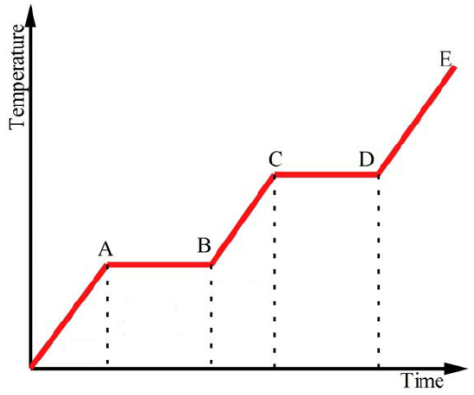
**Group members:** 1. 2.
3. 4.

# In-class Exercise

**On your own, begin by reading and answering the questions below. Then, in your group, discuss each problem and reach a consensus on a solution. At the end of today's sessions, one group member's sheet will be selected by me from each group to be graded.**

1. A beaker full of ice is heated with a Bunsen burner. The temperature is recorded every few minutes and the data is plotted in the figure below.



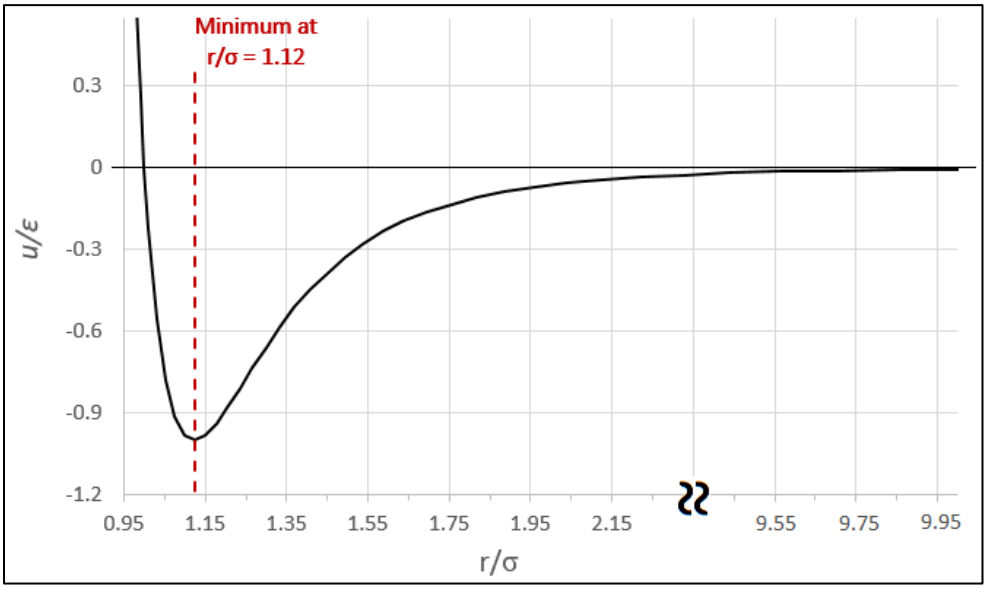

   a. Label the areas under the curve that pertain to the solid, liquid and vapor phases
   b. Shade the areas under the curves where phase transitions are occurring.
   c. What can you conclude about the temperature during phase change?

The Lennard-Jones intermolecular potential energy, $u$, is a function of ε, the attractive strength between the molecules, σ, the size parameter of the molecules and r, the intermolecular distance.

2. For liquid argon at T=130 K, the intermolecular distance between two atoms is approximately 4.0 Angstroms. Calculate the value of $u/\varepsilon$ for the Lennard-Jones model using $\varepsilon/k_B$ =115 K, σ=3.45 Angstroms (approximate Lennard-Jones diameter of an Argon atom). 1 Angstrom = 1E-10 m. $k_B = R/N_A$ = 8.314 (J/mol-K) / (6.022E23 (1/mol)).

$$\frac{u}{\varepsilon} = 4\left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6}\right]$$

3. Place a circle where liquid argon would fall on the potential energy graph below.




4. The molar volume of an ideal gas at standard temperature and pressure is 22.4 L/mol. Calculate the value of r (the intermolecular distance) for argon and use this number to evaluate the $u/\varepsilon$. (Avogadro's constant is 6.022E23 molecules/mol). *Hint: the intermolecular distance can be estimated to be the cube root of the volume per molecule.*

5. Add an 'x' where the vaporized argon (modeled as an ideal gas) would fall in the diagram above. Based on your answers to 3 and 4, how does the potential energy change when a liquid evaporates?

6. Which has an intermolecular potential energy closer to zero, a liquid or a gas?

7. List one strength of your group dynamics in this session and one change that could be made to make your group even more successful next time.