Except for questions 21, 25, 28 and 30–32 marks/answers on these sheets are not graded.

Answer *TRUE* or *FALSE* (<u>not</u> *T* or *F*) (2 pts each)

1. Doppler effect: Stopped in the station the train's whistle sounds an A (440 Hz), but after it has passed me at high speed at a railroad crossing it sounds an $A^{\flat}$ (415 Hz).
2. Since an ice skater spins faster and faster as she draws her arms in close to her body, her angular momentum is increasing.
3. For sound: higher pitch means longer wavelength.
4. Longer wavelength means bigger frequency.
5. A microwave photon carries more energy than a ultraviolet photon.
6. *Temperature* is a measure of the kinetic energy of the constituent particles (e.g., atoms).
7. The Sun produces an emission spectra.
8. Visible light moves faster through space than radio light.
9. Every object is incandescent, but the light emitted may not be visible to people.
10. In a refracting telescope, the objective is a lens.
11. The main reason for building bigger telescopes is to achieve greater magnification.
12. The slight blurring of telescopic images due to turbulence in the atmosphere limits the resolution of large Earth-based optical telescopes.
13. Parcels of air don't fall for the same reason airplanes don't fall: the air pressure force pushing up on the bottom of the parcel/plane is equal to the air pressure force pushing down on the top of the parcel/plane plus the weight.
14. When the TV meteorologist says a high pressure system has moved into Minnesota, it simply means that the mass of air directly over our heads has increased.
15. If the *optical depth* (τ) is large a photon is likely to bounce around a bit before escaping.
16. Homo-nuclear diatomic molecules like O_2 do not contribute to the greenhouse effect.

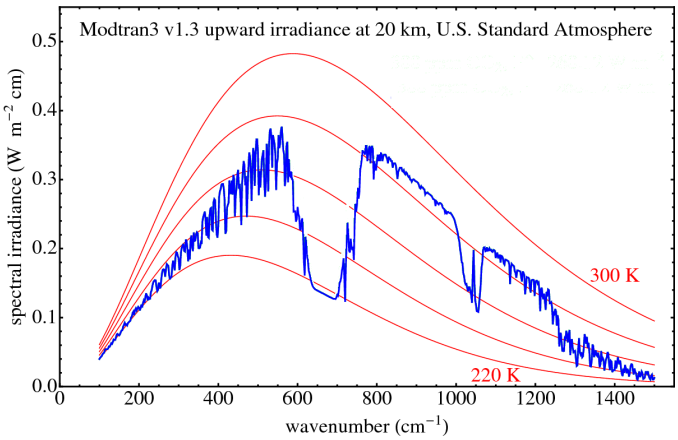
Give a short explanation (5 pts each)

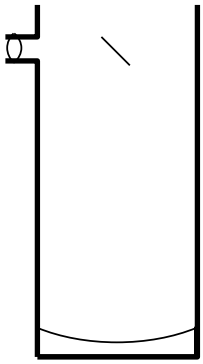
17. Order the following list of types of light from shortest to longest wavelength: X-rays, microwaves, blue, red, AM radio, and infrared.

18. Generally speaking, long-wavelength light is less dangerous than short-wavelength light. Describe why short-wavelength photons can cause more damage than long-wavelength photons.

19. In class you viewed the spectra produced by normal incandescent bulbs (Edison type), Reveal bulbs, and the fluorescent tubes currently illuminating this classroom. Describe (i.e., don't just name) each of the three spectra! What did they look like through the spectroscope?

20. The below left shows the spectra of Earth-light as viewed from space. (The smooth curves show various blackbody approximations to the curve.) What sort of spectra is it? What exactly is producing the feature between 600 and 700 wavenumbers?





21. Find above right a sketch a Newtonian reflecting telescope. Using the provided ruler measure and report the numerical values (in cm) of the following: aperture, focal length, and f number. Draw an arrow directly on the diagram showing the direction to the stars.

22. Consider two famous old telescopes: the "great refractor" at Yerkes Observatory in Williams Bay WI and the Hale telescope on top of Mt. Palomar (5600 feet up and 60 miles northeast of San Diego, CA). The great refractor is a f/19, 40 inch telescope on the shores of Lake Geneva. The Hale has a 200 inch mirror and may be configured as a f/3.3 Newtonian. Which telescope should you use to photograph dim objects? Which telescope shows the finest details? Which telescope produces the most "magnified" images?

23. Compared with an optical telescope with the same diameter, a radio telescope will produce much fuzzier images. Why? How can the resolution of radio telescopes be improved?

24. List the terrestrial planets. List the gas giant planets. Select an extensive planetary property and report how this quantity differs between/among the jovian and terrestrial planets. Select an intensive planetary property and report how this quantity differs between/among the jovian and terrestrial planets.

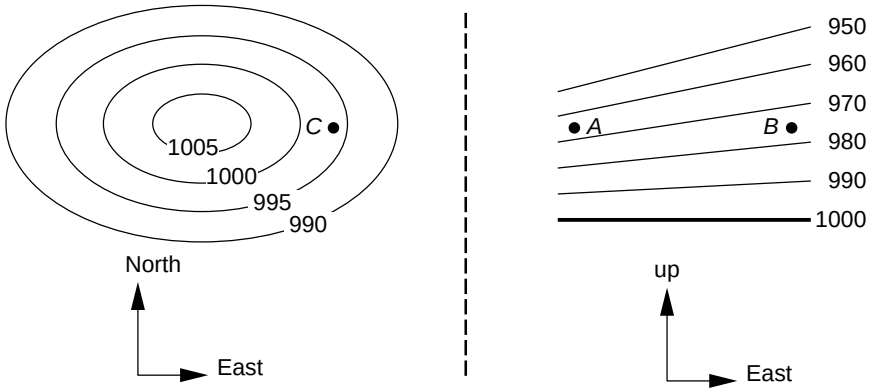
25. Three factors that control whether a particular molecule is retained or lost from a planet's atmosphere are the planet's _____, the atmosphere's _____ and the molecule's _____. Report these factors, and state how each factor would need to change to make it *more* likely that the particular molecule is *retained*.

26. Define and give an example of two of the following three methods of heat transfer: conduction, convection, radiation.

27. For a convective atmosphere the adiabatic lapse rate ($\Delta T/\Delta z$) is fixed by the planets gravity and the average mass of the atoms making up the atmosphere. For a radiative atmosphere the temperature depends on the optical depth τ. Pick either type of atmosphere and explain **why** increasing the amount of CO_2 in the atmosphere results in a higher surface temperature, even if the effective temperature (i.e., the equation in question 29) remains constant.

28. Consider the below left "bull's eye" diagram which shows a set of surface isobars in the Earth's northern hemisphere. The numbers are the pressure in hPascal. Draw an arrow at C (on this sheet) showing which way the wind would blow.

    Consider the below right diagram which shows a *vertical* cut through the Earth's atmosphere. Points A and B are at exactly the same altitude above the ground (the ground is at the 1000-level isobar). Of the two points (A and B), which is at the lower *temperature*? Which way (into this page or out of this page) will the wind end up blowing in the region between A and B?



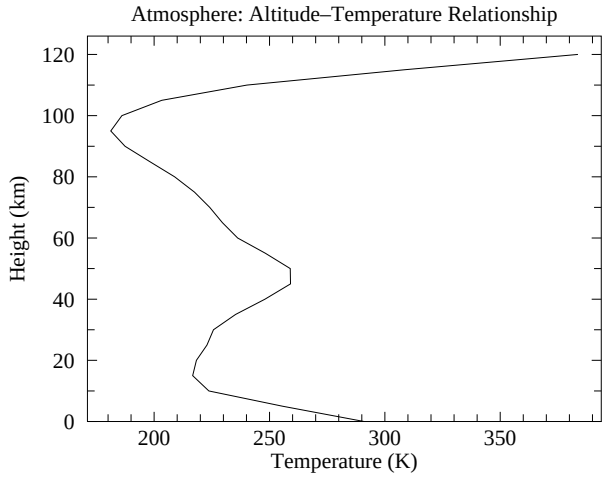
Write out a complete answer (10 pts each)

29. In class we derived a formula for "the" temperature of a planet:

$$T = T_{\odot}\sqrt{\frac{R_{\odot}}{2a}}\left[\frac{1-A}{\epsilon}\right]^{1/4}$$

    Name/describe three of the factors in this formula. For each factor report how *increasing* the factor would change the planet's temperature. What is this "the" temperature of? How/why could the "surface" temperature differ from this formula temperature?

30. The graph displays the relationship between altitude and temperature in the Earth's atmosphere. Locate, name, and label (directly on this graph) the layers in the Earth's atmosphere. According to this graph ground level and heights of 45 km and above 120 km are hotter than nearby layers. In each case report the cause of the high temperature region shown in the graph.



31. Answer this question by directly drawing/labeling on the graph below.

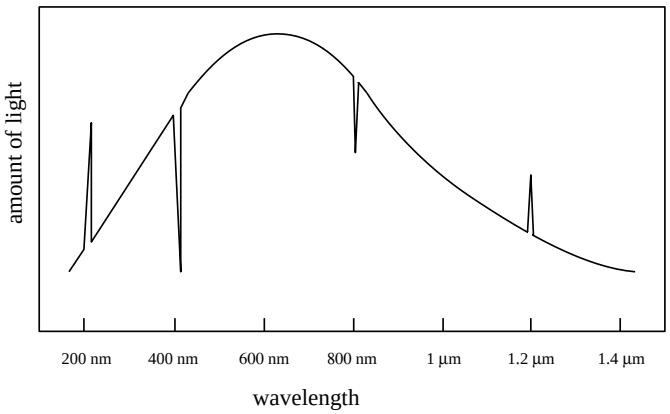
    (a) Label/locate: **G** where the green light is, **IR** where the infrared light is and **UV** where the ultraviolet light is.

    (b) Label: an absorption line **A**, an emission line **E**.

    (c) What is the numerical value of the peak wavelength?

    (d) Sketch (label **d**) how the graph would change if the object producing the light were cooler.

    (e) Sketch how the graph would change if in the quantum leap producing your labeled emission line the final energy level were slightly higher.



32. Name each of the below constellations.