1) Problem 4.5 from the second edition of *Planetary Sciences* (de Pater & Lissauer).

2) Firestorms sparked by a major nuclear war would release large amounts of soot into the atmosphere. Explain qualitatively why surface temperatures would be expected to drop well below freezing. (This scenario is widely known as nuclear winter.). Your answer should be at least about 100 words.

3) Problem 4.16 from the second edition of *Planetary Sciences* (de Pater & Lissauer). *In addition:*  
- determine the ratio of the number density of CH4 to the number density of hydrogen (H2). (In the literature, mixing ratios are often expressed relative to H2 for consistent comparison with the mixing ratios of other bodies.)
- can we assume that this mixing ratio value is representative of all of Uranus' atmosphere? Why or why not?

4) Geysers have been observed on several bodies within the Solar System. Water shot up by Old Faithful in Yellowstone Park reaches a height of up to 50 m. The Prometheus plume on Io is 60 km high, much of the water escaping Enceladus's south polar plume escapes the moon entirely, and plumes on Triton reach a height of 8 km.
   a) Assuming that the heights of each of the above geysers are controlled by ballistics, compute the exit velocity for each geyser as the erupted material leaves the vent. Express your answer both as a velocity and as a ratio to each world's escape velocity.
   b) Consider where this simple ballistic assumption may be wrong; then, discuss what your answers may be telling you about the fundamental mechanism behind each type of plume.

5) Essay question. *(For PHYS 480 students, this is an optional/bonus question.)* Discuss where you think humans will first find life beyond Earth (a solar system planet, a solar system moon, an exoplanet, etc.), and why. Or, you may choose to argue that we will never find life beyond Earth (note that this is not the same as saying that there isn't/never has been life beyond Earth).

Think deeply about what we have learned so far about solar system and exoplanet atmospheres. For example, is the diversity of atmospheres random, or does it depend on how, when and where the planets/moons formed, their history, their masses? Consider the methods used to study solar system bodies (noting that not all planets have been studied with all methods), and those used to study exoplanets (some of which have also been used to study solar system planets and moons). Consider also any dynamical factors (if relevant). But I encourage you to also go beyond just what is in the textbook (chapter 12 may provide some additional inspiration) and what we have covered in class. Since we have not yet discussed planetary interiors, it's fine to focus on atmospheres (and possibly dynamics) in your discussion, but if you wish, feel free to also delve into a discussion of the impact of planetary interiors and surfaces (e.g. plate tectonics).

Write approximately 2 pages (Times fontsize 11, 1 inch margins), plus references (you should be using references for this one).