

## Question 1.

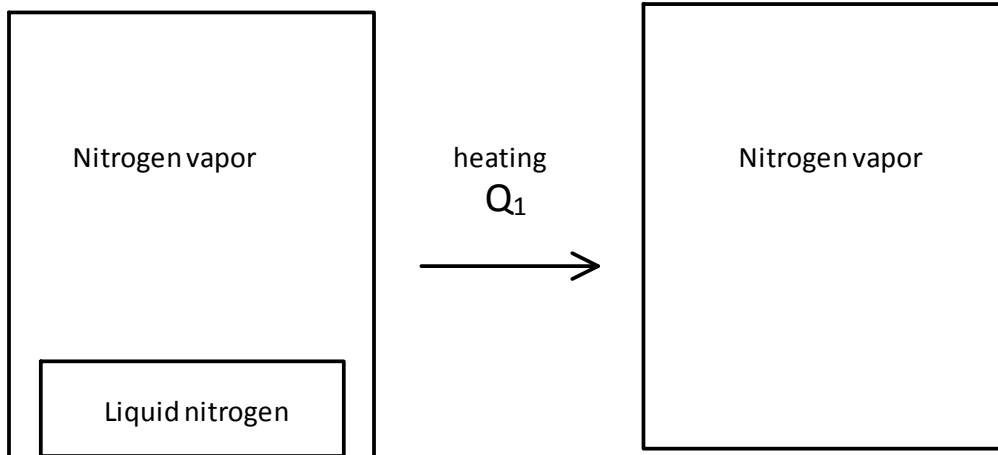
Estimate how much energy input by heating was transferred into the nitrogen.

Phase change liquid to vapor (constant volume)

Neglect air in container for energy calculations

Mostly vapor by volume

Mostly liquid by mass



Temperature = 77K  
Pressure = 1 atm  
Volume = 2L

Temperature increases  
Pressure increases  
Volume = 2L

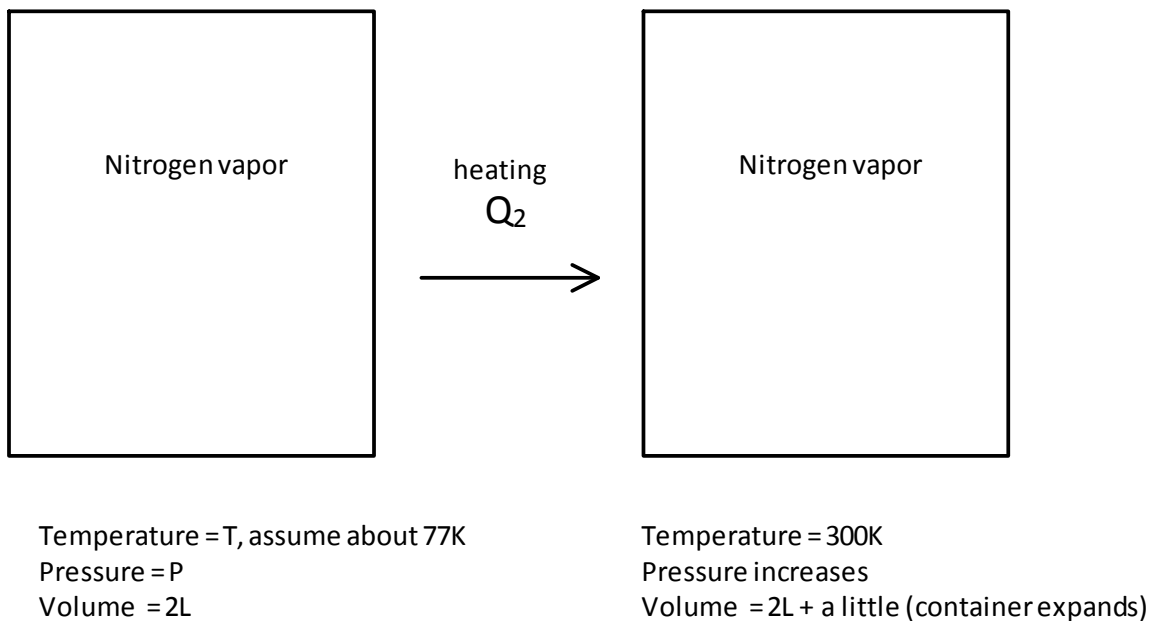
Mass of 50 ml of liquid nitrogen

$$m = \rho V = (0.808\text{g/ml})(50\text{ml}) = 40.4 \text{ grams}$$

\*Energy input by heating

$$Q_1 = mL_v = (40.4\text{g})(199\text{J/g}) = 8040 \text{ J}$$

## Heating nitrogen vapor to 300K (80°F)



\*Energy input by heating (constant volume)

$$Q_2 = mc_v \Delta T = (40.4\text{g})(0.743\text{J/gK})(300\text{K}-77\text{K}) = 6700\text{ J}$$

Estimate for total amount of energy input by heating

$$Q = Q_1 + Q_2 = 14,740\text{ J}$$

**About 15,000 J**

\*Approximations were made to simplify the calculations. The phase change did not occur under constant temperature or pressure. The heating of the nitrogen vapor starts at a higher temperature than 77K. Also the specific heat at constant volume changes a bit with temperature. The air in the container was not considered in these energy calculations. Even with these approximations, I think the result of several thousand Joules is a good estimate.