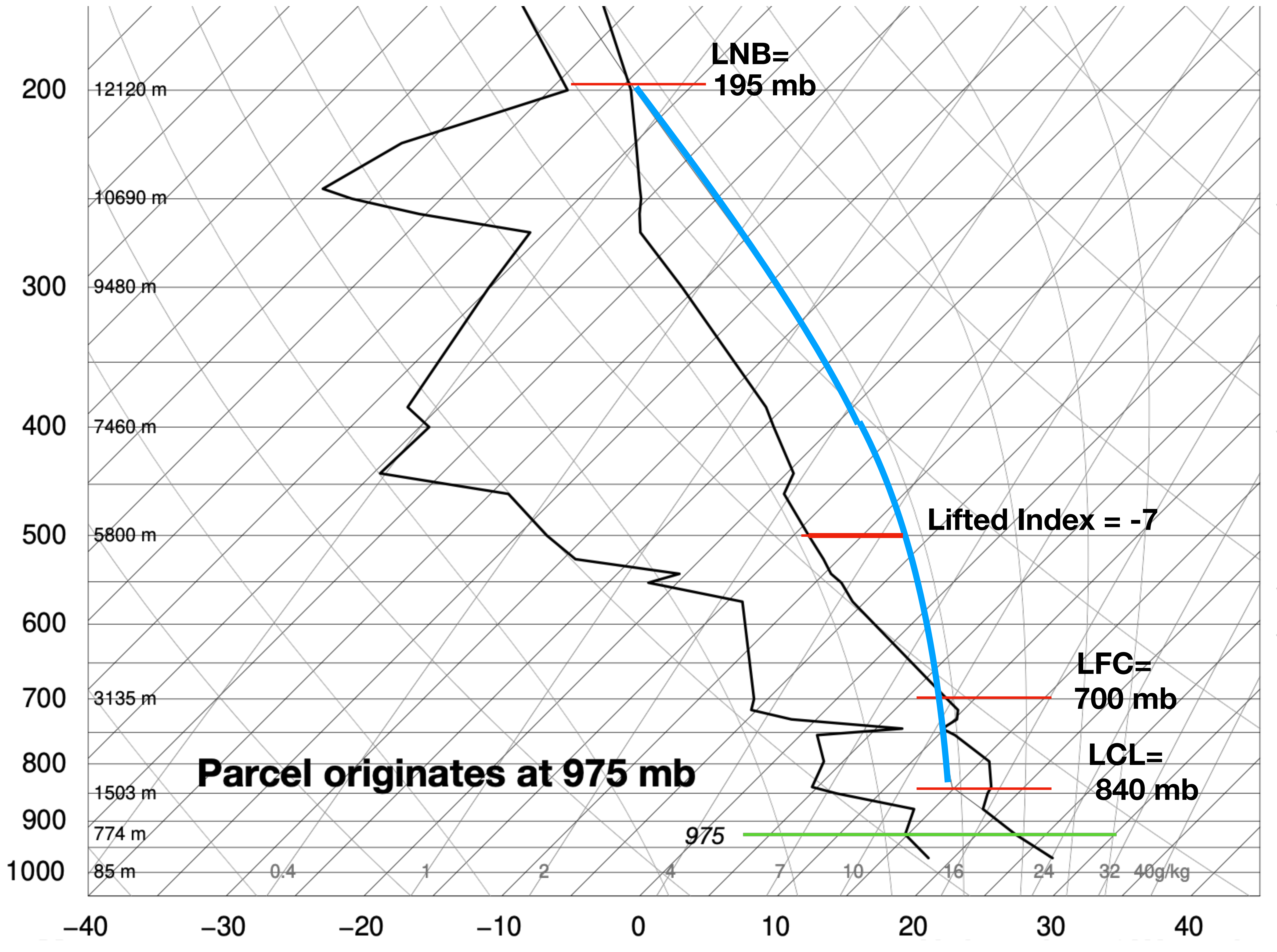
(a) A parcel ascends adiabatically from $p =$ **975** mb, where its temperature and dewpoint are the same as those measured by the radiosonde, to 100 mb. Plot the parcel's temperature on the skew T-log p diagram.

(b) Indicate the parcel's LCL (lifting condensation level), LFC (level of free convection), and LNB (level of neutral buoyancy) on the skew T-log p diagram. *Label each level with its corresponding pressure.*

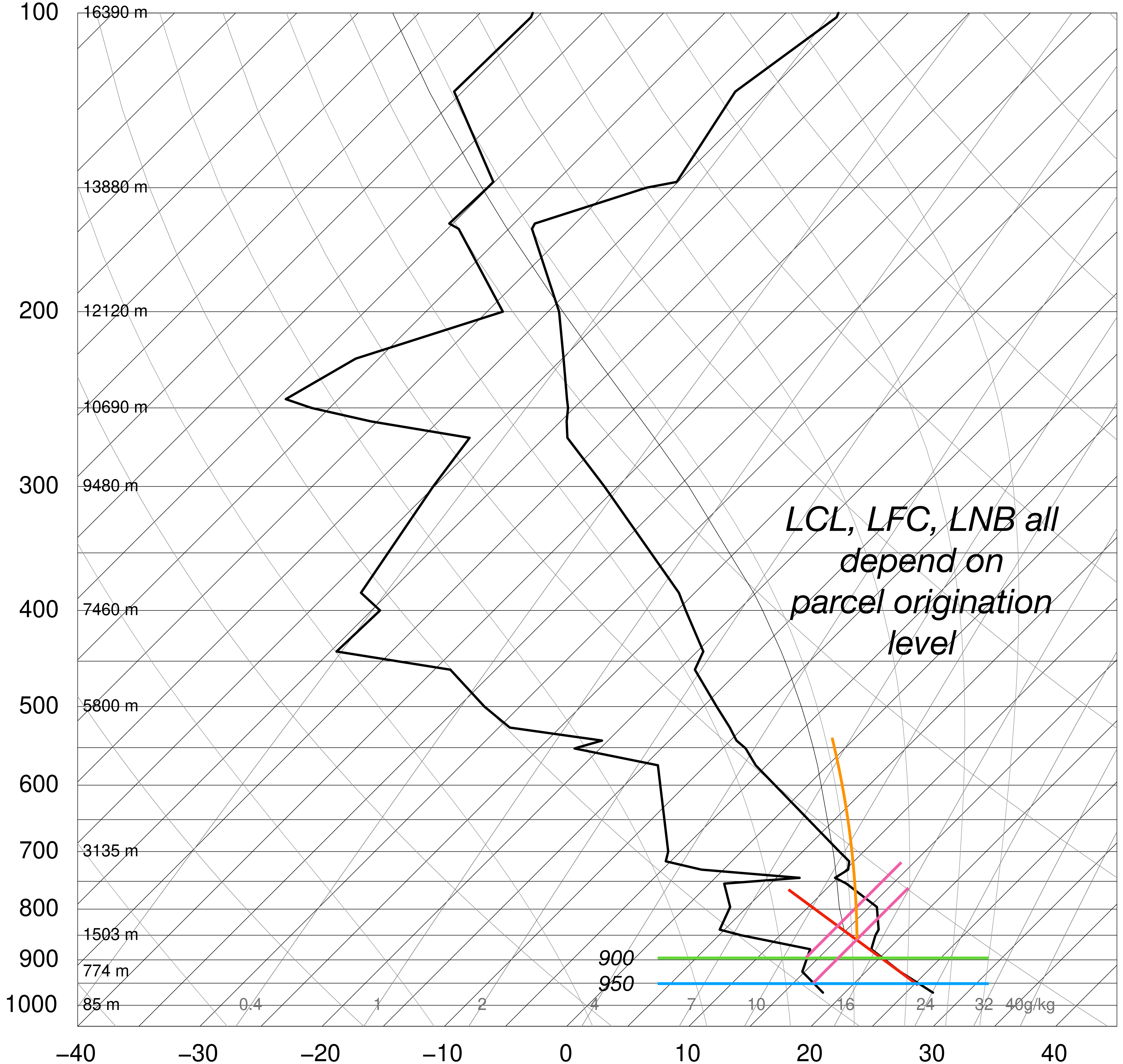
(c) Indicate the Negative Area (NA) and Positive Area (PA) on the skew T-log p diagram.

(d) What is the Lifted Index for this parcel?


200
300
400
500
600
700
800
900
1000
12120 m
10690 m
9480 m
7460 m
5800 m
3135 m
1503 m
774 m
85 m
Parcel originates at 975 mb
975
0.4
1
2
4
7
10
16
24
32
40g/kg
−40
−30
−20
−10
0
10
20
30
40



LNB=
195 mb
Lifted Index = -7
LFC=
700 mb
LCL=
840 mb
Parcel originates at 975 mb
975
200
300
400
500
600
700
800
900
1000
12120 m
10690 m
9480 m
7460 m
5800 m
3135 m
1503 m
774 m
85 m
0.4
1
2
4
7
10
16
24
32
40g/kg
−40
−30
−20
−10
0
10
20
30
40



LCL, LFC, LNB all depend on parcel origination level
900
950
100
200
300
400
500
600
700
800
900
1000
16390 m
13880 m
12120 m
10690 m
9480 m
7460 m
5800 m
3135 m
1503 m
774 m
85 m
0.4
1
2
4
7
10
16
24
32
40g/kg
–40
–30
–20
–10
0
10
20
30
40

24. Dry microbursts occur due to evaporative cooling of air, followed by dry adiabatic descent. If the parcel temperature is equal to the environment temperature, -2° C at $p = 540$ mb, and the parcel cools due to evaporation of 2 g/kg of rain as it descends saturated from 540 to its SEL, and the surface pressure is 800 mb, what is the descending parcel's SEL pressure, DCAPE (downdraft CAPE), and maximum possible downdraft speed?

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Needed for DCAPE:
p_LCL - given
p_SEL = 620 mb
p_sfc - given
dT = 5 K

DCAPE (J/kg) = 465
downdraft speed at surface (m/s) = 30.5

Note that dT estimates from skew-T can vary from person to person.

4. (20 points) (a) A parcel ascends adiabatically from 1000 mb, where $T = 32^\circ$ C K and mixing ratio = 12 g kg^{-1} [redacted] For this parcel, use the skew-T log p diagram to determine the:

saturation pressure* (p_s)	
saturation temperature* (T_s)	
[redacted]	
equivalent potential temperature (θ_e)	
wet-bulb potential temperature (θ_w)	

* at LCL

4. (20 points) (a) A parcel ascends adiabatically from 1000 mb, where $T = 32^\circ$ C K and mixing ratio = 12 g kg^{-1} [redacted] For this parcel, use the skew-T log p diagram to determine the:

saturation pressure* (p_s)	**800 mb**
saturation temperature* (T_s)	**13 C**
[redacted]	
equivalent potential temperature (θ_e)	**68 C**
wet-bulb potential temperature (θ_w)	**21.5 C**

* at LCL

Need LCL p and T (i.e., location on skew-T)

18. For p = 900 mb, T =15° C, and T_d=5° C, use the skew-T log p chart to determine mixing ratio (w), relative humidity (RH), and wet-bulb temperature (T_w).

19. For $p = 1000$ mb, $T = 21^\circ$ C, and w=5 g kg^{-1}, use the skew-T log p chart to determine dewpoint temperature (T_d) and relative humidity.

20. If $T = 10°$ C and RH $= 50$ percent at $p = 800$ hPa, determine T_d using a skew-T log p chart.