San Francisco State University Name ________________________
Department of Earth & Climate Sciences Spring 2018

ERTH 260: Physical Processes of the Atmosphere

Lab 2: Quantitative and Conceptual Problem Solving
100 Points

Due Friday 9 Feb 2018; Last Day to Work on in Class Wednesday 7 Feb 2018

A. Numerical Problems

For questions 1 through 4, use the methodology summarized in Appendix A of Stull and in the assigned summary sheet on Structured Problem Solving discussed in class.

Provide the answers to the following, showing all steps, on separate sheets.

1. It is observed that the updrafts in supercell thunderstorms, such as the thunderstorm that produced the Joplin tornado, are on the order of 40 m s^{-1}. Convert this to mph. (10 pts)

2. Convert 5.5^{o}F to its Centigrade equivalent.(10 pts)

3. Convert -40^{o}C to its Fahrenheit equivalent.(10 pts)

4. It is observed that when small groups of air molecules, collectively called "air parcels", are lofted relative to surrounding quiescent air (that is not moving up or down) that these air parcels cool at a rate of around 5.5^{o}F for every 1000 feet they rise if water vapor is not condensing. This rate (5.5^{o}F/1000 ft or 5.5^{o}F (1000 ft)$^{-1}$ is called the "dry adiabatic lapse rate." Convert the dry adiabatic lapse rate to its metric equivalent (15 pts) (Answer units: ^{o}C/100m)

B. Thought Problems

Provide the answers to the following questions. No calculations are needed.

5. We will be learning about a powerful "basic" law of nature that is directly used in the computer modeling of the atmosphere. It is known by various

names, but we will call it the Ideal Gas Law. It is written somewhat incorrectly below for simplicity's sake:

$$p = \rho R T$$

where p is pressure, **R is a constant** (just consider it a number that never changes), T is temperature, and rho (the greek symbol just to the right of the equals sign) is density.

You can think of pressure as a measure of the weight of the atmosphere, density as a measure of how close the air molecules are together, and temperature a measure of the vibrational activity of the molecules (which humans refer to as temperature).

(a) Why is the following statement wrong unless you make an important assumption?

"...the warmer the temperature, the higher the pressure..."(10 pts)

(b) At sealevel, the average density of the atmosphere is around 1.225 kg m^{-3}. This can be considered a constant at sealevel, even though there are small variations depending on certain meteorological situations.

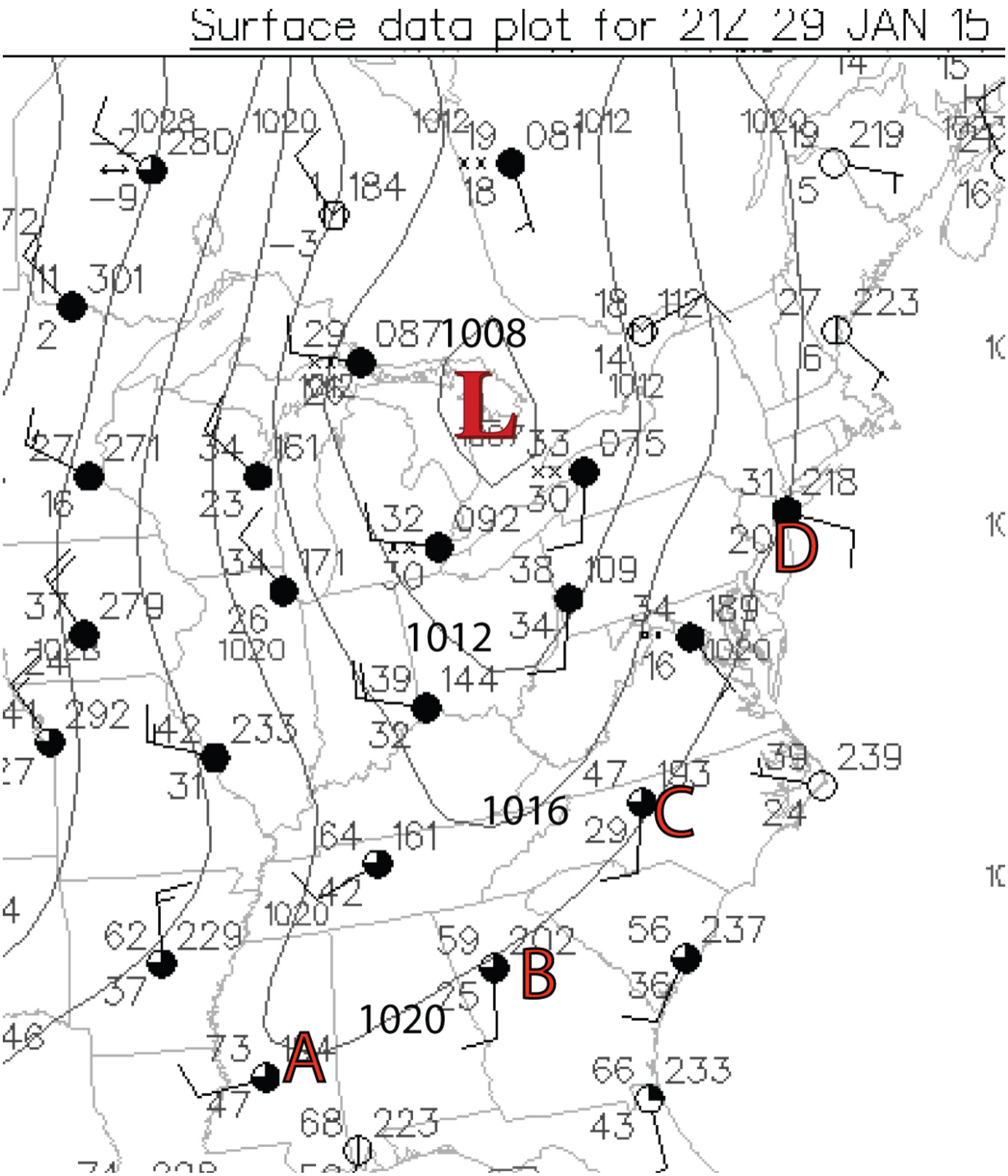
Given that information is the following statement true *"...the higher the pressure the lower the temperature..."*

Please say why, given the constraints of the problem.(10 pts)

(c) Algebraically solve the Ideal Gas Law above for temperature.

Show all steps. In essence you are simply rewriting the Ideal Gas Law.(15 pts)

6. Here's a surface weather map.



The solid lines connect locations that experience the same atmospheric pressure. The isobars are labeled in whole numbers. You already know how to decode the temperature information. Although no calculations are part of this, just be aware that the Ideal Gas Law requires that the temperatures be in the Kelvin or Absolute scale. For this question, you don't need to worry about that.

Now note that weather stations A, B, C, and D are roughly on the isobar labeled 1020. No calculations are needed to answer the following question. To answer it, do not assume that the density is constant, even though scale analysis shows that density roughly is constant at sea level at the scale of weather maps.

Question: Assuming that air density is only determined by the Ideal Gas Law the conceptual treatment of which is given above, use the equation as written in your answer for 5 (c) above to decide which of the weather stations above given as A, B, C, or D, has the air that is most dense.

Please explain carefully in a paragraph or two. (20 pts)