Course work questions

1) Decaffeination of coffee and tea is an increasingly widely used technology in the food industry. For this process not only the separation efficiency (caffeine content needs to be reduced by a minimum of 94-96%) but also of selectivity as you would not want to remove other compounds such as aromas that give these drinks their flavour the consumers like to enjoy. While there are a number of organic solvents that can selectively remove caffeine they are increasingly avoided because of their negative environmental impact.
   Based on a thorough literature search design a separation process using green solvents, i.e. water, supercritical CO_2, *etc.*, to produce decaffeinated coffee from a coffee type of your choice (*i.e*. *robusta* or *arabica* of the origin of your choice) while minimising the environmental impact, i.e. the volume of the solvent used, pressure or the temperature of the process.
2) Water quality requirements differ for human consumptions from various agricultural needs. Recently the severe drought in New South Wales Australia have been among the new headlines. This area has access to much sea water however, access to fresh water is limited. Design a water desalination plant based on reverse osmosis near Nowra that will enable the production of enough water of sufficient quality that may irrigate 5 acres of land. Consider an unlimited access to land and finances.
3) Before reliable satnav and ocean cartography shipwrecking was a relatively common occurrence. Even nowadays seafarers may be at the mercy of the elements. Imagine that you were taking a transatlantic ship journey alone when all your communication devices stopped working and even your compass was swept off board. To compound that your engine stopped working so you are looking at a journey of weeks ahead. While you have a large quantity of food stockpiled you notice that you have only have a small amount of drinking water left, what can you do? Using your mass transfer and separation technology skills you have acquired at uni you could purify enough water to convert sea water to potable water. Design the setup that may produce sufficient drinking water to you each day with the least amount of components you would need, what are the items you would have needed to pack before the journey began?
4) Astronauts may have an exciting life but they cannot be overly choosy when it comes to their diet, in particular their water source. They have no option but to recycle their urine. Distillation is an excellent way of producing fresh water but we know that this requires a lot of energy. You may use classis distillation and solar power as the heat source or you may lyophilise the urine and draw off the water at low temperature (below its freezing point) with the help of vacuum. Provide an illustration of both techniques. Which one of them is a more favourable method in terms of the complexity and the energy requirements? Would your choice differ if the astronauts landed on Mars? Explain why.
5) Cells maintain a proton gradient across their membrane in order to live. They actively pump protons from one side to another to maintain this gradient. When a bacterium is invaded by viruses, it may need to kill itself before the virus replicates, or it may infect all the bacteria in a colony. In such (noble, self-sacrificing) programmed cell death, one of the quickest methods for cells is to perforate their membrane, and let ions rush in and destroy the gradient. Find out approximately the size of the pores formed and use your knowledge of mass transfer to estimate the timescale of such cell death. Moreover, provide scaling of the time for three different size cells – sphere 2 μm, sphere 100 μm, and cylinder 1 μm diameter, 5 μm long.

6) To sterilise water, we often either distil it (taking special precautions), or usually boil it for a long time at high temperatures to make sure microorganisms are dead. But there have been recent technologies where you could sterilise water as easily as passing through a filter. As long as the pores of the filter are small enough not to pass any of the viruses or bacteria (as small as 30 nm in some cases), you could do that.
   Give an estimate of the energy needed to sterilise water by passing through a 0.02 μm filter. Expand and comment on the types of extra challenges coming from level of contaminants in the water – caking, the increased pressure-drop, the lifetime of a filter, etc.