UCF Physics: AST 6165 Planetary Atmospheres

Spring 2020 Mid-Term Examination

Do not write on this page, not even your name. It will be discarded and not graded. Use separate paper for answers and calculations. Use both sides. Put your name on each page.

Give complete answers that address the question. For example, if the question asks, why is X brighter than Y, don't say, "It's hotter," say "It's hotter. The Planck function says hot things are brighter than cool things." Justify all answers completely, but as briefly as you can. In general, explanations require a small number of sentences, not paragraphs. **Derive a mathematical expression for the answer before plugging in numbers. Show all work if you wish to receive partial credit for incorrect answers.**

No calculation devices are allowed; use one significant digit in your final answers, but preserve precision as much as you reasonably can in the steps leading to those answers.

Annotated diagrams are encouraged where they help.

The exam will be graded out of no more than 88 points.

1. (5 points) Define potential temperature (in words).

2. (10 points) Draw the potential temperature profile of the Earth's atmosphere and label all the "spheres" and "pauses", including the ones for escape and plasma.

3. (8 points) Referring to your thermal profile, explain the origin of the lapse rate in each thermal "sphere."

4. (4+3×2 points) What is Brunt-Väisälä frequency? Considering the three cases where the square of this quantity (i.e., N^2) is positive, negative, or zero, what happens to gas that is displaced vertically by a modest amount?

5. (5 points) What do multiple cloud layers imply for the local thermal profile? Use a diagram to explain.

6. ALRs

   (a) (3 points) What is the SALR and when does it apply (expand acronyms and define)?

   (b) (3 points) What is the DALR and when does it apply?

   (c) (4 points) Explain the difference between them in terms of a relevant quantity and a process, describing the effect of these.

   Use diagrams as necessary in your explanation.

7. (5 points) Based on fundamental principles, explain why noble gases can never be terrestrial greenhouse gases regardless of abundance.

8. (10 points) Describe how to determine the temperature in a planetary atmosphere from a small interval of its spectrum. What part of the atmosphere is this method sensitive to? What instrument characteristic does this method require?

9. (5 points) Do only one, and not one you reported on.

   (a) Why is Uranus's magnetic field offset from the center of the planet?

   (b) Describe an atmospheric escape mechanism that increases with magnetic field strength.

   (c) Describe how photochemistry is improving Earth's environment (non-steady-state process).

   (d) What evidence does Venus's atmosphere provide for active volcanism?

——If you hand in the problems above, you may now use the paper textbook and paper notes.——

For these problems, calculate to one digit accuracy only in the final answer. Leave things like logs, powers, and roots in simplest form if not easily calculated. Electronic devices are not allowed.

10. (10 points) Consider a parcel of air on Jupiter at 900 mbar and 158.8 K that contains ammonia vapor with a relative humidity of 80%. Assume $m_{\text{dry,Jupiter}} = 2.285$ g/mol, and the saturation vapor pressure of ammonia ice is given by $\log_{10} e_s(T) = 11.9 - 1588.0/T$ (e_s in Pa, T in K). Calculate the ammonia vapor pressure.

11. A beam of radiation passes horizontally through 1 km of a homogeneous gas with density 0.01 kg/m^3, an absorption coefficient of 0.1 m^2/kg, and no scattering.

    (a) (4 points) What is the optical thickness of the gas?

    (b) (2 points) What is the transmissivity of the gas?

    (c) (4 points) How far would the beam need to travel in this gas for the gas to absorb half of the incident radiation? Do not leave a negative sign in your answer.

12. (10 points) An infinite, planar, non-conducting, black wall is a distance d from a point radiation source with luminosity L. Find an expression for the temperature of the wall as a function of distance r from the closest point to the source.

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