# 1 Cognitive reasoning in the chemical sciences 2.6

1) The atmosphere of the moon *Oberon* is a mixture of only carbon dioxide and helium. It has a an atmospheric pressure of 1.4 atm. A sample of Oberon's atmosphere is collected in a sealed balloon. The balloon has elastic walls. This balloon is brought back to Earth, and brought to conditions of STP. When the balloon is chilled to -100 ℃ but is left otherwise on a laboratory bench, the carbon dioxide becomes entirely solid while the helium remains entirely gaseous, it is found that the balloon volume has contracted to 0.3 times its initial laboratory volume.

Assume the volume of solid carbon dioxide is negligible. Assume all gases obey the ideal gas law. On Oberon, what is the $CO_2$ partial pressure?

2) The atmosphere of the moon *Ariel* consists entirely of $H_2$ and $O_2$. The Ariel atmosphere is 2.0 atm. A sample of Oberon's atmosphere is collected in a sealed balloon. The balloon has elastic but extremely strong walls. This balloon is brought back to Earth, and brought to conditions of STP. A spark is set off, igniting the $H_2$ and $O_2$ converting as much $H_2$ and $O_2$ as possible to $H_2O$. The balloon heats up to 110 ℃ but it does not break and its volume, although it could have changed, stays constant! Assume all gases obey the ideal gas law. On Ariel, what is a possible $O_2$ partial pressure?

3) A 2L flask is opened and then closed on the planet *Titania*. Titania has a temperature of 250 K. The only gases in the atmosphere are He and $N_2$. This sealed flask is then brought to the Earth. At 0 ℃, the pressure in the flask is measured at 1.4 atm. The density is measured at 0.8 g/L. What is the partial pressure of He on Titania?

4) Two sealed flasks are connected to one another by an initially closed thin tubing of negligible volume. The first flask is 2L big and contains 0.1 mole He at 300K. The second flask is 6L big at 200K and contains 0.2 mole Xe. The tubing is opened allowing the two gases to mix with one another. Assume that no energy is gained or lost from contact with either the walls of the flasks or the walls of the tubing. What is the final Xe partial pressure and what is $v_{rms}$ of the Xe atoms?

5) On the planet *Iolanthe*, atmospheric pressure is 2 atm. Iolanthe's ocean consists of pure water with a 30 meter thick layer of organic oil placed on top. The density of the organic oil is 0.80 g/mL. This oil boils at a temperature much much greater than that of water. You may therefore assume that the oil never boils. (Also please note, the density of Hg is 13.6 g/mL and 1 atm = 760 mm Hg.)

In the summer, Iolanthe becomes extraordinarily hot, so hot, that on the hottest summer days, the water in Iolanthe's oceans start to boil.

Using the data above, together with the data in the accompanying graph, please find the temperature at which the water in Iolanthe's ocean begins to boil.
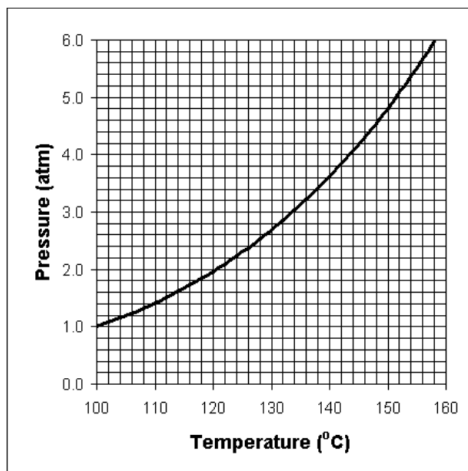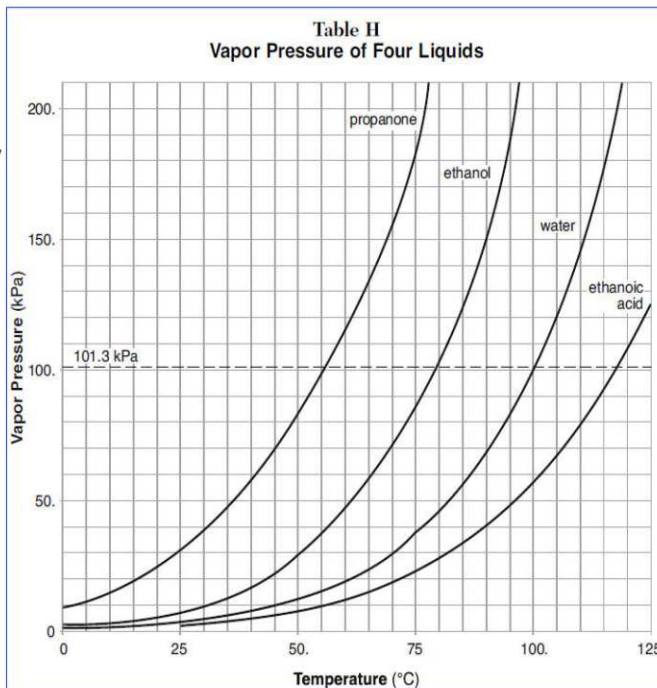
6) A sealed 20 L container contains one mole of water and nothing else. The container is initially at 0 °C. The container is slowly heated.

Assume that liquid $H_2O$, steam, perfectly obeys the ideal gas law.

What is the lowest temperature where **all** the $H_2O$ in the flask is converted into steam?

You will need to use the water vapor pressure data in the graph on the right to solve this problem. Unlike many Chem 2070 problems, this question will require a graphical solution.



**Table H**
**Vapor Pressure of Four Liquids**

7) A sealed 25 L container contains one mole of water on one side of a small divider and one mole of ethanol on the other side of the divider and nothing else. The container is initially at -10 °C. The container is slowly heated.

The divider is quite short allowing the ethanol and water **gases but not the liquids** to mix.

Assume ethanol and water can both evaporate but neither water condenses in the liquid ethanol side of the divider nor ethanol in liquid water side. Assume volume occupied by liquid can be ignored. Assume that $H_2O$ and ethanol as gases perfectly obey the ideal gas law.

What is the lowest temperature where all the ethanol is vaporized?

You will need to use the water and ethanol vapor pressure graphs on the right to solve this problem. Unlike many Chem 2070 problems, this question will require a graphical solution.



**Table H**
**Vapor Pressure of Four Liquids**

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