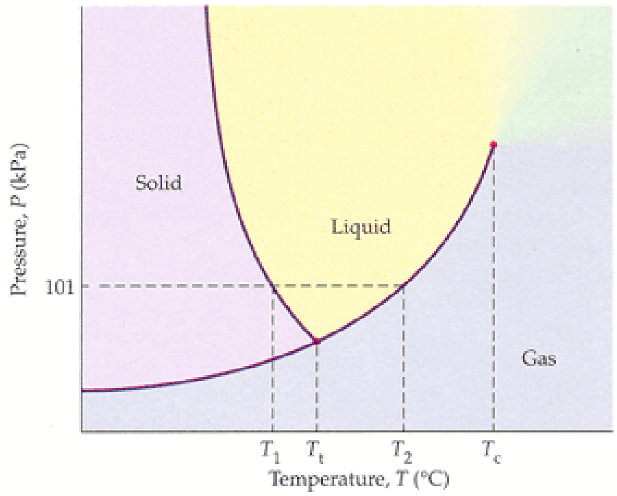
1. Walker3 17.P.042. [565929] Show Details

The phase diagram for water is shown in the figure below.



(a) What is the temperature T_1 on the phase diagram?

0°C

(b) What is the temperature T_2 on the phase diagram?

100°C

(c) What happens to the melting/freezing temperature of water if atmospheric pressure is *decreased*?

- It increases.
- It decreases.

Justify your answer by referring to the phase diagram.

Key: The slope of the fusion curve is negative.

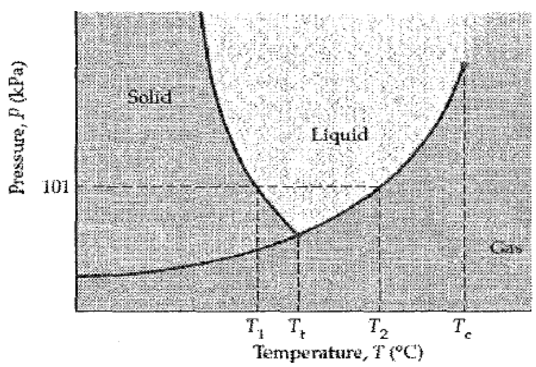
(d) What happens to the boiling/condensation temperature of water if atmospheric pressure is *increased*?

- It increases.
- It decreases.

Justify your answer by referring to the phase diagram.

Key: The slope of the vapor-pressure curve is positive.

42. **Picture the Problem:** The phase diagram for water shows the pressures and temperatures for which water is in the solid, liquid, and vapor phases. The lines separating the phases are the sublimation, fusion, and vapor pressure curves.



Strategy: Examine the graph to note that T_1 is at the boundary of the solid liquid phase when at atmospheric pressure (101 kPa). Also note that T_2 is at the boundary of the liquid and gas phases at atmospheric pressure.

Solution: 1. (a). T_1 is the melting point of water at atmospheric pressure or 0°C

2. (b) T_2 is the boiling point of water at atmospheric pressure or 100°C

3. (c) It increases since the fusion curve has a negative slope.

4. (d) It increases since the vapor-pressure curve has a positive slope.

Insight: Note from the graph that the melting and boiling points approach each other as the vapor-pressure decreases.

2. Walker3 17.P.044. [565648] Show Details

A sample of pure water is initially at atmospheric pressure and has a temperature that is just below the boiling point.

(a) If the temperature of the sample is increased while the pressure is held constant, what phase changes occur?

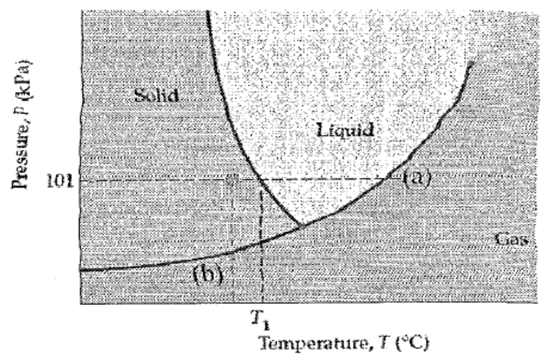
- melting
- evaporation
- condensing
- freezing
- sublimating

- [ ] gas to solid
- [ ] none of these

(b) Suppose, instead, that the pressure of the sample is increased while the temperature is held constant. What phase changes occur now?

- [ ] melting
- [ ] evaporation
- [ ] condensing
- [ ] freezing
- [ ] sublimating
- [ ] gas to solid
- [ ] none of these

44. **Picture the Problem:** The phase diagram for water shows the pressures and temperatures for which water is in the solid, liquid, and vapor phases. The sample of water ice begins at atmospheric pressure just below the melting temperature.



Strategy: Examine the phase diagram. Locate the melting point at atmospheric pressure and note that the initial state is just to the left of the melting point. Observe the phase change that occurs if the temperature increases. Observe what phase change would occur if the pressure decreases.

Solution: 1. (a) As the temperature increases, first the water ice changes from solid to liquid. Then the liquid changes to a gas.

2. (b) As the pressure decreases, the solid water sublimates to a gas.

Insight: If the process in part (b) began at a pressure above atmospheric, the water would transform from liquid to solid to gas, at constant temperature, as the pressure decreases. Most substances, such as CO_2, would pass from solid to liquid to gas as the pressure decreases.

3. Walker3 17.P.078. [565974] Show Details

A 5.0 kg block of ice at -1.5°C slides on a horizontal surface with a coefficient of kinetic friction equal to 0.056. The initial speed of the block is 6.9 m/s and its final speed is 5.5 m/s. Assuming that all the energy dissipated by kinetic friction goes into melting a small mass *m* of the ice, and that the rest of the ice block remains at -1.5°C, determine the value of *m*.

0.00014kg

78. **Picture the Problem:** An ice cube slides across a surface and slows due to friction. The heat produced by the friction melts some of the ice.

Strategy: Use the work-energy theorem (equation 7-7) to calculate the heat produced by the friction. Calculate the mass of the ice that is melted using equation 17-17.

Solution: 1. Use the work-energy theorem to determine the heat produced by friction:

$$Q = -\Delta KE = -\frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

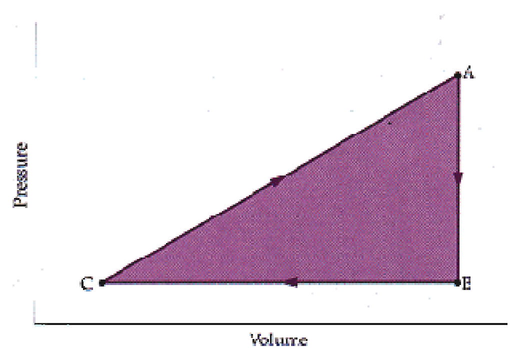
$$= -\frac{1}{2}(5.0\text{ kg})\left[(5.5\text{ m/s})^2 - (6.9\text{ m/s})^2\right] = 43.4\text{ J}$$

Kinetic Energy was stolen by friction and was converted into heat. By comparing the loss of KE, you know how much heat is created. That heat is absorbed by a small amount of ice, and raised that amount of ice's T to 0 C, and melted that small amount of ice. You can find this part of energy change by checking how much work was done by the friction force. The only force which did work is the friction. The work done by friction steals kinetic energy and converts it to thermal energy, heat. How to find the work done by friction? If you know

initial and final velocity, you can directly find change of Kinetic Energy, which is equal to work done by friction. Its absolute value is equal to the generated heat.
Another way of doing it is to find out the actual kinetic friction force using the friction coefficient. And find out the total distance moved. In order to find out the distance, you need to find out horizontal acceleration due to friction. You will then find W=- F*d= -43.4 J. And the generated heat due to the friction is Q=-W=43.4 J
To directly use energy change as shown in the last page is an easier way than using constant acceleration method.
All these heat was absorbed by a small amount of mass, $m_{melt,}$ the rest of the ice didn't change Temperature and didn't absorb this part of the heat. So:
$Q = m_{melt}\ c_{ice}\ (T_{melt} - T_{initial}) + m_{melt}\ L_f$ $\quad\quad 43.4 = m_{melt}$ *(2030*1.5+33.5 *10^4)
$m_{melt} = 0.00014$ kg
Since latent heat of melting ice is so huge, 43.4 J of heat can only melt a tiny amount of heat. 0.14 g.
Since this amount is so tiny, when we calculate the kinetic energy lose we assumed the total mass was always 5 kg.

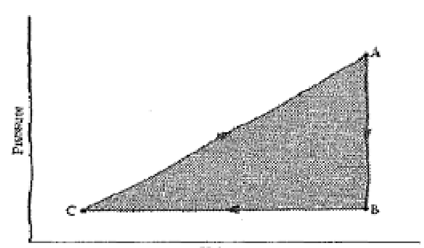
4. Walker3 18.P.009. [565978] An ideal gas is taken through the three processes shown in figure below.

Fill in the missing entries in the following table.	***Q*** **(J)**	***W*** **(J)**	**Δ*U*** **(J)**
A →B	-53	0	-53
B →C	-280	-130	-150
C →A	203	150	353



9. **Picture the Problem**: The three-process cycle for an ideal gas is shown by the pressure–volume diagram at right.

Strategy: For each process in which two of the parameters Q, W, or ΔU are known, use the First Law of Thermodynamics to solve for the third parameter. Process $A \to B$ is at constant volume, so use $W_{AB} = 0$. Since the three processes form a complete cycle, we can find the change in internal energy for Process $C \to A$ by setting the net change in internal energy equal to zero.



Solution: 1. (a) Find the constant volume work: $W_{AB} = P\Delta V_{AB} = P(0) = \boxed{0}$

2. (b) Use the First Law to solve for the change in internal energy: $\Delta U_{AB} = Q_{AB} - W_{AB} = -53\text{ J} - 0 = \boxed{-53\text{ J}}$

3. (c) Use the First Law to solve for the change in internal energy: $\Delta U_{BC} = Q_{BC} - W_{BC} = -280\text{ J} - (-130\text{ J}) = \boxed{-150\text{ J}}$

4. (d) Set the net change in internal energy equal to zero: $\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CA} = 0$

5. Solve for ΔU_{CA}: $\Delta U_{CA} = -\Delta U_{AB} - \Delta U_{BC} = -(-53\text{ J}) - (-150\text{ J}) = \boxed{203\text{ J}}$

6. (e) Solve the First Law for the heat transfer: $Q_{CA} = \Delta U_{CA} + W_{CA} = 203\text{ J} + 150\text{ J} = \boxed{353\text{ J}}$

Insight: This three-step process converts 17 J of heat $(Q_{AB} + Q_{BC} + Q_{CA})$ into 17 J of work $(W_{AB} + W_{BC} + W_{CA})$. Any time a cycle forms a clockwise loop on a pressure–volume diagram, heat will be transformed into work. If the cycle is counterclockwise, the net result will be work transformed into heat.

Because from A to B, then B to C, then C to A, you went back to condition A, (This system has exact the same Temperature at A before and after this whole loop. Hence, the total Internal energy change in this whole loop from Point A to Point A is zero. Hence you have the equation of the 4th step.
Or you can consider that from A to B, internal energy lost 53 J, from B to C it lost another 150 J, hence, in order to go back to A from C, the internal Energy needs to increase 53+150=203 J

Since Internal energy, and internal energy's change is only related to the initial and final states, not related to the processes and path, (similar to Potential energy), ΔU is the more reliable thing that you should calculate, before finding out Q, in part C to A.

5. Walker3 18.P.010. [565850] Show Details
A system consisting of an ideal gas at the constant pressure of 110 kPa gains 920 J of heat.
(a) Find the change in volume of the system if the internal energy of the gas increases by 920 J.
[ ] m^3
(b) Find the change in volume if the internal energy increases by 360 J.
[ ] m^3

10. **Picture the Problem:** An ideal gas absorbs the same amount of heat during two different constant pressure processes.

Strategy: Use the First Law of Thermodynamics (equation 18-3) and the work at constant pressure (equation 18-4) to solve for the change in volume.

Solution: 1. Solve equation 18-3 for the work: $\Delta U = Q - W \Rightarrow W = Q - \Delta U$

2. Replace the work with equation 18-4 and solve for the change in volume: $P\Delta V = Q - \Delta U \Rightarrow \Delta V = \frac{Q - \Delta U}{P}$

3. (a) Insert numeric values with $\Delta U = 920$ J: $\Delta V = \frac{920\text{ J} - 920\text{ J}}{110 \times 10^3\text{ Pa}} = \boxed{0}$

4. (b) Insert numeric values $\Delta U = 360$ J: $\Delta V = \frac{920\text{ J} - 360\text{ J}}{110 \times 10^3\text{ Pa}} = \boxed{5.1 \times 10^{-3}\text{ m}^3}$

Insight: When the heat absorbed and change in internal energy were equal, no work was done. Therefore the volume remained constant. If the change in internal energy were greater than the heat absorbed, then the volume would have decreased, as work was done on the gas.

 # 4 and # 5 are very important.
You have to really understand the relationship between work, heat and change of internal energy.

6. Walker3 18.P.014. [565847] Show Details
Consider a system in which 2.25 mol of an ideal monatomic gas is expanded at a constant pressure of 101 kPa from an initial volume of 2.15 L to a final volume of 3.30 L.
(a) Is heat added to or removed from the system during this process?

- no change in heat
- removed
- added

Key: The **expansion** of the gas at constant pressure implies that **work was done by the gas**. Also, at constant pressure, when volume increases, **Temperature increases, hence internal energy increases.** Heat is required for a gas to do work and increase internal energy, therefore heat was added to the system.

(b) Find the change in temperature for this process. [ ] K

(c) Determine the amount of heat added to or removed from the system during this process. [ ] J

14. **Picture the Problem**: A monatomic ideal gas expands at constant pressure.

Strategy: Use the ideal gas law to calculate the initial and final temperatures, and thus calculate the change in temperature. Finally, use the First Law of Thermodynamics to solve for the heat.

Solution: 1. (a) The expansion of the gas at constant pressure implies that work was done by the gas. Heat is required for a gas to do work; therefore heat was $\boxed{\text{added}}$ to the system.

2. (b) Solve the ideal gas law for temperature: $PV = nRT \Rightarrow T = \frac{PV}{nR}$

3. Calculate the initial temperature: $T_i = \frac{PV_i}{nR} = \frac{(1.01\times10^5\ \text{Pa})(2.15\times10^{-3}\ \text{m}^3)}{(2.25\ \text{mol})(8.31\ \text{J/mol K})} = \underline{\underline{11.61\ \text{K}}}$

4. Calculate the final temperature: $T_f = \frac{PV_f}{nR} = \frac{(1.01\times10^5\ \text{Pa})(3.30\times10^{-3}\ \text{m}^3)}{(2.25\ \text{mol})(8.31\ \text{J/mol K})} = \underline{\underline{17.83\ \text{K}}}$

5. Calculate the change in temperature: $\Delta T = T_f - T_i = 17.83\ \text{K} - 11.61\ \text{K} = \boxed{6.22\ \text{K}}$

6. (c) Solve the First Law for heat: $Q = \Delta U + W = \frac{3}{2} nR\Delta T + P\Delta V$

7. Insert numeric values:

$$Q = \tfrac{3}{2}(2.25\ \text{mol})(8.31\ \text{J/mol}\cdot\text{K})(6.22\ \text{K}) + (101\times10^3\ \text{Pa})(3.30\ \text{L} - 2.15\ \text{L})\left(\frac{1\ \text{m}^3}{1000\ \text{L}}\right) = \boxed{290\ \text{J}}$$

Insight: The temperature of an expanding gas must always increase if it is to remain at constant pressure. This requires that heat be added to the expanding gas.

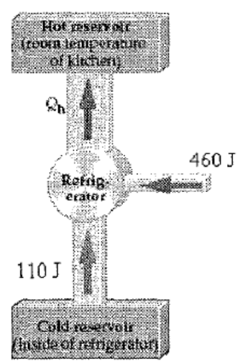
7. Walker3 18.P.055. [565903] Show Details

The refrigerator in your kitchen does 460 J of work to remove 110 J of heat from its interior.

(a) How much heat does the refrigerator exhaust into the kitchen? 525J

(b) What is the refrigerator's coefficient of performance? 0.25

55. **Picture the Problem:** A refrigerator extracts heat from the cold reservoir and ejects the heat to the hot reservoir. This process requires work to be input into the system.



Strategy: Solve equation 18-10 for the heat exhausted to the hot reservoir. Then use equation 18-15 to solve for the coefficient of performance of the refrigerator.

Solution: 1. (a) Solve equation 18-10 for Q_h: $Q_h = Q_c + W$

2. Insert given values: $Q_h = 110\ \text{J} + 460\ \text{J} = \boxed{0.57\ \text{kJ}}$

3. (b) Insert the values into equation 18-15: $\text{COP} = \frac{Q_c}{W} = \frac{110\ \text{J}}{460\ \text{J}} = \boxed{0.24}$

Insight: This refrigerator exhausts to the room over five times the amount of heat extracted from inside the refrigerator. The additional heat comes from the work done by the refrigerator.

8. Walker3 18.CE.003. [612730] Show Details

You plan to add a certain amount of heat to a gas in order to raise its temperature. If you add the heat at constant volume, is the increase in temperature greater than, less than, or the same as if you add the heat at constant pressure? ☐ greater than ☐ less than ☐ equal to

Explain. You get a greater increase in temperature when you add the heat at constant volume. At constant pressure, the gas **expands and does work** as the heat is added. Hence, only part of the heat goes into increasing the internal energy. When heat is added at **constant volume no work is done**. In this case, **all the heat** goes into **increasing the internal energy, and hence the temperature**.