Useful Equations

✔ Heat : \[ Q = m c_x \Delta T \] (The specific heat of element \( x \))

✔ State Change : \[ Q = m L \]
  - \( L_f \) is the Latent heat of fusion – which corresponds to the melting/freezing
  - \( L_v \) is the Latent heat of vaporization – which corresponds to boiling/condensing

✔ Useful Quantities :
  - \( c_{H_2O} = 4,186 \text{ J/}(\text{kg K}) \)
  - \( L_f(\text{water}) = 334 \text{ kJ/kg} \)
  - \( L_v(\text{water}) = 2,256 \text{ kJ/kg} \)
  - \( c_{Fe} = 470 \text{ J/}(\text{kg K}) \)

Problems :

1. (*) Why does a tea kettle become quieter just before it begins whistling? (Use what you've learned from the nitrogen demo in lecture today)

2. (**) A hot water heater uses 5 kW of power. A typical shower uses 20 gallons (75 L) of water. If the ground water is at 5\(^\circ\)C and you want to take a 35\(^\circ\)C shower – how long does it take to heat up?

3. (**) One liter of water is at a boiling point when an unknown mass of ice at 0\(^\circ\)C is added. If the final temperature is 30\(^\circ\)C water, how much ice was added?
4. (***) Shown below is a pT diagram for water. Use this to speculate on the following:
   Can there be liquid water on the moon? Can liquid water exist on Mars? (The atmospheric pressure on Mars is 1/12th of that on Earth). The largest temperature reachable on certain moons of Jupiter is around -10°C, can liquid water exist there?

5. (***) How many degrees of freedom are there for a single water molecule? If the water molecule is frozen in a solid, how does the number of degrees of freedom change? If the water is a gas?

6. (***) One kilogram of steam at 125°C is put into contact with 1 kg of ice at -77°C. What is the final result of this mixture? (The specific heat of ice is 2,100 J/(kg K) and the specific heat of steam is 2,060 J/(kg K))