I. The cylinder shown has a piston top and contains an ideal gas. There is no friction between the piston and the cylinder walls. The cylinder is immersed in a hot water reservoir and is allowed to come to thermal equilibrium with its surroundings. The piston is then allowed to move upward very slowly in such a way that the gas is always in thermal equilibrium with the surroundings.

a) Please put a checkmark in the cell that best describes what happens to each of the following quantities in this process:

<table>
<thead>
<tr>
<th></th>
<th>Increases</th>
<th>Decreases</th>
<th>Stays the same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of the gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature of the gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal energy of the gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure of the gas</td>
<td></td>
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</tbody>
</table>

*Please succinctly explain your reasoning:*

b) Sketch the process on the P-V diagram provided. **Be sure to indicate which point is the initial state and which is the final state.**

c) Circle whether the following quantities are positive, negative or zero, and **explain your answers.**

- **Work done on the gas:** positive negative zero
  *Explanation:*

- **Heat transfer to the gas:** positive negative zero
  *Explanation:*

- **Entropy change of the gas:** positive negative zero
  *Explanation:*
When a system is taken from an initial to a final state along path $i$-$c$-$f$, there is 82 J of heating, and the system does 30 J of work.

a) How much heating occurs along the path $i$-$d$-$f$ if the work done is 10 J?

$$Q_{idf} = \text{_______}$$

b) The system is returned to the initial state $i$ along the curved path shown in the diagram. If the work done on the system is 20 J along the curved path:

i) What happens to the gas along the curved path (circle one): heated cooled

ii) by how much?

$$Q_{fi} = \text{_______}$$

c) Find the real efficiency of the cycle $i$-$c$-$f$-$i$. 
3. One mole of an ideal gas is confined to a container with a movable piston. The P-V diagram shown describes a cyclic process made up of three legs: I, II and II in the figure. The cycle goes X-Y-Z-X...

Compare the net energy transferred to the gas through heating/cooling with the net amount of work done by/on the gas in one cycle:

a) You need to know the pressures and volumes in order to determine which amount of energy transfer is bigger.
b) The net quantity of energy transferred to the gas through heating/cooling is greater than the net work done by/on the gas.
c) The net quantity of energy transferred to the gas through heating/cooling is less than the net work done by/on the gas.
d) The net quantity of energy transferred to the gas through heating/cooling is the same amount as the net work done by/on the gas.
e) The net quantity of energy transferred to the gas through heating/cooling can be greater than or less than the net work done by/on the gas, depending on the temperatures.

4. In both cases shown in the diagram, a block is floating at rest in a liquid. The liquids in the two beakers have the same density. Both blocks have 55% of their volume below the surface, but the volumes of the blocks are not the same. Find the mass \(m_2\) in terms of \(V_1\), \(V_2\), and \(m_1\).

a) \(m_2 = m_1 \left( \frac{V_1}{V_2} \right)\)
b) \(m_2 = m_1 \left( \frac{V_2}{V_1} \right)\)
c) \(m_2 = m_1 \left( \frac{(V_2 - V_1)}{(V_2 + V_1)} \right)\)
d) \(m_2 = 0.55 \ m_1\)
e) \(m_2 = 0.45 \ m_1\)

5. An incompressible fluid of uniform density flows through an infinitely long pipe. In the section shown, the pipe narrows from a diameter of 4 cm to a diameter of \(x\) cm, and the fluid is flowing through the narrow region at a speed of 3 m/s. What is the flow speed of the fluid in the wide region of the pipe?

a) \((12x) \ m/s\)
b) \((16/3x^2) \ m/s\)
c) \((4x/3) \ m/s\)
d) \((3x/4) \ m/s\)
e) \((3x^2/16) \ m/s\)
6. In your physics lab you have a sample of a pure compound that is contained in a closed, well-insulated container. The sample is heated at a constant rate and its temperature is recorded. The data are show in the graph. Which of the following conclusions is justified from the data shown?

a) The sample was initially at its melting temperature.
b) At 20 minutes the sample was completely gas.
c) The sample gas was heated above its boiling temperature.
d) The heat of vaporization is greater than the heat of fusion.
e) At 10 minutes the sample was completely liquid.

7. The P-V diagram shown at the right describes a 3-leg cyclic process, that goes 1-2-3-1-2-3… as shown. The mass of the gas is constant. Circle the Pressure vs Temperature graph that best describes this cycle, or select E if none describe this cycle.

E none of the above are correct

8. The pressure and volume of an enclosed sample of an ideal gas are measured at two different times during an experiment, shown as measurement X and measurement Y on the P-V diagram at the right. Is it possible for the gas to be in a state in which it has the same volume as in X and the same temperature as in Y? If yes, then select the lower case letter that represents this case on the P-V diagram. If no, select “not possible.”

a) a  
b) b  
c) c  
d) d  
e) not possible