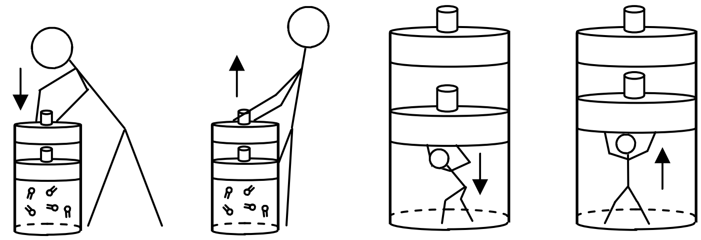
Due Mon., Feb 27

2012 Heat and Thermo 4



I II III IV

In the first two diagrams, Slim Jim is pushing or pulling on the piston from the outside. In the second two diagrams, we imagine Slim Jim is the gas inside the cylinder, also known as the system. The arrows show the direction the piston moves. Remember: when a gas is compressed it's molecules speed up due to the collision with the piston, raising its temperature and internal energy.

1. Which diagram (or diagrams) shows the following?

   A. _____ The gas increasing its temperature.
   B. _____ Positive work done on the gas.
   C. _____ Negative work done by the gas.
   D. _____ Gas losing internal energy.
   E. _____ Negative work done on the gas.
   F. _____ Positive work done by the system.
   G. _____ The system gaining internal energy.
   H. _____ The piston losing potential energy.
   I. _____ The gas molecules gaining kinetic energy.

1. A: I, III
B. I; C: III
G: I, III
H. I, III
I. I, III

The First Law of Thermodynamics is $\Delta U = Q + W_{on\ the\ gas}$ OR $\Delta U = Q - W_{by\ the\ gas}$. Let me show you why these are equivalent.

2A: +200J (added)
2B: +60J
2C: 200 + 60 = +260J

2. A sample of gas absorbs 200 J of heat while 60 J of work is done on the gas, compressing the cylinder.
   A. What is Q? B. What is $W_{on\ the\ gas}$? C. What is ΔU?

3. There is 200J of heat exchanged in an endothermal process for a gas. The gas does −60 J of work.
   A. What is Q? B. What is $W_{by\ the\ gas?}$ C. What is ΔU?

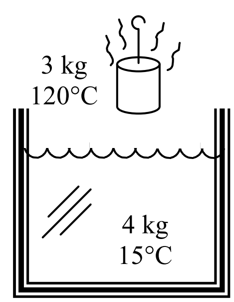
3A: +200J (endo=Qin)
3B: −60J
3C: 200−(−60) = 260J

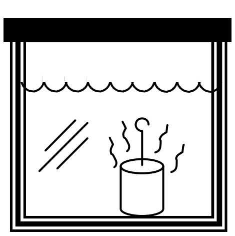
So, it doesn't matter if the work is on or by the gas. The only important thing is that the gas compressed.

4. 400 J of heat is removed from a gas while 250 J of work is done on the system. Calculate the change of internal energy.

4. −400 + 250 = −150 J

5. 300 J of work is done by the system while 1200 J of heat is added to the system. What is the total change of internal energy of the gas?





6. A 3 kg copper mass (c_p = 387) is heated to 120°C. It is then placed into a well insulated container with 4 kg of water at 15°C.
   A. Heat always travels from ______ to ______.
   B. Which object will lose energy?
   C. Which object's temperature will go up?
   D. Will the final temperature of the water be above, below, or at 15°C?
   E. Since the copper loses heat, where does the heat go?
   F. Since the container is well insulated, the amount of energy lost to the outside of the container is:

   After a while the two objects come to thermal equilibrium at 21.8°C.

   G. What is the change of temperature for the copper?
   H. Calculate the amount of heat gained or lost by the copper.

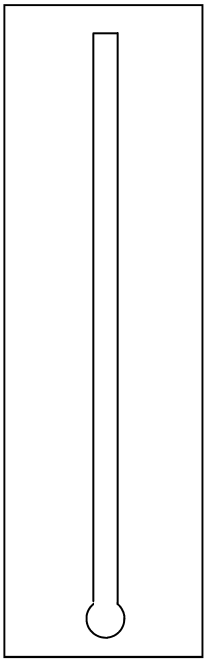
A. Hot to cold.
B. Copper
C. Water
D. Above (it gains Q)
E.
F. 0J
G. −98.2°C (Tf−Ti)
H. −1.14E5J

Specific heat	Liquid	Solid
aluminum	1180	899

Latent Heat	L_{fusion}	$L_{vaporization}$
aluminum	$3.97x10^5$	$1.14x10^7$
Boiling point	2494°C	
Freezing point	660°C	

You can calculate total heat for substances other than water. Let me walk you thru it.

7. 4 kg of aluminum is at 80°C. How much heat is necessary to raise it to 750°C?



A. Label the boiling point and freezing point of aluminum on the thermometer.

B. Mark the first and final temperature on the thermometer. Don't worry about an exact position. Just make sure they are in the correct phase.

C. The aluminum starts as what phase?

D. The aluminum ends as what phase?

E. Remember that $Q = mc_p\Delta T$ and that $\Delta T = T_{final} - T_{initial}$, calculate amount of heat necessary to raise the aluminum to its melting point.

Now that aluminum is at 660°C (its melting point), it needs to be melted.

F. Will you use the latent heat of fusion or vaporization to melt the aluminum?

G. Calculate the heat necessary to melt the aluminum.

H. What is the starting temperature of the liquid aluminum?

I. Now, calculate the heat necessary to raise the aluminum from its melting point to 750°C.

J. Calculate the total heat necessary to raise the aluminum from 80°C to 750°C.

A. See above.

B. Ti = 80°C
Tf = 750°C

C. Solid
(below 660°C)

D. Liquid

E. Q = (4)(899)
(660−80)
= 2.09E6J

F. Fusion: melting is "unfusing"

G. Q = mL fusion
= $4(3.97x10^5)$
= 1.59E6J

H. 660°C

I. Q = 4(1180)
(750−660)
= 4.25E5J

J. Add em up:
2.09E6J
+ 1.59E6J
+ 4.25E5J
= 4.11E6J

1C: + 1D: 50 J 1E: 5 m/s 2C: − 2E: 0 m/s 3B: +
4: − 5: increase 6A: − 6B: − 6C: + 7A: $A = \pi r^2 = 0.0113\ m^2$ (r = 0.06 m)
7B: $\Delta V = -1.36E-3\ m^3$ 7C: W = −411 J