1. Of the following city pairs, circle the city that likely has a colder/cooler winter (on average) and then give a plausible reason for the difference. You may have to do a little research with your atlas or the internet. For a very good source of maps try: http://www.lib.utexas.edu/maps/united_states.html#usa. Consider the role of large water bodies, prevailing winds and how the temperature of the atmosphere changes with height.


   c. Crescent City, California or Boston, Massachusetts? Why? [1]


   e. Santa Fe, New Mexico or Oklahoma City, Oklahoma? Why? [1]

2. Absorption and Emission of Electromagnetic Radiation

   a. As objects increase in temperature:

      i. What happens to the (kinetic) energy of the molecules? [1]

      ii. What happens to the wavelength of the emitted radiation? [1]
b. We can see the earth from a spacecraft, but we learned in class that the radiation emitted by the earth is invisible to our eyes. Explain this apparent paradox. [1]

c. In what range of wavelengths would a sunscreen have to absorb in order for it to be effective? Give the approximate wavelength range in micrometers (µm) and the description of this range (ie. visible, IR, etc.) [2]

3. Indicate the dates of the following observations for Seattle, Washington (note that question ‘E’ does not refer to a Seattle observation):

a. The longest day (most daylight hours). [1]

b. The longest night (most hours of darkness). [1]

c. Equal hours of day and night. [1]

d. The day(s) would Seattle receive the most energy from the sun (assuming clear skies)? [1]

e. Assuming clear skies, for a location on the equator, what day(s) would receive the most energy from the sun? [1]
4. **Radiative balance.**

   a. What region(s) of the electromagnetic spectrum do the following encompass? Give an approximate wavelength range(s) in μm as well as the description (ie. visible, IR, etc.).

   i. Incoming solar radiation [1]

   ii. Outgoing terrestrial radiation [1]

   b. Explain what would happen to the air temperature on earth if there were no atmosphere, and why. [2]

   c. Explain what would happen to the air temperature on earth if the earth’s atmosphere were composed solely of very high concentrations of methane and carbon dioxide (CO₂). [1]

5. **Seasons and Latitudes.**

   a. Despite the long day length, explain why the North Pole is much colder in the summer than latitudes further south. Give three reasons: one involving heat capacity, another involving latent heat, and another involving albedo. [3]

   b. Would the temperature difference between summer and winter in Seattle be larger, smaller, or unchanged if the tilt of the earth were reduced from 23.5° to 10°? Briefly explain. [2]