Questions before Exam 3

1. **Why does hot water freeze faster?**

   It doesn't. If the hot water loses an appreciable mass to evaporation (say, in a low pressure environment) in the process of cooling down, there could be noticeably less of a water mass to freeze once the remaining water reaches 0°C. In that case, the *remaining* water will of course freeze faster, but that's not generally what this popular belief is about.

   Question I could ask: You have a lake which is frozen, with a layer of ice of 0.11 m thickness separating water at 0°C from the outside air at −5°C. Assuming that the only relevant heat conduction mechanism is conduction, what is $\Delta L/\Delta t$, the rate at which the thickness of the ice increases? You can find all the physical data you require about ice and water in your textbook or online.

2. **Would a small hole in a space station cause an explosive or a slow leak of air?**

   The space station will be constructed of materials such that a puncture will not increase in size as air rushes through the hole. So it will be a slow leak.

   Question I could ask: The air pressure inside the space station is standard atmospheric pressure, while the pressure in space is zero. What will be the speed of air flow through the hole?

3. **Why do your ears pop as you take off and land on an airplane?**

   Air pressure gets smaller as your altitude increases. As you change altitude, the air pressure inside your eardrum becomes unequal to the pressure outside, and your eardrum feels a force. You typically need to open your mouth or swallow to equalize the pressures.

   Question I could ask: As your altitude changes, there are also changes in the temperature of the air. Would colder air increase or decrease the pressure?

4. **Does Santa need an oxygen mask or get the bends?**

   If Santa flies at high altitudes, comparable to commercial aircraft, he would probably need an oxygen mask. If he changes altitude rapidly, his ears may pop, but the bends would not be an issue. Because the density of water is much higher than air, the pressure varies much more strongly with depth changes in water.

   Question I could ask: Let's do ear-popping in a pool of water, where there are no temperature and density variations to complicate things. Say you start at the surface, and dive to the bottom of a pool that is 4.0 m deep. A typical eardrum area is about 5.0×10^{-5} m^2. What is the force on your eardrum due to unequal pressures? Given your experience with everyday force magnitudes, does this seem dangerous?

5. **Take an upside-down bucket, and force it down into a pool of water with the air still in it. How will the buoyancy force on it change with its depth?**

   Since no air escapes, and the temperature doesn't change, $pV = Nk_BT$ means that the increased pressure on the air at greater depths results in a lower volume. The buoyancy force is equal to the weight of fluid displaced, so lesser fluid displacement means a smaller buoyancy force.

   Question I could ask: Draw a graph showing, qualitatively, how the buoyancy force on the air in the bucket depends on the depth of the bucket.

6. **How do pressure suits (diving, or space suits) work?**

   Physically, there is not much to them: they are suits that don't leak any air out, that you can pump in air at the required pressure.

   Question I could ask: Not anything interesting.

7. **How do sandbags work against overflowing rivers?**

   Sandbags help you build small, portable dams. As with dams in general, the job of the sandbags is to withstand the lateral forces due to the water pressure.

   Question I could ask: Explain why you cannot solve for the forces on a dam without using calculus.